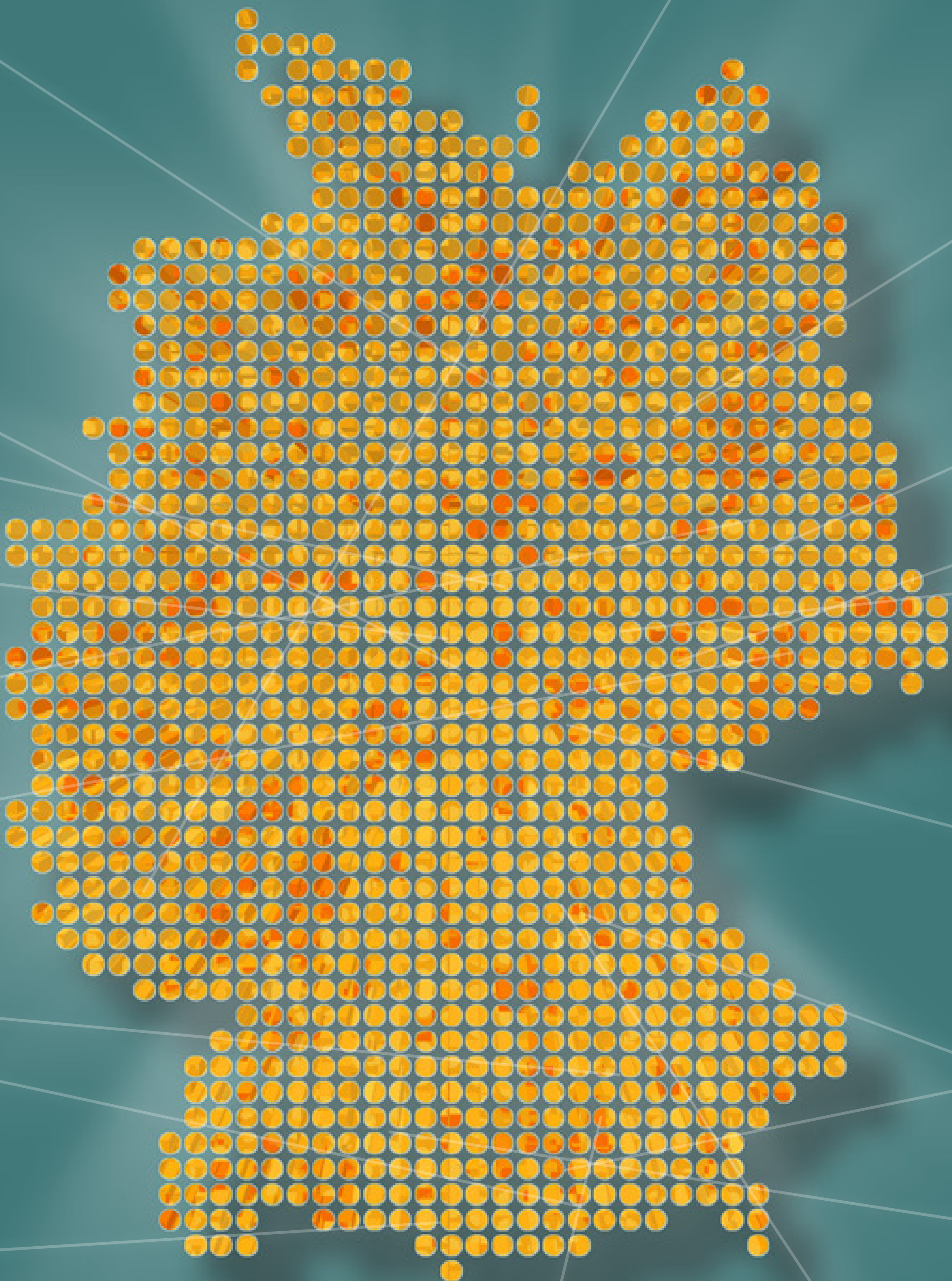
Federal Ministry
of Education
and Research

Federal Report on Research and Innovation 2014

Abstract



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Foreword

Digital technologies are becoming ever more pervasive. Our society is undergoing profound demographic change, and it is striving to make a transition to sustainable economic practices. These three major trends confront us with important questions: How can we protect people's privacy and yet still exploit the opportunities inherent in digital technologies? How can a society of longer life expectancy function for the benefit of all its citizens? How can we make our production systems and consumption patterns more sustainable, socially compatible and environmentally friendly?

To be able to address such questions, and the larger, global challenges they are part of, we are relying on education and science, research and development. These areas of endeavour offer our societies and economies – and each and every individual – a never-ending wealth of new opportunities. This is because they stand for innovation, and innovation is the key to growth, prosperity and employment.

The Federal Report on Research and Innovation presents and describes the activities of the Federal Government and the *Länder* in the areas of research and innovation, taking account of the findings of the latest report of the Commission of Experts for Research and Innovation (EFI). As the Federal Report clearly documents, the Federal Government has continuously increased its investments in education and research over the past few years, and these increases are paying off. Germany was quicker and more effective than many other countries, for example, in managing the impacts of the economic crisis. It has achieved the Lisbon goal of bringing research and development investments to 3 percent of GDP, it has record numbers of new enrolments in higher education and it is among global leaders in exports of research-intensive goods. And Germany is a recognised centre for innovation, as international rankings attest.

Germany's innovation model is a success. And we want to build on this success. Since 2006, working within its *High-Tech Strategy,* the Federal Government has been concentrating its activities in research and innovation across governmental departments. In the process, it has provided an example for European countries and other international partners. The time has now come to further develop the *High-Tech Strategy* into a comprehensive, interdepartmental innovation strategy – in order to ensure that Germany continues to be a country of knowledge and of innovation.

Prof. Dr. Johanna Wanka
Federal Minister of Education and Research

Content

Introduction

This short version of the Federal Report on Research and Innovation 2014 provides an overview of the German research and innovation system. It contains selected texts, figures and tables from the long version of the report.

Part I presents **the Federal Government's objectives and measures** in the area of research and innovation policy. It shows how the Federal Government, with the help of its *High-Tech Strategy,* is focusing resources in order to enhance competitiveness and quality of life; is safeguarding progress and competitiveness in a globalised world by research and innovation; is building a new architecture for the country's science system; is promoting high-quality education as the basis for the knowledge society; and is promoting advice and strategic foresight on research, innovation and education.

Part II contains five chapters on the structures, resources and funding measures in place in the German research and innovation system.

The first chapter, on the **German research and innovation system**, presents the structures of the German research and innovation system. Thereby it answers three key questions: "Where do research and development take place?", "Who finances research and development?" and "How does government research and innovation funding work?".

The second chapter, on the **Federal Government's research and innovation policy**, outlines the emphases of federal research funding in Germany.

The third chapter, on **the research and innovation policies of the *Länder,*** provides an introduction to the funding priorities of Germany's *Länder.*

The fourth chapter, covering **international cooperation in research and innovation**, highlights and describes the international orientation in German research and innovation policy. Significantly, it includes an overview of the objectives and priorities in Germany's international cooperation in research and innovation.

The fifth chapter presents **selected facts and figures about the German research and innovation system**. It is enhanced with a selection of tables.

Comprehensive, detailed information about the activities of the Federal Government and the *Länder* in these areas; about the organisations and institutions that conduct and/or promote research and development; about research and development in the country's industrial sector; and about relevant international cooperation can be found in the long version of the report, which is available online for download and ordering (www.bmbf.de/publikationen).

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

1 Research and innovation for prosperity and competitiveness

Germany's prosperity depends especially on knowledge. Knowledge is a key basis for new ideas and better solutions, and thus, for healthy and sustainable growth. New knowledge is generated by insight and research.

And yet knowledge, even a wealth of knowledge, is not enough by itself. Knowledge has to be put to productive use; it has to be translated into innovations that lead to sustainable products and services. If jobs are to be protected and prosperity and quality of life are to be increased, knowledge has to be exploited.

Around the world, innovation and product cycles are becoming ever shorter. Powerful new competitors are moving into global markets and challenging the established players. New forms of international work-sharing are emerging and shaping the ways in which innovation takes place. Value-creation chains are acquiring an increasingly global orientation, and companies are selecting their research locations with unprecedented flexibility.

More and more technological innovations are coming from Asia. China, India and other countries are continually boosting their investments in research and development (R&D). Today China accounts for 15 % of global R&D expenditure, thereby ranking globally second following the United States, which registers nearly 30 % of such expenditure. Germany accounts for 7 % of global R&D expenditure even though it has only 1.2 % of the world's population.

Germany needs to find the right emphases to position itself, and to thrive, in this dynamic, competitive environment. To achieve these goals, the German economy needs new growth perspectives. Germany can work from an excellent position as a highly attractive centre for innovation. This has become amply clear in Germany's success in managing the recent economic and financial crisis. Whereas other countries have cut their R&D expenditure, the Federal Government since 2005 has systematically invested in science, research and education, increased its expenditure in these areas – and still managed to consolidate the national budget. With these efforts, it has laid a solid foundation for growth, prosperity and social participation. From 2010 to 2012, the German economy grew at an annual rate of 3.4 % – thereby considerably outperforming the EU-27 average of only 2.3 %.

Germany's power to innovate has grown considerably in recent years. Besides others the *Commission of Experts for Research and Innovation (EFI)* has confirmed this success. Innovations "made in Germany" are internationally recognised as forward-looking solutions that lead to superior competitiveness. This positive trend is substantiated by numerous indicators:

- Germany is a world leader in exports of research-intensive goods, accounting for about 12 % of the global trade volume in this category.
- The EU Industrial R&D Investment Scoreboard shows that five of the ten top corporate R&D investors in Europe now come from Germany.
- German companies are among the strongest in Europe in terms of their involvement in R&D and innovation. For example, the percentage of German companies that introduced new products or services in 2010 is, at a total of 42 %, higher than the comparable figures in all other EU Member States.
- Germany ranks third globally, just behind the United States and Japan (2011), in the area of transnational patent applications.
- Germany accounts for a total of 7.2 % of the world's scientific publications (2012). In this category, Germany ranks fourth, behind the United States, China and the UK.
- Most international comparisons rank Germany very high in the categories of innovation and competitiveness: among the top ten countries, or even among the top five. In the European Commission's Innovation Union Scoreboard 2014, Germany ranks third, and is thus among the leaders in this category.
- Germany's growing strength in innovation also had an impact on its labour market: between 2005 and 2012, a total of 114 000 new jobs were created in the country's research sector alone. In addition, technology-sector employees account for an extremely high share of the country's workforce. Overall, Ger-

many has reached an all-time high in the size of its workforce: 42 million (2013).

These successes attest to the farsightedness of Germany's innovation and economic policy. They also highlight the effectiveness of the Federal Government's priorities in the areas of education, research and innovation.

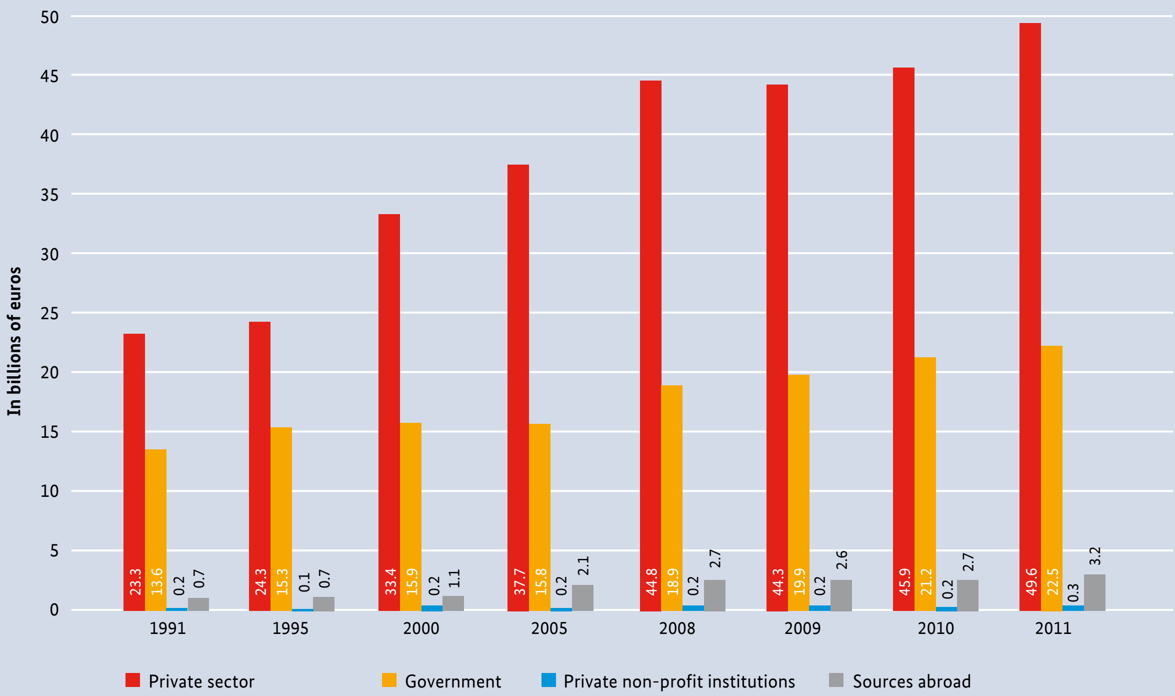
The German government, and Germany's science and industry sectors, have continuously increased their R&D expenditure, and thereby invested effectively in the country's future (cf. Figure 1). In 2011, R&D expenditure in Germany reached a record level of more than EUR 75 billion.

Between 2005 and 2011 alone, the pertinent increase amounted to nearly 36 %. A further increase, to 79.4 billion euros, is expected for 2012. With that increase, Germany's R&D expenditure, as a share of gross domestic product (GDP), will reach an unprecedented maximum of 2.98 % (cf. Figure 2). The 3 % objective for R&D intensity established by the Europe 2020 Strategy has nearly been achieved in Germany. Germany is thus among Europe's leaders in this category. Only the Scandinavian countries Finland (3.55 %), Sweden (3.41 %) and Denmark (2.99 %) invested even higher levels of funding in R&D, in relation to their gross domestic products, in 2012. Over the same period, R&D intensity in France amounted to 2.26 %, while it was 1.72 % in the UK. The European average (EU-28) was 2.06 %. Countries outside Europe that achieved higher levels are Israel (4.20 %), South Korea (4.36 %) and Japan (3.34 %). The corresponding figure for the United States is 2.79 %.

The Federal Government has contributed significantly to the achievement of Germany's good position in this category. In the years 2010 through 2013, the government invested more than 13 billion euros of additional funding in education and research. These investments exceeded the originally planned 12 billion euros, and were made despite the consolidation of the Federal Government's national budget. From 2005 to 2013, the Federal Government thus increased its expenditure in R&D by a total of 60 %, to a level of about 14.5 billion euros (cf. Figure 3). From 2005 to 2013 the Federal Government's investments in education increased by nearly 90 %.

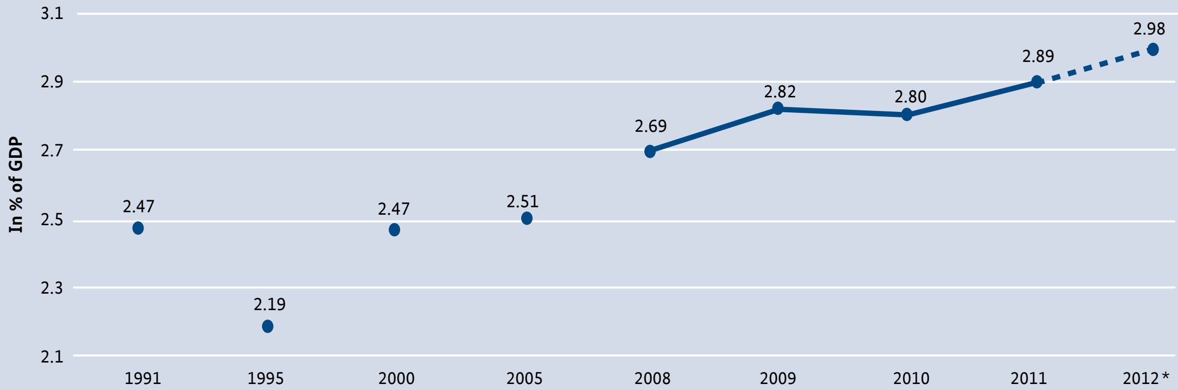
The foundations for Germany's economic success will continue to consist of innovative products and services, developed and produced by excellently trained, creative people, and applied knowledge and know-how.

Fig. 1 **Gross domestic expenditure on research and development (GERD) in the Federal Republic of Germany, by funding sectors**



Database: Table 1

Fig. 2 **Gross domestic expenditure on research and development (GERD) in the Federal Republic of Germany, in % of GDP, over time**

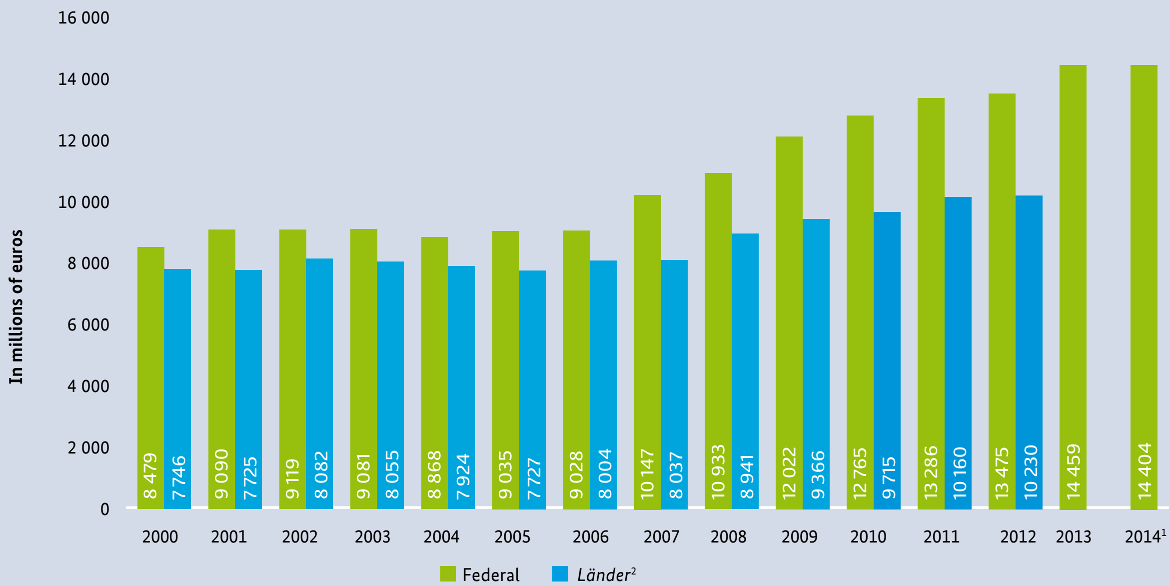


* Estimate
Database: Table 1

This is why the Federal Government is investing additional 9 billion euros in education and research in the current legislative period. All such measures have to be in conformance with the federal budget and with the new German government's coalition agreement.

The Federal Government's efforts in this area are sending a clear signal to partners in science and industry, urging them to pursue a similar course, and to ensure that Germany safeguards its reputation as a competitive, attractive centre for innovation.

Fig. 3 **Expenditure on research and development (GERD) by government and *Länder* governments, over time (financing view)**



[1] Status as of the Federal Government's pertinent draft legislation of 26 June 2013
[2] *Länder* expenditures for 2012 are estimated
Database: Tables 4 and 17 (cf. long version, in German only)

In 2012, German industry spent a record sum of nearly 54 billion euros on R&D. This shows that German companies are going to great lengths to be successful with innovative solutions in global markets. Universities and state research institutes have also been contributing to these efforts: R&D expenditure of universities (+6.0 %) and research institutes (+3.3 %) increased noticeably in 2012.

Germany has considerably improved its competitive position over the past few years to become one of the world's most attractive locations for research and innovation. This trend needs to be secured in the long term, to ensure that Germany continues to be a country in which curiosity leads to ideas, and in which ideas lead to innovations that can be translated into sustainable products and services.

Three factors in particular will be key to success in this area: knowledge, audacity and value creation.

- New knowledge creates innovations: Unless a country has creative minds, trained hands and brilliant ideas, it cannot produce marketable products and services that are superior to their predecessors.
- Innovations arise only when people are willing to take risks and think entrepreneurially – when researchers and entrepreneurs dare to undertake long-term projects, and are willing to enter uncharted technological territory.
- Only value creation translates inventions into innovations: economic success comes only when ideas can be implemented within markets.

In order to properly address these factors, innovation policy has to focus on providing good conditions for creative minds, on promising topics, on ensuring that all players are closely networked and on providing an innovation-friendly framework , so that knowledge can lead to value creation. Germany is innovative and innovation-friendly. It is a country that is home to the joy of discovery and a growing wealth of ideas, and a home that is an attractive location for the world's best and most talented researchers. That is our guiding focus and aim.

2 Focusing resources in order to enhance competitiveness and quality of life

The challenges we are facing in Germany are also concerning other countries in Europe and the entire world. New answers to the pressing questions and issues of our time have to be developed, in forms that can be marketed worldwide and that can truly help to solve global problems. As a leading nation of industry and science, Germany also has responsibility on the international level.

The High-Tech Strategy – A success story

Since 2006, the Federal Government has been addressing such challenges by focusing its research and innovation activities in an interdepartmental *High-Tech Strategy.* This strategy links key framework aspects, such as the conditions for innovative start-ups, the availability of suitable mechanisms for knowledge and technology transfer and the ongoing availability of enough skilled and specialised personnel, with funding for research and innovation. Instead of concentrating separately on individual technologies or research topics, the *High-Tech Strategy* looks at the "big picture", covering the entire value-creation chain from basic research to applications.

Orienting efforts to societal needs

In the past legislative period, the Federal Government has oriented the *High-Tech Strategy* to efforts that are helping to tackle the major societal challenges of our time. Until 2013, acting under the umbrella of the *High-Tech Strategy*, the Federal Government has invested about 27 billion euros in the development of viable solutions for areas such as environmentally friendly energy systems, high-quality health care, sustainable mobility, secure communications and the continued thriving of Germany's production sector. Such orientation to major societal challenges – backed by funding for selected future technologies – is the major difference between current research and innovation policy and past policies.

The move towards a consistent, overarching research and innovation policy has met with broad support throughout science and industry, and it has proven to be exemplary in Europe and for many of our international partners. The European Commission, for example, has identified innovation policy as a priority area for action to protect Europe's competitiveness in a globalised world. In *Horizon 2020,* the new European Research and Innovation Programme, the EU is taking a very similar approach, and making societal challenges a central focus of innovation policy.

Orientation to key models and objectives

The *High-Tech Strategy* defines specific research-policy models and objectives in connection with major societal challenges. Theme areas such as the "*CO_2-neutral, energy-efficient, climate-adapted city*", which outline and describe realistic ways of achieving a viable vision for healthy urban environments, dispense with scientific jargon and enable all citizens to deeply look into and understand the opportunities that new technologies and scientific breakthroughs can offer our lives. In a total of ten *forward-looking projects*, the *High-Tech Strategy* focuses on trends of decisive importance for Germany's future. The *forward-looking projects* provide a means of looking beyond the relevant research itself, in order to shape the necessary framework and to plan steps for effective implementation. The projects are being jointly implemented by the industry, science and policy-making sectors, and they are open for broad participation by all relevant players (cf. the info box on p. 10–12).

Info box

The 10 Forward-Looking Projects

All Forward-Looking Projects share a common central characteristic: in each case, all players involved in relevant innovation cooperate in working toward a specific goal. Each project facilitates the finding of systemic solutions within a specific field of innovation. On the basis of innovative networks of companies and public research, the projects develop answers to the major questions of our time, answers that enhance the quality of people's lives and that can – within a context of global competition – secure a leading place for German industry in key markets of the future.

The CO_2-neutral, energy-efficient and climate-adapted cities

In Germany, most consumption of energy and resources takes place in cities. Cities and urban living environments thus have a key function to play in efforts to meet the great challenges of the 21st century. Cities will be affected in many ways by climate change, and they will have to make major, continually growing adjustments to deal with it and other challenges. Such efforts will call for interdisciplinary contributions from all societal stakeholders, and in all areas of policy-making. All such players and fields of action will need to be coordinated and brought together, in conceptual frameworks and in real-world, practical terms. The National Platform for the City of the Future has been established to support implementation of this forward-looking project. The purpose of the platform is to identify research requirements for the achievement of resources-conserving, low-CO_2 lifestyles in our cities.

Renewable biomaterials as an alternative to oil

Oil, as a fuel and as a raw material for many chemical products, is currently the basis of the global economy. Supplies of oil are being depleted, however, and oil combustion helps drive climate change. Renewable resources that can be used as sources of both energy and valuable raw materials offer promising alternatives to oil, as well as to other fossil fuels such as coal and natural gas. The task of this project is to explore and develop the potential of such resources. It is an integral part of the Federal Government's National Research Strategy "BioEconomy 2030". In 2009, the Federal Government established a Bioeconomy Council in order to support the implementation of the strategy. In 2012, the Council's mandate was renewed for a second phase. In 2013, the Federal Government approved a "Bioeconomy Policy Strategy".

Intelligent restructuring of the energy supply

The tasks of discontinuing use of nuclear power, transforming the country's energy system and moving into the renewable energies age are extremely ambitious and call for close cooperation between policy-makers, industry, science and society. Scientists in particular are called on to provide the necessary foundations, and achieve the necessary technological breakthroughs, as quickly as possible. At the same time, efforts to assure Germany's energy supply in the long term, and to make it sustainable, will have to consider issues relative to citizens' participation and suitable governance formats. In August 2011, the Federal Government introduced its 6th energy research programme, which outlines the way forward for this forward-looking project. The programme is the result of an extensive consultation process, and it has been structured in light of the ongoing research activities of industry and the country's scientific institutes. In the "*Energiewende* Research Forum" ["Energiewende" is the word used in Germany to refer to the country's energy-system transformation], a strategic agenda for key basic research is being developed, with the participation of all stakeholders – the Federal Government, the *Länder*, science, industry and society. The research agenda will be applied to the further development of the energy research programme.

Treating diseases more effectively with the help of personalised medicine

Modern molecular biology, working in conjunction with medical informatics, is opening up new perspectives for evidence-based medicine. It is doing so, for example, by identifying diagnostic markers that facilitate estimation of disease risks and prediction and monitoring of therapies' success. The area of "personalised medicine" was first identified by the Federal Government, as a research field in its own right, in the Health Research Framework Programme that the Federal Government adopted in December 2010. The focuses of such medicine include developing customised procedures for prevention and therapy, and minimising the side effects of medications by taking account of individual circumstances, in order to enhance treatment and therapy success. A range of relevant new funding initiatives have been launched in connection with the "Personalised Medicine" action plan, which was introduced in 2013, and which starts a new course in health research and health care.

Better health through targeted prevention and an optimised diet

Healthy lifestyles and living environments can help prevent chronic diseases, or at least delay their onset. For this reason, funding of prevention and nutrition research is aimed at providing the scientific foundations for effective, convenient prevention and health promotion tailored to the needs of specific target groups. In addition, it calls for developing strategies for improving the eating habits of the population and the availability of healthy foods.

Living an independent life well into old age

The numbers of senior citizens, as a percentage of the population, continue to increase. By the year 2030, Germany will have 22 million people who are 65 or older. That figure represents 29 % of the population as a whole. Demographic change leading to a society of longer life expectancy confronts us with special challenges – and offers valuable opportunities at the same time. To address these opportunities, the Federal Government, working through the direction of the BMBF, developed the "New Future of Old Age" research agenda and approved it at the end of 2011. The agenda defines six research fields, and the major lines of action of this forward-looking project, along with a range of measures of various government departments, are oriented to these fields.

Sustainable mobility

The *Sustainable Mobility* project is aimed at the development of innovative, ecologically sustainable and affordable mobility solutions. The broad range of areas it covers includes drive and propulsion system technologies; vehicle and aircraft concepts and fuels; the transport system as a whole; and changing patterns in societal mobility behaviour. The aim of achieving viable, sustainable mobility systems calls for an integrated transport policy that seeks to a) optimise the efficiency of individual modes of transportation, and of their interactions, and b) make the "Umweltverbund", i.e. the entire complex of "green" transportation options, including walking, cycling and public transportation, more attractive and thus more popular. As part of the effort, the energy efficiency and environmentally friendliness of both passenger transports and goods transports are to be improved. The project also includes efforts to prepare the entire transport infrastructure to meet the challenges of climate change. Furthermore, transport planning in cities is to be oriented more closely to the actual needs of people.

Web-based services for businesses

The Internet has very rapidly grown into something much greater than a global infrastructure for access to information. Within a few short years, it has become an "always and everywhere" platform for services, manifested in hundreds of thousands of successful applications covering virtually all areas of life. To date, most of these applications have been aimed at the needs of private users. Increasingly, business applications are being integrated into the business processes of many companies and administrations, however. Relevant Internet-based services offer great potential for growth, for both providers and users of IT services. With this forward-looking project, the Federal Government is addressing such opportunities.

Industry 4.0

Industry now stands at the threshold of a fourth industrial revolution. Via the evolution of the Internet, the real world and the virtual world are increasingly converging, to form an "Internet of Things". The key characteristics of the industrial production of the future will include production of extensively individualised products, within highly flexible (large-series) production environments; extensive integration of customers and business partners within relevant business and value-creation processes; and linking between production and high-quality services, to yield "hybrid products". German industry now has the opportunity to actively help shape this fourth industrial revolution. With the forward-looking project Industry 4.0 we plan to support this process.

Secure identities

Trust is a valuable asset, and trust is the basis of every stable and enduring relationship. Trust can indeed be cultivated and protected in the Internet, if people can know that a) their own identity is secure on the Internet and b) the other people they encounter on the Internet are who they claim to be. With this forward-looking project, the Federal Government plans to identify strategies for achieving such identity security and reliability. With secure identities, users will be able to exercise their "rights to informational self-determination" in the global network (i.e. rights to control the manner in which their personal information is handled). In addition, secure identity functionalities are expected to provide a solid foundation for business and commerce in cyberspace. Such functionalities can thus be expected to open up long-term growth perspectives for network-based business models. They are also expected to provide an effective means of addressing still-common cybercrime issues, such as identity theft and phishing. This forward-looking project is working closely with the forward-looking projects "Internet-based services for industry" and "Industry 4.0".

Turning knowledge and ideas into innovation more rapidly

Good networking between science and industry in the realm of R&D has long been one of the German innovation system's strengths. From a comparative international perspective, Germany has improved its ability to transfer research-based knowledge and technologies to applications. Increasingly, companies are opening up their research departments in order to integrate customers, suppliers and science institutions in the development and improvement of their products and processes. Existing forms of cooperation between science and industry are being rapidly refined on this level, and are being adapted to new requirements within innovation processes. This trend is shaping a new culture of "open innovation". And all of these developments are accelerating the rates at which ideas are turned into marketable products.

Working on the basis of such achievements, the Federal Government is now aiming to even further improve coordination of the country's existing scientific and industrial strengths and resources – and to unleash new energies in the process. Efforts in this area are focusing on cluster and network formation, especially with the participation of small and medium-sized enterprises (SMEs).

As a result, networking in this sense has intensified considerably in the past few years. From 2008 to 2013, in the framework of the *Central Innovation Programme SME (ZIM)*, the percentage of SMEs that cooperate with universities increased from 16.7 % to 42.9 %, and the percentage of SMEs that cooperate with non-university research institutes grew from 15.6 % to 39.9 %. A total of 15 leading edge clusters in the *Leading Edge Cluster Competition,* more than 90 innovation clusters in the *go-cluster* programme and 287 SME-led networks in the ZIM programme are drawing international attention to the powerful regional partnerships, involving industry, science and other stakeholders, that are now underway in Germany. The *Cluster Platform Germany* at www.clusterplattform.de provides an overview of the cluster-oriented activities of the Federal Government, the *Länder* and the EU.

The *High-Tech Strategy* has brought Germany's science and industry sectors even closer together. Cooperative efforts between these sectors have become an increasingly attractive option. In addition, at more and more universities and research institutions, cooperation (and commercialisation) concepts enter into R&D processes from the outset. The following programmes exemplify these trends:

- The funding initiative *Research Campus*, in which ten long-term strategic cooperative efforts, with

scientists and companies working together on new and emerging research areas, are being tested jointly, under a common umbrella.
- The pilot measure *Validation of the Innovation Potential of Scientific Research – VIP*, in which some 140 projects are working to close the innovation gaps between academic research and commercial applications.
- For about ten years now, and in the context of more than 400 networks, the programme *Entrepreneurial Regions – The BMBF Innovation Initiative for the New German Länder* has been promoting the development of the innovation potential of eastern German regions. The effort is oriented to the establishment of dynamically growing, internationally competitive science-industry centres of excellence and clusters.

Creating favourable framework conditions for innovation

The Federal Government is aiming to create framework conditions that are conducive to innovation. With its *High-Tech Strategy*, the Federal Government focused especially on promoting innovative small and medium-sized enterprises (SMEs) and innovative start-ups, in order to help build strengths and resources in research-intensive industries, knowledge-based services and in market development.

In many areas, it is the small and medium-sized enterprises that blaze trails of technological progress. This is why the Federal Government has been providing substantial support for innovative SMEs, especially via the *Central Innovation Programme SME (ZIM)* and through the *KMU-innovativ (SME innovative)* initiative for funding cutting-edge research by SMEs and in cooperative industrial research. In 2013 alone, it provided more than 1.4 billion euros to support research and innovation by, and for the benefit of, SMEs. SMEs receive a disproportionately high share – about half – of the Federal Government's R&D funding for industry. On the other hand, in 2011 they accounted for only about 11 % of industry's internal R&D expenditure.

To promote start-ups, the Federal Government has created a framework, in its *High-Tech Strategy,* that improves start-ups' access to financing and advising:

- The *EXIST* programme is designed to enhance the conditions for start-ups at universities and research institutions. To that end, in the *EXIST Culture of Entrepreneurship* competition, universities are being supported in developing and implementing university-wide start-up strategies. The broadly effective business start-up grants available through

Info box

Promoting R&D in the Private sector

The research and development carried out by companies builds prosperity and employment. The great majority of the value creation that takes place in Germany is based on research-intensive products and services. By investing in R&D, companies with innovative products and services seek to enhance their competitiveness and create avenues for profitability growth. With such investments, such companies also create new knowledge that is of great value for the country's economy and entire society. Such knowledge becomes available to other researchers, in both the science and industry sectors, who can then build on it to obtain further knowledge and insights. On the other hand, companies' investment decisions often do not take full account of these interrelationships. For policy-makers, therefore, it would be economically short-sighted to rely solely on market forces for the necessary corrections.

Without public support for basic research and for applied R&D, investments in new products and services would be too low. And every technological innovation that small and medium-sized enterprises – in particular – fail to capitalise on weakens such enterprises' competitiveness in international markets. Conversely, well-targeted state support can provide new impetus in this area. It can trigger a flurry of new activity, and it can help protect innovation leadership. It can thus exert considerable leverage. At the same time, state research support has to function strategically, by enabling progress in central areas of innovation. For this reason, the Federal Government is emphasising research that addresses the most pressing societal and global issues and thus benefits the largest possible numbers of people. Another advantage of state research funding is that many of the new findings and results it facilitates are publicly accessible. Such findings thus benefit additional researchers.

EXIST promote innovative start-ups in university environments, while excellence-based, *transfer-of-research* funding supports research-based spin-off projects at universities and research institutions. The *GO-Bio* project provides targeted support for spin-offs in the life sciences that require high levels of financing and long periods of gestation.

- Innovative start-ups should not be permitted to fail simply because of a lack of financing. This is why the *High-Tech Gründerfonds (HTGF)* has been providing technology-based start-ups with initial financing on the basis of venture capital. The *HTGF* fund has been a success, and in 2011 it was followed by a successor, *HTGF II*. The *HTGF II* framework considerably increases the scope for participation by industry partners. The *HTGF* has become the largest and most important early-phase financer in Germany.
- The Federal Government is supporting venture-capital financing for young, innovative companies. In the past legislative period, the venture capital market was strengthened especially via the programme *INVEST – Investment Grant for Business Angels*, a newly developed instrument for business angels. In this legislative period, the Federal Government – as set forth in its coalition agreement – is seeking to make the legal and taxation frameworks for venture capital internationally competitive, and to make investments in young companies more attractive.

To be able to make far-reaching investment decisions, companies require a reliable basis for their planning and a favourable investment climate. Many improvements have been made in this area:

- Support for commercialisation: The *SIGNO* project supports universities, companies and independent inventors in legally protecting and commercialising their innovative ideas.
- A boost for innovative procurement: In its procurements, the Federal Government welcomes innovative products and services and seeks to intensify use of procedures that help stimulate innovation. This orientation provides additional impetus for innovation in industry. A *Competence Centre for Innovative Procurement* has been established, under commission to the Federal Government, to provide support in this regard to procurement agencies. In addition to providing comprehensive information and advisory services, the Centre uses pre-commercial procurement options to support pilot projects for the development of new products and procedures tailored especially to the needs of public institutions.
- Progress in standardisation: The project *Innovation with Norms and Standards*, which is being financed by the Federal Government, and coordinated and conducted by the German Institute for standardisation (DIN), is providing options for early initiation of norming and standardisation in innovative fields, with a view to optimising the processes by which innovations reach market maturity.

The project is working to structure the legal framework for such norming and standardisation in keeping with the needs of a coherent overall innovation policy. For example, the relevant quality infrastructure, including the elements standardisation, metrology, accreditation and conformity assessment, needs to be refined in step with technological progress, in order to foster industry's acceptance for innovations and to facilitate rapid market introduction of innovations. Policy-makers need to be able to recognise at an early stage whether a new technology is going to generate requirements for new regulations. Legal certainty makes it easier for companies to assess their chances of market success. International activities in the area of quality infrastructure help eliminate technical barriers to trade, thereby significantly promoting German companies' global trading activities and export opportunities.

The *Renewable Energy Sources Act (EEG)* provides yet another example. It has opened up the possibility of transforming the country's energy generation system into a renewables-based system by adhering to the principle that system innovation depends on interactions between direct and indirect innovation, and between technical and process-oriented innovation. In its current report, the *Commission of Experts for Research and Innovation (EFI)* is reserved in its assessment of the *EEG* from the standpoint of research and innovation policy. And yet the *EEG* has been successful in spurring expansion of renewable energy use, and it has triggered significant pertinent market and technology development. The *EEG* will be a central instrument in the further structuring and implementation of the country's energy-system transformation.

Exploiting the opportunities provided by key technologies

Innovation is being driven by a range of technologies, including information and communications technologies, nanotechnologies, photonics, production technologies, materials research, biotechnology and aerospace technology. In addition, innovative services are playing an increasingly important role. Such services provide a basis for new business models, and for the marketability of technical innovations, and they open up new markets and employment opportunities. The Federal Government is thus continuing with its efforts to expand Germany's leading position in key technologies and to accelerate translation of research findings into products, processes and services. By promoting key technologies and innovative services, Germany can expect especially to strengthen its position as a provider of system solutions. Germany already has considerable relevant strengths in research and industry:

- Areas such as the automotive industry, medical technology, biotechnology and the consumer goods sector would now be unthinkable without electronics and microsystems technology. Many German companies, including many small and medium-sized enterprises (SMEs), have been able to maintain leadership in global markets by virtue of great expertise in design automation, systems integration and microsystems technology.
- Space technologies tend to push the limits of what is technically feasible. As a result, they function as important basic and key technologies for other technology areas and for a wide and diverse range of applications, especially terrestrial applications. Examples of terrestrial technologies and systems that have been so influenced by space technologies include plasma technologies for coating of surfaces, highly efficient solar cells, robotic systems, mechatronics and autonomous systems.
- German manufacturers have maintained a leading position, in both development and production, in the world market for power electronics. A new site for production of 300 mm silicon wafers is being established in Dresden.
- Germany is also among the leading countries in the high-tech field of photonics, with a world market share of about 8 %. From 2005 to 2012, German companies in this field increased their revenue by 70 %, to about 29 billion euros, and created more than 30,000 new jobs in Germany.

With its *High-Tech Strategy*, the Federal Government is seeking to strengthen links both a) between various disciplines and b) between technologies and application areas. The resulting synergies are expected to lead to and enhance intelligent solutions. With a range of efforts, such as the funding programmes *ICT 2020 – Research for Innovation, Photonics Research Germany, Nanotechnology in Construction – NanoTecture, NanoChance* and the *LED Lead Market Initiative*, the Federal Government has already developed precisely tailored measures for a number of key-technology areas. The programmes now planned, including *Innovations for the production, services and jobs of tomorrow (Innovationen für die Produktion, Dienstleistung und Arbeit von morgen)* and *Self-guided and secure in the digital world (Selbstbestimmt und sicher in der digitalen Welt)* can be expected to continue providing excellent conditions for transfer of research findings into applications.

Infobox

Info box: Evaluation in research and innovation policy

Evaluations are an integral part of funding processes. Taking account of the specific characteristics of project funding in the areas of education, research and innovation, evaluation procedures make use of the best available and suitable instruments for quality assurance, results monitoring and impact analysis. The legal basis for evaluating the Federal Government's funding measures consists of the Federal Budget Code (BHO) (Art. 44 in conjunction with Art. 23 BHO) and the administrative regulations for the Federal Budget Code.

To ensure that the available funding resources are used efficiently, decisions on the emphases and structures of education and research policy are prepared by various advisory bodies, such as the *Commission of Experts for Research and Innovation (EFI),* scientific advisory boards and peer review boards. Such bodies provide support for the processes of selecting suitable instruments, defining basic thematic orientations, monitoring, applying accompanying controls and carrying out final assessments of programme results. Quality assurance is also carried out via status seminars, meetings for exchange of relevant experience, specialised conferences, etc..

Enhancing effectiveness

Quality assurance in project funding, and assessment of the success of funding measures, both play an important role in the Federal Government's innovation policy. All major initiatives and measures in the *High-Tech Strategy* – including such efforts as *ZIM*, *the KMU-innovativ* programme for funding cutting-edge research by SMEs, *VIP*, *Entrepreneurial Regions*, the *Foresight Process* and the *Leading Edge Cluster Competition* – are evaluated ex ante, while they are in progress and/or ex post (cf. the info box).

In its 2014 report, the *EFI* emphasises the importance of evaluations in assuring the effectiveness of funding measures. In some Federal Government departments, such evaluations have been given a permanent institutional foundation. The *EFI* urges that such structures be expanded and refined. In keeping with an objective specified in its coalition agreement, the Federal Government plans to work to enhance the effectiveness of government action. With a view to systematically reviewing such effectiveness, plans call for intensified use of impacts analyses in the development phases for political measures, as well as of evaluations of existing laws and programmes.

Further development of the High-Tech Strategy, to produce a comprehensive, interdepartmental innovation strategy

We want to maintain the energy and activity that we have triggered with the *High-Tech Strategy*. We face major challenges. Megatrends such as digital technologies, demographic change and the transition to more sustainable business practices are bringing radical changes. They are changing our economies and societies in ways that reach far into the everyday lives of each and every person. New technologies are being introduced, and business models have to be adjusted to completely new conditions or even invented completely from scratch.

- *Digital technologies:* Information and communications technologies are having ever-greater impact on our lives. Dealing responsibly with data of unprecedented quantity and quality is not the only challenge we face as a result. We also have to address the following questions: How do we want to live, learn and work in the digital world? How can we best use the opportunities and potential that digital technologies hold for the knowledge economy and society, and how can we reduce the attendant risks? The *EFI* sees good opportunities for growth and employment, especially in the further spread of information and communications technologies (ICT). They are key technologies that serve as the basis for value creation in many private sectors. Germany's future competitiveness will hinge on its success in integrating digital technologies within various application sectors. Media literacy and education oriented to secure, responsible use of ICT – and the ways in which social interactions are managed in a digital world – are acquiring growing importance in this context.
- *Demographic change:* In the year 2030, about half of all people in this country will be older than 50, and nearly one in every three persons will be over 65. At the same time, according to forecasts, the population is shrinking. This trend brings up central questions: What sort of community life do we want to cultivate in a society of longer life expectancy, and how can we best exploit the economic and societal potential inherent in demographic change? As digital technologies pervade all areas of life, how will they affect a population that is ageing – and becoming more diverse via immigration – and how will they affect the population's participation in important areas and functions of society? Concepts are needed for promoting a society of longer life expectancy in which all generations can live together in harmony, for their mutual benefit.
- *Sustainable economy:* The ways in which we produce and consume need to become more resource-efficient, more environmentally friendly and more socially compatible. In short, they need to become more sustainable. With its prowess in research and technology, and with its commitment to sustainability, Germany has the opportunity to serve as a good example – as an international model for energy-efficient, sustainable economic practices. How can our society conserve resources, and protect our environment and climate? What is more, how should our society foster equal opportunity and social participation, and how should we live, work and do business in green, socially compatible societies? By delivering pioneering, innovative answers to such questions, Germany can provide valuable international impetus and become the world market leader in green technologies.

These trends, which equally challenge all countries, present great opportunities for growth and employment in key emerging, cutting-edge fields. We want to address these and other challenges, with our science, industry, society and policy-makers acting in concert. In the process, we want to focus especially on technological and societal innovations. This is because being "innovative" means more than simply implementing technological innovations in industrial production. More and more, being innovative also has to do with the development of new consumption habits, new behaviour patterns and new societal structures.

To these ends, Germany needs a holistic innovation policy. This is why we plan to develop the *High-Tech Strategy* into a comprehensive, interdepartmental innovation strategy for Germany – and to implement the new strategy in this new light. This approach will develop new innovation resources and energies for actively meeting the major societal challenges of our time, and it will systematically move the resulting new answers into the sphere of application.

3 Research and innovation in a globalised world: Progress and competitiveness by internationality

Globalisation is a reality today. In 2011, a total of 1,435 billion dollars was spent worldwide on R&D. The largest share of that sum was spent in Asia, which now accounts for 34 % of worldwide R&D expenditure. North America accounts for 32 %, and Europe accounts for 24 %.

For these reasons, the issue is not one of whether we are going to act globally; it is one of how well we are going to develop our global position. Nearly half of all scientific publications produced by German scientists are now produced by international cooperation. And since German scientists are becoming more and more mobile, this trend will only continue. In their own R&D, German companies are also showing an ever-greater international orientation, although since 2007 foreign companies' investments in R&D in Germany have been exceeding German companies' investments in R&D abroad. In 2011, the balance of this "account" amounted to about 4 billion euros.

More and more countries realise that education, research and innovation are of vital importance for their own economic and social development and, consequently, have been seeking to intensify their international cooperation in these areas. Germany is being watched closely in many policy areas, and interest in cooperation with Germany is growing.

The root causes, and the consequences, of the financial and economic crisis have considerably reinforced this trend. The area of vocational training provides an illustrative example. In this area, we have been working to enable others in Europe and beyond to profit from our good experience with the dual system.

In keeping with this orientation, internationalisation is one of the Federal Government's priorities in this legislative period. The Federal Government is seeking to make even better use of the potential and opportunities available for Germany in international cooperation. At the same time, Germany has to accept its global responsibility: to help find ground-breaking answers to the challenges of globalisation and to help shape and structure the resulting solutions. It must do this, for example, in areas such as making its economy more sustainable, transforming its energy systems and addressing shortages of skilled personnel, issues related to migration and issues related to occupational mobility. In addition, international cooperation opens up opportunities, in converging economic, science and education areas, to define Germany's role more clearly and to enhance the effectiveness and efficiency of Germany's international science and research presence. Significantly, commitments in Europe are central in Germany's spectrum of international commitments.

An equal footing in international encounters

The Federal Government first adopted an internationalisation strategy in 2008. That strategy has proved to be a successful response to the challenges of globalisation. It has intensively advanced political dialogue and cooperation in education, science and research, at the international level, and it has given German research and intermediary organisations valuable impetus for internationalisation strategies of their own.

The internationalisation strategy is being further refined in the current legislative period. Overall, the Federal Government's measures in this area aim to take international cooperation by the German science sector to a new level. Among its priorities, the strategy will continue to focus on emerging and developing countries – especially on those countries that have considerably increased their investments in science and research in recent years.

Since internationalisation is now profoundly affecting the entire science system – including research institutes, universities, intermediary organisations and researching companies – and since Germany needs to find answers to the resulting challenges, one of the strategy's special emphases will be to enhance networking among science institutes.

The Federal Government has a broad range of means for working toward its objectives. Such means include intensifying networking of international activities of German science and research organisations; attracting and assisting foreign students and scientists; and internationalising measures and initiatives in the framework of developing the *High-Tech Strategy* into a comprehensive, interdepartmental innovation strategy.

We want to achieve better solutions, and do so more rapidly. We want to enhance our market access, while also highlighting Germany's expertise in system solutions. We plan to achieve these goals by expanding international research cooperation, internationalising leading edge clusters, conducting new innovation-oriented dialogue with selected emerging and transition countries and orienting the forward-looking projects internationally. Another priority will be to improve Germany's international visibility as an attractive centre for science, research and innovation. Marketing of Germany's research sector, and strengthening a welcoming culture for foreign researchers, play an important role in this regard.

At the political level, bilateral intergovernmental consultations, with research functioning as an increasingly important topic, are of central importance. Along with bilateral instruments for international cooperation, international organisations, such as the OECD, UNESCO and the United Nations University (UNU), are playing an increasingly important role, especially with regard to the dissemination of recognised scientific standards and to collaborative development of solutions for the global challenges of our time. For example, at the initiative of the Federal Government and the state *(Land)* of North Rhine – Westphalia, and with their financial support, a UNU research institute focusing on prevention of global natural disasters (the UNU-EHS) has been established in Bonn. At the same time, the UNU's European Vice Rectorate has been located in Bonn, with a view to strengthening Bonn's science sector.

A focus on Europe: Horizon 2020 and the European Research Area

Horizon 2020, the new European framework programme for research and innovation, is already a success story for Germany. The EU has emulated Germany's approach in this area, i.e. in pursuing a comprehensive research and innovation strategy oriented to global challenges. Key requirements submitted by Germany have been taken into account in the design of *Horizon 2020*. These include especially the following: retaining the principle of excellence; strengthening the *European Research Council (ERC);* making promotion of transnational collaborative research projects a central funding instrument; intensifying interdisciplinary cooperation between the humanities and social sciences and the natural and technical sciences; and integrating the *European Institute of Innovation and Technology (EIT)* within *Horizon 2020*.

In the programme's implementation, Germany plans to continue working for efficient, user-friendly processing and approval procedures. Overall, the new framework programme offers the potential for synergies, in terms of both content and structure, between national and European measures. Examples of areas in which such synergies can occur include links between a) national promotion of leading edge clusters and b) promotion of innovation clusters at the European level and links between thematic focuses, at the two levels, on key societal challenges and technology areas. The relevant conditions for industry have also been improved. Examples of the pertinent improvements include the new instrument for SMEs and the "Fast Track to Innovation" (FTI) pilot project.

Horizon 2020 consolidates research funding programmes at the European level and, in comparison to previous programmes, it is more strongly oriented to cooperation between science and industry (cf. Figure 4). The programme thus contains important strategic and structural measures for strengthening innovation in societally relevant areas, and it will accelerate translation of findings from basic research into new products, processes and services. The programme is making directly targeted investments in technologies of key importance for Europe's future. At the same time, *Horizon 2020* funding resources are expected to generate leverage for mobilisation of private capital for innovation.

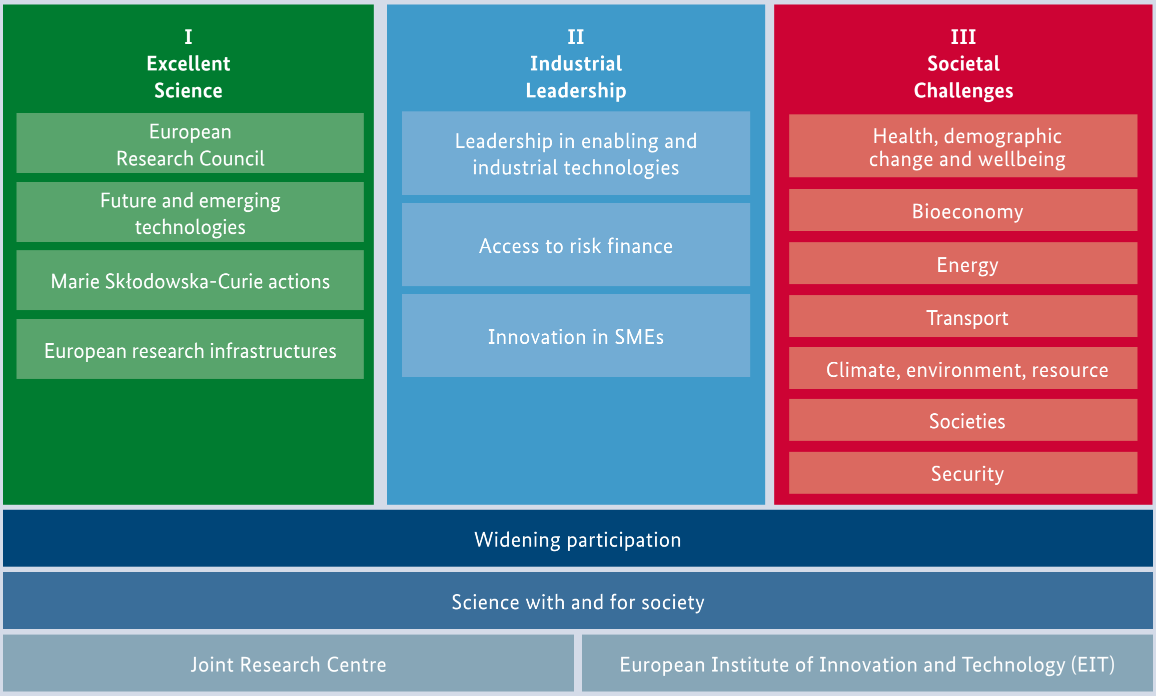
If the objectives of the *Europe 2020 strategy* and of the Innovation Union are to be achieved, excellence-driven research and innovation funding in *Horizon 2020* has to be intelligently combined with the possibilities available in structural assistance. The synergies being built between the Structural Funds and *Horizon 2020* are considerably expanding the EU Member States' funding and support options.

As synergies between different European funding programmes emerge, it will also be necessary, as the *High-Tech Strategy* is developed into a comprehensive, interdepartmental innovation strategy, to also generate synergies with *Horizon 2020* – and, wherever possible, to dovetail the relevant national and European programmes. In the next seven years, about 77 billion euros will be invested in Europe, via *Horizon 2020*, in research and innovation.

The *Europe 2020 strategy* adopted by the Heads of State and Government includes, inter alia, the Innovation Union flagship initiative, the *Horizon 2020* framework programme for research and innovation and the European Research Area (ERA).

The *Horizon 2020* programme, a central instrument at the EU level, is designed to help complete and further develop the ERA – which, since the entry into force of the Treaty of Lisbon in December 2009, has been an EU goal anchored in primary EU legislation. In keeping with the spirit underlying the fundamental freedoms of the internal market, the ERA upholds the principles of the free movement of researchers and the free exchange of scientific findings and technologies. At the same time, the central decisions made in order to use the ERA's opportunities and potential in the best possible way have to be made at the national level. For this reason, the Federal Government plans to work actively for the intensification of ERA activities and, to this end, to formulate and implement its ideas of ERA in the form of a strategy. Thereby, it will take account of the relevant priorities agreed at the European level:

Fig. 4 The structure of Horizon 2020, the new EU programme for research and innovation



Source: BMBF

- ***More effective national research systems:*** Measures in this regard include open competition in awarding of research funding; review of proposals by independent experts, in keeping with core principles of international peer-review assessment; efforts to reverse the brain-drain; support for harmonisation of the EU Member States' and regions' various research and innovation promotion activities; and development of intelligent specialisation strategies.
- ***Transnational cooperation:*** Efforts in this area include enhancement of coherence in joint programme planning and in implementation of research agendas; intensified efforts to carry out joint research plans relative to major challenges; measures to improve quality, via open, Europe-wide competitions; and continuation of the establishment and effective operation of central research infrastructures on a pan-European basis.
- ***Open labour market for researchers:*** The aims in this area are to eliminate existing obstacles to the development of an attractive labour market for researchers, and to improve researcher mobility between countries and research institutions and between industrial and academic research.
- ***Gender equality and gender mainstreaming:*** This area is focused especially on greater consideration of gender dimensions in the design, evaluation and execution of research, as well as on balanced participation of both women and men in decision-making bodies and research projects.
- ***Optimal circulation, access to and transfer of scientific knowledge:*** The emphases in this area include the transfer of scientific findings into innovations; and the development of strategies for access to scientific information, for knowledge transfer between the public and private sectors and for access to, and utilisation of, public electronic infrastructures (e-infrastructures).
- ***ERA initiative for international cooperation in research and innovation:*** As part of this initiative, the current status of international cooperation in research and innovation is to be assessed, a new strategic approach is to be developed and the implementation of international cooperation in *Horizon 2020* is to be initiated.

Germany already has a very good position in most relevant areas – and this shows that the strong political support that Germany provides for research and innovation is paying off. In Europe, Germany's research and innovation system is considered worthy of emulation in many areas. Germany's strategy on the European Research Area (ERA) is expected to help secure this position and, at the same time, help achieve a new level of quality in cooperation between the EU Member States and the EU as a whole.

4 A new architecture for the science system

Germany is a leading centre for science, research and innovation. Its aims for the future include securing and maintaining this position, while also enhancing the international standing of its excellent research sector. To these ends, it needs outstanding research sites, excellent overall performance and an even better ability to attract the world's best minds. The German research sector comprises a large number of different players.

New approaches to cooperation will play an important role in further strengthening Germany as an internationally leading centre for science. The governing coalition's coalition agreement calls for providing universities with reliable perspectives and a reliable basis for planning. In addition, it calls for the Federal Government to participate in providing basic funding for universities. Currently, the Federal Government is reviewing ways of meeting this requirement. In its latest report, the *EFI* urges that Art. 91b of Germany's Basic Law be amended with regard to universities. The *EFI's* experts see such a reform as a necessary basis for providing reliable financing for universities – and, thus, for strengthening them in a lasting way as the foundation for an excellent research and innovation system. In the past legislative period, the Federal Government proposed a relevant amendment that would enable the Federal Government and the *Länder* to collaborate in funding science and research institutions at universities, in cases of supra-regional importance. The amendment would thus expand the options for such collaboration beyond the area of projects of supra-regional importance.

Industry, which focuses especially on applied research, should seek to intensify its already excellent cooperation with the science sector and to develop long-term strategic cooperation with that sector. In future, the universities that are particularly successful internationally will be those that seek to strengthen their profiles on the basis of research, teaching and commercialisation of research findings, and that give equal weight to all three of those areas.

Building on successes: A package of pacts: the *Excellence Initiative*, the *Higher Education Pact* and the *Pact for Research and Innovation*

The Federal Government and the *Länder* have jointly sponsored a "package of pacts" – the *Excellence Initiative*, the *Higher Education Pact* and the *Pact for Research and Innovation* – that has significantly increased the financial resources available to the science system. The added funding has enabled the science sector to investigate new research topics, create additional opportunities for studies, test new teaching concepts, establish new institutes, attract young science researchers from abroad, produce world-class level publications and pursue successful patent strategies. The science pacts have provided major impetus and tangibly enhanced the performance and capabilities of the science system (cf. info box p. 22).

Germany's science system is attractive for keen minds from throughout the world. In its 2014 report, the *Commission of Experts for Research and Innovation (EFI),* drawing on publications from the years 1996 through 2011, speaks of an exodus of scientists from Germany. Current figures now indicate that Germany's attractiveness for foreign researchers is again increasing, however. "Brain-drain" trends definitely did occur in the 1990s. Since then, German science policy has vigorously countered such trends, however, with measures such as the above range of pacts.

The overall situation has thus improved since then. For example, the "*Wissenschaft weltoffen*" report notes that in 2011 more than 32 000 foreign scientists – a new record level – were working in Germany, with support from the German science organisations. Key percentages applying to foreign researchers have also increased since the beginning of the *Pact for Research and Innovation.* In the Max Planck Society in 2012, for example, about 49 % of all doctoral candidates, 86 % of all postdoctoral fellows and 31 % of all directors came from abroad. Furthermore, the Freedom of Science Act, which entered into force at the end of 2012, has given science institutes, and other research-performing and research-funding organisations, additional options, in an intensifying competitive environment, for successfully recruiting excellent scientists from throughout the world. As part of implementation of a relevant Cabinet resolution of May 2012, relevant department-specific and institution-specific measures are being sought for departmental research institutions.

The positive impact of the *Excellence Initiative*, which the *EFI* report authors single out for praise, has been palpable at universities. In 2011, for example, while 10 % of all persons in the higher education system came from abroad, the percentage of foreigners at graduate schools was 36 %. The corresponding percentage for clusters of excellence was 24 %, while

Infobox

The three reform initiatives of the Federal Government and the *Länder*

The Excellence Initiative

- The *Excellence Initiative*, which provided funding of about 1.9 billion euros in the two selection rounds held in 2006 and 2007, has accomplished more than simply helping funded universities sharpen their profiles. It has garnered considerable international recognition for its science-guided, competitive procedure. In 2009, the Federal Government and the *Länder* agreed to continue the *Excellence Initiative,* with funding totalling 2.7 billion euros. The Initiative's third selection round, which took place in summer 2012, has led to funding for a total of 45 graduate schools, 43 clusters of excellence and 11 institutional strategies.
- In the relevant graduate schools, young scientists are being promoted, and considerable interdepartmental and interdisciplinary collaboration is taking place.
- Clusters of excellence pursue research at the highest international level. As a rule, they integrate at least two subject areas.
- A total of 11 universities are now successfully implementing institutional strategies for becoming established within the relevant internationally leading groups.
- International networking plays a major role in all these efforts, as a cross-cutting, management task.
- Universities are cooperating with regional, national and international partners from academia and industry in all of the three funding lines. To date, about 5,750 scientists (of which more than 80 % are young scientists and 25 % are from abroad) have been recruited in this framework.
- In all three funding lines, the review criteria include gender equality. The measures in the funded projects span a diverse range, covering such aspects as quotas for women, mentoring and grant programmes, dual-career programmes and expansions of child-care services. The special focuses that have emerged include career development for young female scientists in doctoral-studies and postdoc phases.

The effort is to be evaluated by a commission of international experts (by early 2016) on the basis of a data-backed report to be produced by the German Research Foundation (DFG) and the German Council of Science and Humanities (WR) (by summer 2015).

Higher Education Pact

- The Federal Government and the *Länder* are providing the basis for a suitable, demand-oriented range of higher education study programmes. The Federal Government has increased its financial commitments for the second programme phase of the *Higher Education Pact 2020*, which will continue until 2015, to a full seven billion euros. Additional funding of about 2.7 billion euros is available for the period through 2018. The *Länder* will provide comparable additional funding, thereby assuring the overall funding for the effort. As a result, about 624 000 additional new students will be able to enrol in higher education by 2015.
- In 2013, Germany's higher education institutions had a total of about 507 000 new students, and a total student body of 2.6 million. These figures highlight the continuing attractiveness of higher education. These positive enrolment trends also extend to MINT subject areas.
- The Federal Government and the *Länder* have also decided to facilitate overhead financing, in the framework of research funding of the German Research Foundation (DFG). The DFG has introduced programme-overhead financing amounting to 20 % of applicable direct project expenses. This funding is helping universities that are especially strong in research to further strengthen their strategic options for action and operations. By 2015, the Federal Government will bear all relevant costs, amounting to about 1.6 billion euros.
- The *Teaching Quality Pact*, which forms the third pillar of the *Higher Education Pact,* is supporting a total of 186 universities, from all 16 *Länder*, in improving their conditions for studies. The Federal Government plans to invest about 2 billion euros in this effort through 2020.

Pact for Research and Innovation

- The *Pact for Research and Innovation* intensifies and accelerates the dynamic development taking place in non-university research. The Pact ensures that the science organisations Helmholtz Association (HGF), Max Planck Society (MPG), Fraunhofer-Gesellschaft (FhG) and Leibniz Association (WGL), and the German Research Foundation (DFG), a funding organisation for university research, retain their positions among the world's leading organisations in this area, in the long term.
- The Federal Government and the *Länder* are planning to increase their joint funding for these science organisations by 5 % annually in the years 2011 through 2015.
- The Pact is being accompanied by mutually agreed research policy goals. In addition to early and systematic identification of cutting-edge research fields, promotion of junior scientists, improvement of the representation of women, interorganisational networking and internationalisation, the main goals of the Pact include transfer of knowledge and technology and formation of sustainable partnerships with commercial partners. The science organisations prepare annual reports, with quantitative and qualitative indicators. The Joint Science Conference of the Federal Government and of the *Länder* (GWK) then combines the reports into Pact-monitoring reports and assesses them in that form. Such monitoring reports are approved by the relevant ministers at the Federal Government and *Länder* levels, in the GWK framework.

for universities with institutional strategies promoted via the Initiative it was 37 %.

In its report, the *Commission of Experts* praised the Federal Government's measures for attracting excellent scientists from abroad and for convincing German scientists abroad to return to Germany. The *EFI* report specifically mentions the DFG's mobility programmes in this regard. Other, similar efforts have been in place for years, such as a programme of the *German Academic Exchange Service (DAAD)* for encouraging German scientists to return from abroad, the Alexander von Humboldt professorships and the Sofia Kovalevskaya Award.

The *GAIN Initiative* is aimed especially at inspiring German researchers in North America to return to Germany. Germany is also becoming more and more attractive for foreign students. In 2013, for the first time ever, Germany registered more than 100,000 new international enrolees, and the pertinent total was 5.8 % higher than the corresponding figure of the previous year. In that year (2013), international students accounted for 19.9 % of all students in Germany.

We continue to strive to provide good conditions that can help enhance the attractiveness of science careers. Reliable career pathways, offering a secure basis for planning, are an essential component of such conditions.

Reliable perspectives

Germany today is in a considerably better position, in terms of both social and economic ways, than many other OECD countries. To a significant degree, this is due to the considerable improvements achieved in the German science system over the past few years. Investing in education and training for the next generation is, and will remain, one of the state's most important tasks. That said, it must be conceded that the existing framework is hampering the ability of the country's universities to fulfil their responsibilities in this area.

With an entire package of measures, the Federal Government is aiming to provide enduring financing for the science system, with a view to providing a reliable, secure planning basis. This, in turn, will make it possible to combine, within a single strategic framework, key measures agreed in the coalition agreement. The Federal Government is aiming to maintain the energy and impetus of the *Excellence Initiative*, the *Higher Education Pact* and the *Pact for Research and Innovation*, to enhance the achievements they provide for the science system and to expand support and funding for science overall. The core focuses in this regard include strengthening the country's universities, reinforcing its science organisations and promoting strategic profiles and cooperation in the science system.

In its 2014 report, the *Commission of Experts for Research and Innovation (EFI)* also emphasises the need to develop a coherent package of measures that will consolidate the pacts' successes and continue the positive development of the German science system.

In this context, the Federal Government's *First Report on Gender Equality,* the *EFI's* 2013 and 2014 reports and the coalition agreement for the 18th legislative period all focus on strengthening the role of women in the innovation process. This focus is also an important research policy task, one that the Federal Government is addressing with efforts such as the structurally effective *Programme for Women Professors* and with ambitious objectives for bringing more women into advisory, decision-making and scientific bodies and into management positions.

Strengthening departmental research

Departmental research is conducted, within a framework of ongoing cooperation, by a total of 37 federal institutions with R&D responsibilities and by six non-university R&D organisations. The various institutions and organisations meet the departments' R&D requirements by conducting research of their own, by cooperating with other research institutions and by awarding research contracts to external researchers. All of the institutions and organisations concerned have a combined focus that sets them apart from other bodies that might otherwise be comparable: all maintain a wealth of scientific expertise that is available at very short notice to support the government's actions and operations, and all also conduct scientific research that has a long-term perspective and that conforms to relevant high international research standards.

Departmental research applies problem-oriented, practically focused, interdisciplinary approaches, and it covers a broad spectrum of tasks. Its portfolio includes such areas as scientific research on legally assigned tasks; scientific and technical services such as permits/approvals; operation of databases, expert systems and measuring networks; collaboration in development and refinement of laws and standards; and research, studies and social reporting on current socio-political issues.

The Federal Government's departmental research is an indispensable part of the country's science system, one that functions at the interfaces between the science, industry and policy-making sectors. It makes important contributions within the German science sector. For this reason, as agreed in the coalition agreement, the Federal Government is working to strengthen the area of departmental research, and plans to ensure that all departmental research institutions are able to profit from the *Freedom of Science Act.* This is because a competitive framework plays an essential role in protecting the sector's recognised high standards, as the *German Council of Science and Humanities (Wissenschaftsrat)* emphasised in the conclusions of its evaluation of the country's departmental research.

5 Good education: The basis of the knowledge society

Good education is the basic foundation for Germany's success in international competition. The quality of the country's education system – like the quality of its research and innovation system – has been a key reason for Germany's success in addressing the recent economic and financial crisis, without suffering major setbacks in its labour market. Germany needs a good education system that can enable it to create knowledge and to activate all the skills, talents and creativity found throughout its population. It needs such an education system, both now and in the future, in order to meet the challenges of demographic change and related requirements for skilled manpower. A good education system in this sense comprises both a formal education system and non-formal and informal education.

Joining hands for equal opportunity in education

Education gives people perspectives and enables them to be fully participating members of society. The task of strengthening and improving the education system calls for committed cooperation on the part of all stakeholders. Germany's Federal Government, *Länder*, municipalities and society share the responsibility for ensuring that all children and adolescents – regardless of background and economic status – are given the opportunity to obtain a good education and receive the best-possible support for the development of their talents. Strengthening equal opportunity in education is thus a central, guiding principle of the Federal Government's education policy. In recent years, Germany has made good progress towards its goal of becoming an "education republic". Youth unemployment is one of the indicators that substantiates this conclusion – youth unemployment in Germany, according to internationally comparable data, is at 7.6 % (January 2014), the lowest level seen throughout the European Union (averaging 23.4 %).

- In 2011, a total of 96 % of all 4-year olds were in preschool or kindergarten. That figure greatly exceeded the corresponding OECD average figure of 82 %. From 2008 to 2011, the numbers of children under the age of 3 in daycare grew by 63 %.
- The percentage of pupils who leave the general secondary school system without obtaining a general certificate of secondary education *(Hauptschulabschluss)* decreased from 9.1 % in 2002 to 7.3 % in 2007 and to 5.9 % in 2012.
- The percentage of young people (age 20 to 29) without a vocational qualification who fail to enter a vocational training programme or higher education decreased from 16.5 % in 2005 to 13.4 % in 2011.
- In 2010, some 182 000 pupils obtained their higher education entrance qualification or restricted university entrance qualification at a vocational school. The number of students without a school-based higher education entrance qualification has more than tripled since the 2007/2008 winter semester, reaching about 37 000 in the 2012 academic year.
- In 2011, a total of 86 % of the relevant German population had either a university degree, a higher education entrance qualification or a vocational qualification; the comparable OECD average figure was 76 %.
- In 2013, the number of new students in Germany reached nearly 507 000, the second-highest level ever recorded. In addition, the entry rate into tertiary education has climbed to a record level – over 50 % in 2012. The corresponding figure in 2008 was 40 %.
- The percentage of people who obtain a first (higher education) degree, with respect to the total number of people of comparable age, has continually increased: in 2000, it was about 17 %; in 2005, it had reached 21 %; and in 2012 it was just short of 31 %.
- In the area of continuing vocational education and training, Germany has a participation level of about 50 %, which considerably surpasses both its own original goal of 40 %, to be reached by 2015, and the pertinent EU average.

These successes show that the efforts the Federal Government and the *Länder* have made over the past few years are working. The Federal Government has continuously increased its commitments. From 2012 to 2013 alone, its investments in education increased by 8 %. In comparison to the corresponding level in 2005, the increase amounted to nearly 90 %. Overall in 2013, planned spending on education, by the Federal Government, the *Länder* and municipalities, amounted to about 116.6 billion euros. That figure is equivalent to growth of about 30 billion euros with respect to the relevant level in 2005. As a result, a comparison of public spending on education with the sum of public budgets shows that about one out of every five euros has been spent on education. Good education does more than simply give people perspectives and enable them to be fully participating members of society. It is also the best recipe for countering shortages of skilled manpower. A good education system must focus on people's entire education biographies – from early childhood education to lifelong learning.

Numerous initiatives of the Federal Government are helping to ensure that Germany's education meets this requirement:

- The "Little Scientists' House" initiative is helping to introduce children to science, mathematics and technical subjects in early childhood education.
- With the programme "Culture is Strength. Education Alliances", the Federal Government is supporting culturally oriented extracurricular programmes for educationally disadvantaged children and adolescents and is promoting active citizenship.
- The "Educational Chains" initiative and a vocational orientation programme are helping to make pupils of general-education schools aware of their options in vocational training. As necessary, these efforts also provide individual support for pupils aiming for training programmes.
- The National Strategy for Literacy and Basic Education of Adults is promoting new learning options and opportunities for functionally illiterate adults.
- "Advancement through Education: Open Universities", a Federal-/*Länder*-sponsored competition, is helping to give employed people and people with vocational qualifications better access to higher education.
- "Upgrading scholarships" and training fellowships are providing additional support for persons seeking further qualifications.
- Since 2008, the federal programme "learning subsidy" *(Bildungsprämie),* has been enabling people with small incomes to enter individual continuing vocational training.
- Enhancement of the *Higher Education Pact* is helping to prepare universities for further increases in the numbers of young people aspiring to higher education.
- Teacher training has a key function within the education system. This is why the Federal Government and the *Länder*, working via a "quality campaign for teacher training" *(Qualitätsoffensive Lehrerbildung),* are supporting the use of innovative concepts in teacher training programmes.

In recent years, Germany's education system has become more effective and more equitable. Nonetheless, social background continues to be a strong factor in educational success. For this reason, the Federal Government's central aims include further improvements in the area of equal opportunity in education. Germany's dual system of training plays an important role in this connection. One of the decisive advantages of the dual system of training is its close orientation to real-world employment. On the one hand, it enables companies to train young trainees in keeping with their specific requirements and actual practice. On the other hand, it offers trainees high rates of retention in regular employment, thereby playing an important role in enabling persons to lead independent lives and participate fully in society. Such opportunities need to be provided to as many young people as possible. The key to providing them is a preventive approach, including individual counselling and orientation for all young people. For this reason, the Federal Government is planning to enhance programmes for vocational and educational orientation and counselling for pupils and trainees and to remove barriers between vocational training and university-based education.

The *Upgrading Training Assistance Act (AFBG;* also known in Germany as the *"Meister-BAföG"),* is a central instrument for supporting quality vocational training for technical specialists and managerial staff – such as persons working toward master-craftsmen certifications and business administrators – in obtaining professional development training. In its coalition agreement, Germany's current governing coalition agreed to amend the AFBG with the aims of improving its payment levels and expanding its support options. In keeping with the ideal that general education and vocational training are of equal value, university graduates with bachelor's degrees and relevant vocational experience are to be given access to subsidised professional development training. In accordance with the coalition agreement, discussion is currently underway with industry, the unions and the *Länder* to find ways of developing the *National Pact to Promote Training and Young Skilled Workers in Germany* into an *Alliance for training and further training*. Along with training and further education recognition of foreign vocational qualifications is also an effective instrument for assuring the availability of skilled personnel. Following the entry into force of the Federal Recognition Act (*Anerkennungsgesetz),* 11 000 applications for recognition of foreign vocational qualifications were submitted in 2012 alone, and most of the pertinent foreign qualifications were recognised as being of equal value to corresponding national qualifications. Such progress is helping significantly to assure the availability of skilled personnel, and it is sending signals to the skilled personnel abroad that Germany urgently needs.

Strengthening the Federal Education and Training Assistance Act *(BAföG)*

One of the reasons why many people in Germany enrol in higher education is that the possibilities for financing such studies have improved in the past few years. Aspiring students have a diverse, attractive range of options available to them, including state grants for education and training, scholarships and supplementary-loan programmes. Via two amendments, enacted in 2008 and 2010, the *Federal Education and Training Assistance Act (BAföG)* has been strengthened and enhanced on a long-term basis. Along with considerable increases in available payments (the maximum *BAföG* rate is now 670 euros per month), the structure of the *Federal Education and Training Assistance Act* has been improved – for example, the age limit for master's degree programmes has been raised, and provisions have been included to make it easier for people to combine family and educational responsibilities. In 2012 alone, the Federal Government provided funding of 2.2 billion euros for support under the *Federal Education and Training Assistance Act.* The numbers of persons receiving support have continued to grow, and they have now reached the highest levels seen in the past 30 years: a total of 979 000 young people (671 000 students and 308 000 school pupils) received state education assistance in 2012 under the Act. The average figure for the year was 630 000. Among students, the percentage of persons receiving support increased from 27.3 % in 2010 to 28 % in 2012. The *Federal Education and Training Assistance Act's* central importance in providing education funding is unquestioned. The Federal Government and the *Länder* have a joint responsibility to maintain the Act and enhance it further as necessary. From the Federal Government's perspective, the results of the 20th report pursuant to Art. 35 of the *Federal Education and Training Assistance Act*, which appeared in 2014, indicate that further reform of the Act is now needed.

Continuing a new culture of grants and scholarships

Excellence funding and broad-based funding are really two sides of the same coin. Development of the overall grant and scholarship "culture" is thus also an issue of great importance, along with further enhancement of the *Federal Education and Training Assistance Act.* Since 2005, the number of grants awarded to students has tripled, increasing from about 13,400 (funding from organisations that fund young gifted and talented students/pupils) to about 43,500 (2012) (funding from organisations that fund young gifted and talented students/pupils; upgrading scholarships, including entitlements; *Germany Scholarships (Deutschlandstipendien)). The Germany Scholarships (Deutschlandstipendien),* which were introduced in 2011, are a powerful new instrument for providing assistance to excellent students. For students at state and state-accredited universities in Germany, *Germany Scholarships* provide funding of 300 euros per month. The programme, which is financed by the Federal Government and private sponsors, is aimed at strengthening responsibility for education, throughout society as a whole, and at building a grant and scholarship "culture" in Germany.

Internationalisation in education

In the area of vocational training, the Federal Government cooperates with numerous partner countries in the European Union, as well as with a number of additional countries, including industrialised, emerging and developing countries. Many partner countries are keenly interested in Germany's dual system of vocational training, which has been a success in the need-based qualification of skilled personnel, and a key factor in assuring employability and social participation, especially with regard to young people. Its value was especially obvious during the financial and economic crisis. In addition, by ensuring that German companies abroad have a sufficient supply of suitably trained skilled, specialised personnel, Germany's dual system of vocational training contributes decisively to such companies' competitiveness. In its latest report, the *Commission of Experts for Research and Innovation (EFI)* emphasised this aspect, noting that the German vocational training system functions as a valuable basis for companies' innovation activities, and "has no parallel in the Anglo-Saxon world". A Europe-wide alliance for training was launched in 2012. In a concerted effort, in cooperation with the European Commission, Germany, Spain, Greece, Portugal, Italy, Slovakia and Latvia signed a memorandum specifying measures for the introduction of a vocational training system modelled after the German system. Many countries are not yet able, within the framework of their own training systems, to meet current and growing requirements for high-quality training. The demand for – and, thus, the potential for – international training/education markets is enormous, especially in the area of vocational training. For this reason, the Federal Government supports German providers of training and education services in developing relevant cooperation opportunities and in creating innovative, viable business models for exporting vocational training.

6 Advice and strategic foresight

Advice on research, innovation and education

The need for a reliable orientational framework keeps growing as scientific and technical progress continues. Political decisions are becoming more and more complex, and thus scientific advice is more necessary than ever before. The Federal Government has a differentiated system of political consulting in place.

Policy-makers and the society's citizens require scientifically sound advice to support their efforts in order to address technological, ecological, social and economic challenges and to shape their future interactions and cooperation. The Federal Government's institutions with R&D tasks provide such advice – both nationally and internationally. They provide scientifically substantiated foundations for decisions, support responsible political action and help to bring about an innovation-friendly framework.

The Federal Government conducts intensive discussions with representatives of science, industry and society regarding strategic decisions to be made in research and innovation policy. With such discussions, the Federal Government helps to ensure that central aspects of its policies are examined, at early stages, in cooperation with experts from relevant practical and real-world spheres.

The *Commission of Experts for Research and Innovation (EFI),* with its internationally recognised expertise, advises the Federal Government with regard to issues of research, technology and innovation policy. Its independent experts compile the latest scientific findings relating to innovation research and, in their annual reports, assess the strengths and weaknesses of the German innovation system. Their observations and recommendations for action provide a valuable basis for innovation-policy and research-policy decisions.

The *German Council of Science and Humanities (Wissenschaftsrat)* has the task of advising the Federal Government and the *Länder* governments regarding the development – in terms of both structure and focus – of the country's universities, science and research. The Council's special functions include serving as a mediator between the science and policy-making sectors. In addition to evaluating individual research organisations, institutes and universities, and carrying out accreditation of private universities, the *German Council of Science and Humanities* considers overarching issues, and current topics and developments, in the science sector. Its programme of work is jointly approved.

The *Leopoldina – the German National Academy of Sciences* represents Germany's scientists in relevant international bodies. It also participates in scientifically based advice of society and policy-makers, regarding research and innovation issues. In the latter task, it cooperates with *acatech* – the *National Academy of Science and Engineering, the Berlin-Brandenburg Academy of Sciences (BBAW)* and the academies of science of the *Länder*, and draws on their expertise. acatech promotes dialogue between science, industry, policy-makers and society, and it advises and informs policy-makers and the public on a scientific basis, regarding current technology-related issues.

Vocational training programmes need to be continually adapted to the labour market's changing requirements. After all, innovative ideas cannot be implemented if no highly qualified skilled personnel are available to implement them. What is more, the high standards maintained in German vocational training help to assure the quality of products made in Germany. On an ongoing basis, working in the framework of the Board of the *Federal Institute for Vocational Training,* and via dialogue with the *Länder* and with the social partners (employers' and employees' representatives), the Federal Government develops and adapts requirements pertaining to training regulations and quality standards.

Looking to the future – strategic foresight

As agreed in the coalition agreement, the Federal Government plans to strengthen strategic foresight responsibilities and capacities in departments, with a view to detecting and identifying the opportunities and risks of medium-term and long-term developments more effectively. The task of optimally exploiting the potential for Germany's development as a centre for innovation calls for farsightedness. Innovations depend on interactions between a) societal demand and b) technological possibilities, and thus the Federal Government considers both aspects in its strategic foresight. From 2012 to 2014, the *BMBF's Foresight processes,* for example, analysed both technological change and societal requirements, preferences and challenges (cf. info box p. 28).

In its strategic foresight processes, the Federal Government, drawing on a broad base of expertise,

Info box

Societal challenges for research and innovation policy in 2030 – an excerpt from one of the Federal Government's foresight processes

In the networked society of tomorrow, science will acquire a new dimension of importance for the country's economy and society. As a result, its public function will change. The country's science sector will become increasingly diversified, differentiated and specialised – as well as more open. The "Science 2.0" approach makes use of trends such as open innovation, citizen science, openly accessible publications and data-intensive, data-driven science. At the same time, it calls for entirely new reputation mechanisms and governance structures. Civil society will play an increasingly important role in the research and innovation system. With projects of their own, citizens are today already making important contributions to research (e.g. in species monitoring), innovation (e.g. in open workshops) and production (e.g. in 3D printing).

Economic centres are shifting, and global political power structures are becoming increasingly multipolar in the process. New forms of global governance are thus called for. Political decisions will no longer be made solely by states, because non-state players and networks will increasingly be involved in the provision of public goods. Cities will become independent players in, and drivers of, supra-regional political discussions and global processes of change. Entirely new types of innovation, and of cultures of innovation, are expected to emerge. Innovations, for example, that creatively address local, often pronounced, shortages of resources – Africa serves as an example – and thereby produce affordable, robust products that are ingenious and yet technically simple (frugal innovations).

identifies, assesses and calls attention to future societal and technological developments. And this process increasingly directly involves the country's citizens. This approach generates a pool of ideas and an early warning system that help ensure that the right decisions are made at the right time.

In the coming years the Federal Government plans to expand its accompanying research in the humanities and social sciences, to intensify its support for interdisciplinary cooperation and to intensify its *Innovation and Technology Analysis (ITA)* – all with a view, inter alia, to helping to ensure that research and research results are handled responsibly. Ultimately, the degree to which new technologies are accepted by industry and society determines the degree to which they spread. Risk and attitude research are important pillars of *ITA*, and they support evidence-based, scientifically oriented advising for policy-makers. By using innovative formats for communication and dialogue, findings from the Federal Government's strategic foresight processes are prepared for their intended audiences and introduced into various decision-making processes.

The Federal Government wants to increase participation by citizens – who are key players in civil society – in discussion about future projects and in the design of research agendas. To that end, extended forms of citizens' participation and of science communication are being developed and brought together within a forward-looking overall concept, where they will complement existing agenda processes, such as the *Energiewende Research Forum*, the *Dialogues with Citizens (Bürgerdialoge)* and the *Years of Science*.

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

The German science, research and innovation system is greatly acclaimed and respected around the world. In addition to achieving directly scientific objectives, German science provides orientational knowledge, and it is a cultural asset. In Germany, findings from basic research and from applied research and development (R&D) have always functioned as drivers of social and economic development. With its measures, the Federal Government is contributing in the long term to the development and maintenance of a highly capable and effective infrastructure that serves as a foundation for innovative research and development, for training scientists and for the science system's excellence and competitiveness.

The Federal Government supports research, development and innovation in Germany on a notable scale. The excellence of German research is founded on excellent framework conditions, as the following two indicators illustrate especially clearly: first, the country's total gross domestic expenditure for research and development increased from about 50.6 billion euros in 2000 to (an expected figure of) 79.5 billion euros in 2012. For 2012, the latter figure translates into an estimated R&D intensity of 2.98 % of the country's gross domestic product. Funding for the science system has also been significantly increased via the *Excellence Initiative*, the *Higher Education Pact* and the *Pact for Research and Innovation.* Second, between 2005 and 2012 alone, the number of foreign scientists working in Germany increased by more than 60 %. This is additional clear proof of the attractiveness and international connectedness of the German science sector.

Initiatives at the European and international levels have been acquiring greater and greater significance for the German research and innovation system. The European Research Area, which is still in the process of being designed and structured, is an important component in efforts to ensure that Germany and Europe can thrive in globalised competition. And this also applies to competition for scientific achievement. The new EU *Horizon 2020* Framework Programme for Research and Innovation, with funding totalling about 77 billion euros, is the world's largest self-contained research and innovation programme. It consolidates research funding programmes at the European level, and it is oriented to cooperation between science, research and industry. *Horizon 2020* facilitates funding of research and innovation – from basic research to market introduction – and it reinforces the efforts of the *European Research Council,* which funds both excellent basic research and application of research findings. For example, for German universities of applied science, which are strongly application-oriented and have outstanding contacts to companies, the programme offers good opportunities in the competition for funding. Improved funding options have also been provided for small and medium-sized enterprises (SMEs).

Germany's competitiveness will continue to depend decisively on having an excellent research, science and innovation system. With regard to societal and global challenges, Germany requires a diverse research sector that is supported by a range of different institutions and stakeholders. Close links between basic research, applied research and industrial development, and collaboration across a broad range of different disciplines, are key bases for efforts to meet global challenges.

1 The German research and innovation system

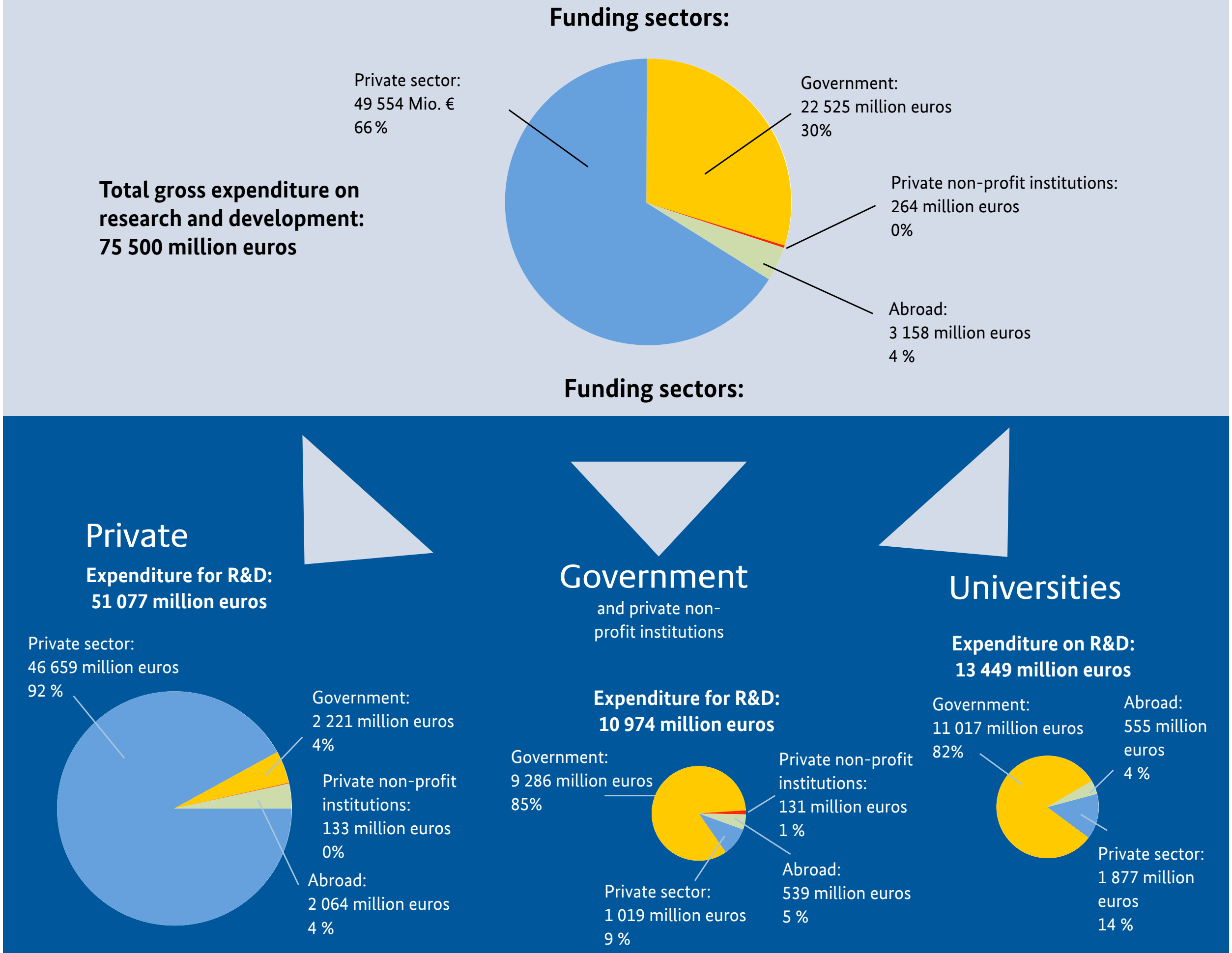
This chapter provides an overview of the German research and innovation system. It addresses questions regarding the system's differentiated structure, financing and modes of operation.

The complex interrelationships between the sectors that conduct research and development and those that finance R&D are outlined in Figure 5.

1.1 Where in Germany does research and development take place?

The German research and innovation system is highly diverse, in part as a result of the country's federal structure and size. It has a broad range of research areas and facilitates high degrees of specialisation in core areas. What is more, German research is highly capable and successful because its many and diverse players are willing to cooperate – for example, by forming col-

Fig. 5 **Gross domestic expenditure on research and development (GERD) in the Federal Republic of Germany, by funding and performing sectors, as of 2011**



Database: Table 1 data for 2011

laborative research alliances between non-university research institutes, universities and companies.

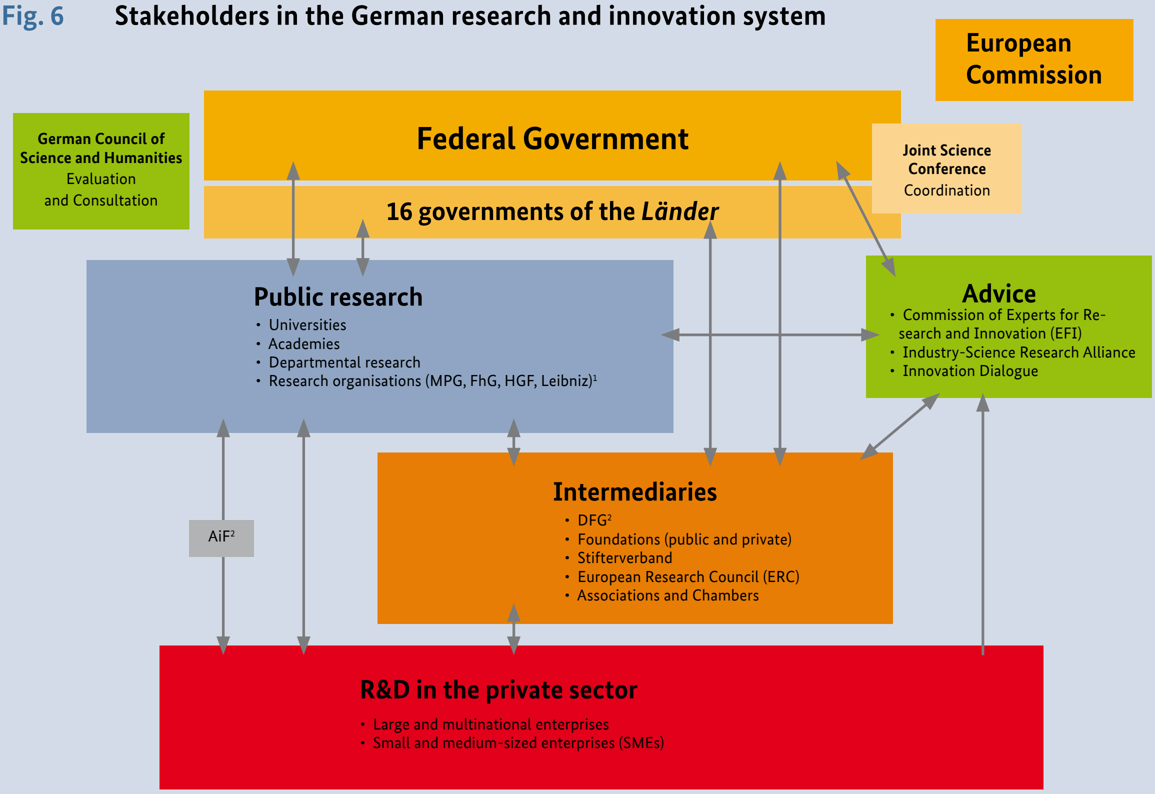
Research and development is pursued in a widely diverse range of public and private institutions. Figure 6 lists the types of institutions involved and schematically illustrates their interrelationships.

Public institutions and private non-profit organisations

The public sector of course includes public higher education institutions – universities and universities of applied science. While universities' research tends to be broadly focused, both thematically and methodologically, research at universities of applied science is largely application-oriented. Training of young scientists and researchers is a key priority for both types of higher education institutions.

In addition to research at higher education institutions, this research sector includes a broad spectrum of non-university research. Such research is pursued at federal and *Länder* (state) institutions charged with R&D and at numerous private non-profit institutions. Along with a range of academies and foundations etc., the spectrum includes four major organisations, each with its own profile and emphases. The 82 institutes of the Max Planck Society (MPG) concentrate on independent basic research in innovative, interdisciplinary areas of the natural and biological sciences and in the humanities and social sciences. The 66 institutes and independent research institutions of the Fraunhofer-Gesellschaft (FhG) pursue research that is mainly application-oriented. In particular, they carry out research for industry, service companies and the public sector. The Helmholtz Association (HGF) comprises a total of 18 scientific, technical and medical-biological research centres. Their research mission is oriented to long-term objectives of the nation and its society. In cooperation with university and non-university organisations, the HGF conducts strategic, programmatically oriented, cutting-edge research in a total of six research fields: energy; earth and the environment; health; aeronautics, space and transport; key technologies; and the structure of matter. The Leibniz Association comprises a total of 89 institutions that carry out application-oriented basic research and provide scientific infrastructure. The Leibniz Association also has numerous cooperative ventures in place with universities, companies and public administrations.

Fig. 6 Stakeholders in the German research and innovation system



[1] MPG = Max Planck Society; FhG = Fraunhofer-Gesellschaft; HGF = Helmholtz Association; Leibniz = Gottfried Wilhelm Leibniz Scientific Association
[2] German Federation of Industrial Research Associations (AiF)
[3] German Research Foundation

Federal and *Länder* (state) institutions with research and development tasks

The research and development activities of the Federal Government and the *Länder* support the preparation and performance of political and administrative action (departmental research). They are linked to the fulfilment of legal assignments. Political decision-making, whether in the areas of health and nutrition, climate protection and energy, mobility or security, always needs to be based on a scientifically solid foundation. Working closely with the relevant departments, the federal and *Länder* (state) institutions with R&D tasks identify key challenges for the society of tomorrow and develop options for state measures.

In addition, federal and *Länder* (state) institutions with R&D tasks perform important research-based services – many of them legally required – for industry and society, in the areas of testing, certification, establishment of rules and standards and monitoring. In particular, they participate in the development and updating of legal regulations and of standards. Federal and *Länder* (state) institutions with R&D tasks also promote young scientists and researchers, and they operate national and international expert systems, databases and scientific measuring networks.

This broad spectrum of important and challenging tasks is served by 37 federal institutions with research and development tasks, as well as by six R&D institutions in ongoing cooperation arrangements. The annexe includes a list of the addresses of the relevant federal institutions and *Länder* (state) institutions with R&D tasks. It also includes Internet links to research programmes and institution-specific quality assurance measures.

Private sector

The private sector is a leading player in the German R&D sector. Private industry provides about two-thirds of the funding invested annually in Germany in research and development. The funding involved includes both funding for companies' own R&D and funding for joint projects with partners in the science sector. The research and development pursued in this sector is oriented strongly to applications, to results that can be directly commercialised. Basic research plays a subordinate role in the industry sector.

Publicly and privately funded research and development in Germany often complement each other and open up opportunities for jointly funded and implemented research projects. Such cooperation structures may be seen as an important indicator for a highly developed and diversified R&D sector. They reach their full effectiveness and potential via concerted interaction between the stakeholders involved.

1.2 Who funds research and development?

The diversity of the German research and innovation system is reflected in the ways the system is funded: R&D projects at publicly funded institutions are also funded via third-party funding, while some private research is also publicly funded. The framework programmes for research that the European Commission administrates are also significant for Germany's R&D sector.

All in all, Germany's R&D expenditure in 2011 reached 2.89 % of the country's gross domestic product (GDP). Estimates of the Federal Ministry of Education and Research (BMBF) indicate that R&D expenditure will reach about 2.98 % of GDP in 2012. In terms of absolute figures, total expenditure (federal, *Länder* and industry) on R&D increased from 55.7 billion euros to 75.5 billion euros between 2005 und 2011. R&D expenditure is expected to remain high in 2012 – at a level of about 79.5 billion euros.

1.2.1 Stakeholders in German research funding

Federal Government and the *Länder*

Germany's federal system enables both the Federal Government and the *Länder* governments to fund and promote German research in their respective spheres of responsibility, even though special research-support laws have not been issued for this purpose.

Furthermore, pursuant to Art. 91 b of Germany's Basic Law (GG), the Federal Government and the *Länder* cooperate in supporting scientific research institutes and projects of supra-regional importance. This is in line with the Federal Government's and the *Länder* governments' joint responsibility for research, which in many cases calls for coordinated action in the interest of the nation as a whole.

The Federal Government's share of government R&D expenditure increased from about nine billion euros in 2005 to 13.5 billion euros in 2012. In 2013, federal R&D expenditure increased still further, to 14.5 billion euros (target), and R&D expenditure of about 14.4 billion euros (first government draft budget) is planned for 2014. With its funding, the Federal Government supports research in scientific fields of societal relevance. This includes fields that do not (yet) relate directly to overall technological and economic development and are in the public interest nevertheless – for example, basic research that can provide impetus for application-oriented research areas. Such funding also has important impact in that the science system trains excellent young scientists.

Private sector

In 2011, the private sector's internal R&D expenditure in Germany amounted to 51.1 billion euros (+ 8.8 % compared to the previous year). A breakdown into sectors shows that the areas involved can differ considerably in this regard. The automotive industry accounts for about 37 % of industry's internal R&D expenditure. About 16 % of all expenditure goes toward R&D in the area of electrical engineering. The mechanical engineering sector accounts for about 10 % of expenditure, while the pharmaceutical industry accounts for about 8 % and the chemical industry for about 6 %.

The private sector funds about two-thirds of all gross domestic expenditure on R&D in Germany (cf. Table 1 in Chapter 5.1). Industry-financed R&D activities accounted for about 1.90 % of GDP in 2011. The corresponding figure for 2005 was 1.69 % of GDP.

The private sector has been carrying out ever-greater amounts of its R&D in cooperation with partners in science and industry. In 2011, the private sector's internal R&D expenditure was only about four times as high as its expenditure for external research projects (projects with funding going to other companies, to universities, to state research institutions, etc.). For comparison: In 2002, the private sector's internal R&D expenditure was five times as high as its external expenditure. And in 1995, industry spent eight times as much on internal R&D projects as it did on external R&D projects.

Figure 7 provides an overview of the German research sector.

Other R&D-funding organisations

In keeping with Art. 91 b Basic law, the Federal Government and the *Länder* fund the German Research Foundation (DFG), a self-governing science organisation in Germany. Its core task consists of identifying and funding the best research projects of scientists at universities and research institutes.

In addition, numerous foundations in Germany contribute in valuable ways to efforts to assure the quality of science and research. The foundations complement public research funding and are outlets for private financial commitment. Their benefactors thus provide excellent examples of responsible action in a democratic country.

Major German foundations – such as the *Robert Bosch Foundation,* the *Volkswagen Foundation* and the *Klaus Tschira Foundation* – fund projects and institutions throughout a wide range of different science fields. The *Donors' Association for the Promotion of Sciences and Humanities in Germany* (*Stifterverband für die deutsche Wissenschaft*) is a joint effort by industry for funding German science and research. In 2012/13, more than 580 foundations received support, and total assets of more than 2.5 billion euros were administrated, under the *Donors' Association* umbrella.

1.2.2 European Union

The *Framework Programme for Research,* which the Council and the Parliament adopted and the European Commission has administrated, has proven to be an important instrument for the creation of a European Research Area. On 1 January 2014, the Framework Programme was supplanted by *Horizon 2020* (2014–2020), the EU's first framework programme for research and innovation. *Horizon 2020* is a key pillar of the Innovation Union. The new programme is contributing significantly to the development of a European Research Area, and it is putting the globally visible profile of the European research landscape into ever-sharper focus. With funding totalling about 77 billion euros, *Horizon 2020* is the world's largest self-contained research and innovation programme. It consolidates research funding programmes at the European level and, to an even greater degree than previous programmes, is oriented towards cooperation between science, research and industry. The new programme provides a framework for funding research and innovation throughout the spectrum from basic research to market introduction. It establishes new priorities in innovation funding and in efforts to focus on major societal challenges. With regard to the instruments and funding mechanisms it uses, such as promotion of excellence, mobility measures and funding of infrastructures, it exhibits a high degree of continuity. Its new aspects also include funding of new and emerging technologies and an expansion of participation by new Member States.

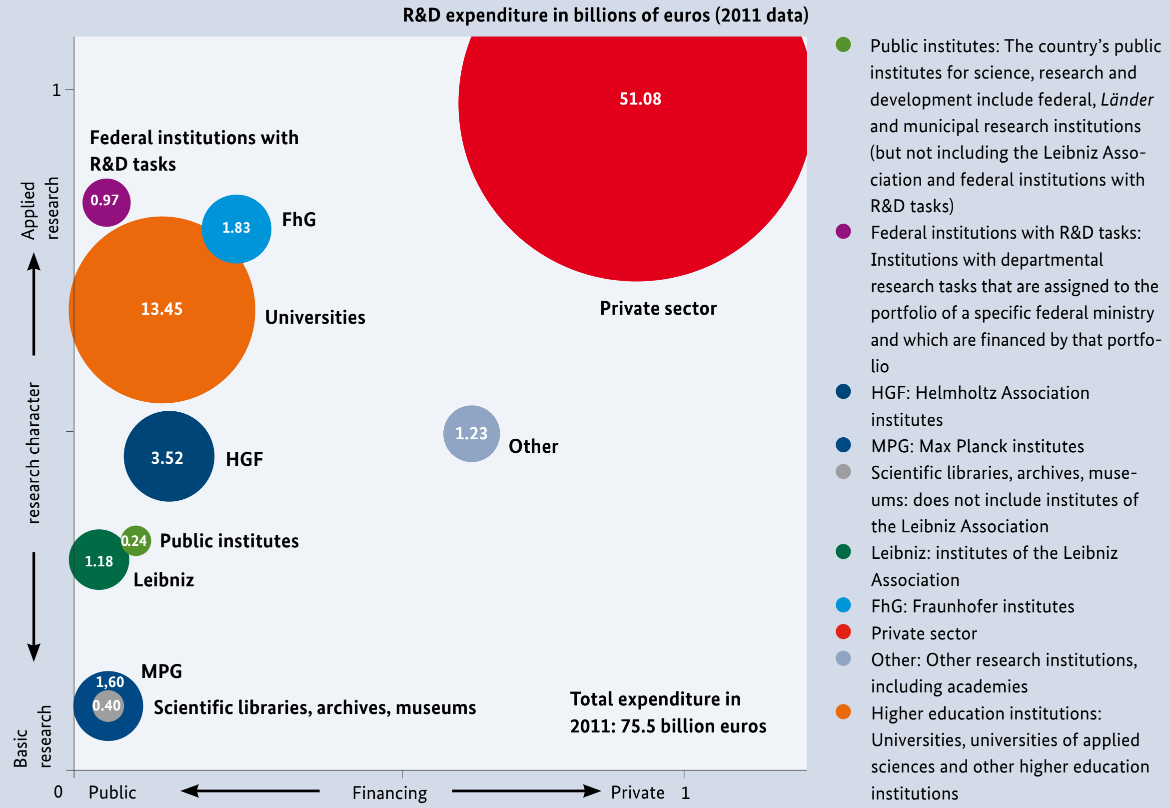
It is flanked by two mechanisms that provide a framework for cooperation between research institutes and companies in Europe, without direct project funding: *COST (European Cooperation in Science and Technology)* and *EUREKA (Initiative for intensified technological cooperation in Europe)*. These cooperation systems are driven largely by the interests of science and industry. They serve as an excellent complement, with variable geometry, to the European framework programmes.

The EU's *Lifelong Learning Programme*, an education programme with a total volume of about 7 billion euros for the period 2007 to 2013, provides for extensive exchange measures and a range of transnational projects for enhancing the quality of education systems. It also facilitates funding for transnational networks in the fields of higher-education and vocational-training research.

1.3 How does government funding for research and innovation work?

Government research and innovation funding, if it is to function properly, has to be placed on a number of different pillars. In Germany, the legal foundation for such pillars is provided by Germany's Basic Law (Grundgesetz); i.e. the Basic Law serves as the basic foundation for cooperation between the Federal Government and the *Länder* in the area of government research funding. A number of instruments are available to the Federal Government and the *Länder* for efficient, targeted research funding: project funding, institutional funding and funding of departmental research.

Fig. 7 **The German research landscape**



The horizontal dimension, "funding", shows the private sector's shares of funding for the relevant institutions' R&D activities. A value of "0" means that the private sector has a 0% funding share, while a value of "1" means it has a 100% share. The vertical dimension, "nature of research", is calculated on the basis of publications (SCI publications per researcher) and patents (patent applications per 1 000 researchers). The higher an institution group's publication rate, and the lower its patent rate, the closer it will be to "0" in this regard (maximum orientation to basic research). Conversely, the lower an institution group's publication rate, and the higher its patent rate, the closer it will be to "1" (maximum orientation to application-oriented research).

The following figures have been estimated: "financing" for HGF, MPG, scientific libraries, archives, museums and "other". "Nature of research" for public institutions, scientific libraries, archives, museums and "other". In a departure from the above-described procedure, for federal institutions with R&D tasks, the "nature of research" figure was estimated not on the basis of patent and publication rates, but on the basis of such institutions' special role in the development and setting of norms and standards.
For universities and universities of applied sciences, the applicable values in the "nature of research" dimension were averaged. The main reason why universities of applied sciences are positioned as being application-oriented is that they have very high patent application rates. The positions of the circles for the various institution groups, within the coordinate system, are determined by the positions of their centres. In other words, their centres' coordinates are in keeping with the relevant horizonal and vertical scale values.

Database: Tables 1 and 28 (cf. long version, in German only) for R&D expenditure of the private sector and of universities
Other sources for R&D expenditure: annual report of the FhG. The remaining data consist of estimates.

1.3.1 Legal foundations

Funding research and development is a joint task of the state and society. If research is to be internationally competitive, and if science and research are to be able to operate freely as set forth in Art. 5 (3) Basic Law, a suitable financial framework must be in place. The relevant financing competencies of the Federal Government and the *Länder* result from Germany's Basic Law.

As noted above, Art. 91 b Basic Law provides the central constitutional foundation for joint funding of science and research by the Federal Government and the *Länder*. It empowers the Federal Government and the *Länder* to cooperate in cases of supra-regional importance, and on the basis of relevant agreements, in funding of

- institutions and projects for scientific research outside of universities,
- science and research projects at universities,
- research-related construction at universities, including efforts related to large research apparatus.

On this constitutional foundation, the Federal Government and the *Länder* can fund joint projects at universities in cases of supra-regional importance, but such efforts are limited with regard to subject area and time – even when efforts are supported by all *Länder*. The situation is different for joint funding at non-university research institutes.

In addition, the Federal Government has funding authority for major scientific projects (such as research projects in the areas of aeronautics, space, oceanography and nuclear technology) and for international research institutes. Furthermore, the Federal Government and the *Länder* have financing competencies in the fulfilment of their legally assigned tasks and in obtaining advisory support for their political and administrative decisions (departmental research).

1.3.2 Cooperation between the Federal Government and the *Länder*

In the area of government research funding, the Federal Government and the *Länder* cooperate in keeping with the applicable constitutional requirements of the Federal Republic of Germany. A number of relevant different departments are active at both the federal and *Länder* levels. Apart from departments of research and science, this group includes federal departments such as the Federal Ministry for Economic Affairs and Energy (BMWi), the Federal Ministry of Food and Agriculture (BMEL; previously: BMELV), the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB; previously: BMU), the Federal Ministry of Labour and Social Affairs (BMAS) and the Federal Ministry of Health (BMG).

The *Joint Science Conference of the Federal Government* and of the *Länder* (GWK) provides a forum for exchange and for coordination of science and research policy. In addition, it supports cooperation in funding of research organisations of projects of supra-regional importance, and it is an important decision-making body (for example, in connection with the *Excellence Initiative* and the *Higher Education Pact*).

The *German Council of Science and Humanities (Wissenschaftsrat – WR)* advises the Federal Government and the *Länder* governments regarding the development – in terms of both structure and focus – of the country's universities, science and research. Its membership consists of scientists, leading public figures and representatives of the Federal Government and the *Länder*.

Joint Science Conference (Gemeinsame Wissenschaftskonferenz)

By an administrative agreement of 11 September 2007, and on the basis of Art. 91 b Basic Law, the Federal Government and the *Länder* agreed to establish a *Joint Science Conference (GWK)* (Federal Gazette 2007, p. 7787). On 1 January 2008, the *GWK* supplanted the *Bund-Länder Commission for Educational Planning and Research Promotion (BLK)*. The *GWK's* members include the federal and *Länder* (state) ministers and senators responsible for the areas of science and research and finances. The *GWK* considers issues that relate to research funding, science-policy and research-policy strategies and the science system, which affect both the Federal Government and the *Länder*. The members of the *GWK* are charged with the following:

- working closely in the area of national, European and international science and research policy, in keeping with their competencies in connection with issues of joint interest, and with the aim of enhancing the international competitiveness of Germany's science and research sector,
- in instances of supra-regional importance, cooperating in supporting scientific institutions and projects outside of the higher education sector, in funding scientific and research projects at universities and in financing research buildings at universities, including large research facilities,
- informing each other regarding important planning and decisions that are not the focus of joint funding.

Such joint funding of science and research also extends to the institutions and projects of supra-regional importance that are listed in the annexe to the *GWK*

Agreement. The group of so-benefiting institutions includes the Fraunhofer-Gesellschaft (FhG), Helmholtz Association (HGF), Max Planck Society (MPG), Leibniz Association (WGL) and the German Research Foundation (DFG). Implementation agreements relative to the *GWK Agreement* cover the details of joint funding; the prerequisites for, and consequences of, departures from joint funding; and the shares of the Federal Government and of the *Länder* in joint funding.

German Council of Science and Humanities (Wissenschaftsrat)

The *German Council of Science and Humanities* is an advisory body that is jointly sponsored by the Federal Government and the *Länder* governments, with the federal and *Länder* sides each providing half of the relevant financing. It is charged with developing overarching recommendations regarding the thematic and structural development of the science, research and higher education sectors and with contributing to efforts to assuring the international competitiveness of German science within the context of the applicable national and European science systems.

Its work includes providing recommendations and expert opinions relative to two main task areas of science policy:

- overarching issues of the science system, selected structural aspects of research and teaching and planning, evaluation and control of individual areas and disciplines;
- scientific institutions (universities, universities of applied science (Fachhochschulen) and non-university research institutions), especially with regard to their structure, performance, development and financing.

The organs of the *German Council of Science and Humanities* include the *Scientific Commission* and the *Administrative Commission.* These two bodies meet, and take decisions, in the *Plenary Assembly.*

The *Scientific Commission* has 32 members. All are appointed by the German Federal President; 24 of them are scientists nominated jointly by the German Research Foundation (DFG), the Max Planck Society (MPG), the German Rectors' Conference (HRK), the Helmholtz Association (HGF), the Fraunhofer-Gesellschaft and the Leibniz Association; and 8 are prominent personalities nominated jointly by the Federal Government and the *Länder* governments. The *Administrative Commission* has 22 members, 16 of whom are *Länder* representatives, each with one vote, and 6 of whom are federal representatives, with a total of 16 votes. The *Plenary Assembly* thus has 54 members, with a total of 64 votes. The Council's decisions are taken by the *Plenary Assembly,* by a two-thirds majority; this promotes finding of consensus solutions.

The Council's current areas of work include:

- tertiary education
- research
- evaluation
- investments in, and accreditation of, higher education institutions
- medicine

1.3.3 Federal funding instruments

The types of funding the Federal Government provides for research and development include project funding, or targeted funding of short- to medium-term duration; funding for contract research, and institutional funding of medium- to long-term duration.

Project funding

Federal departments provide project funding via funding programmes – in each case, on the basis of an application for a term-limited project. Project funding can be provided for both individual projects and collaborative research projects involving several partners of equal status.

Direct project funding is always provided for a concrete field of research. The purposes of such funding include achieving and assuring internationally competitive performance in selected areas of research and development.

The aim of indirect project support is to support research institutes and companies – especially small and medium-sized enterprises – in research and development activities. For example, such support is provided for development and enhancement of research infrastructure, for research cooperation, for innovative networks and for personnel exchanges between research institutes and industry.

Contract research

In the framework of departmental research, federal institutions with R&D tasks conduct their own research, and research contracts are awarded to third parties. Contracts for R&D projects are awarded by the involved government departments themselves and by federal institutions with R&D tasks. In addition to being conducted via project funding, departmental research is often carried out as contract research. Relevant contract awards are subject to the regulations for public procurement law. In each case, the resulting research findings become the property of the party awarding the contract. That party also assumes the full costs of the contract.

Figure 8 shows the Federal Government's expenditure for research and development, in the framework of direct project funding and departmental research (by departments), as well as R&D expenditure of the EU that is effective in Germany.

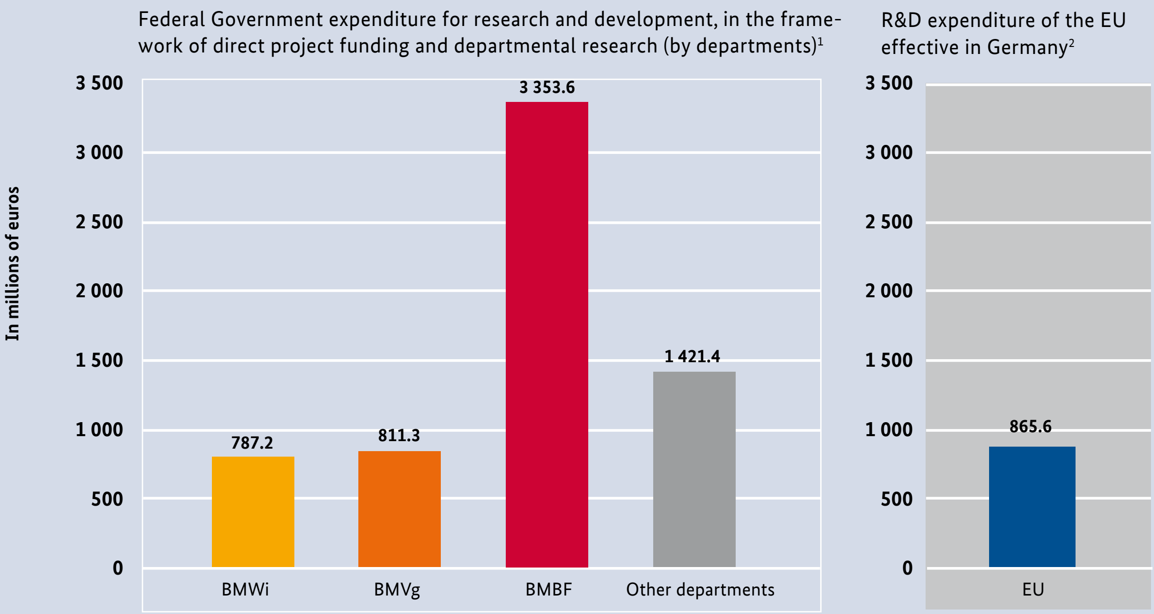
The European Commission's Community framework for state subsidies for research, development and innovation also plays a decisive role. The applicable national framework conditions are set forth especially by the *Federal Budget Code (BHO)* and the *Federal Budget Act*. Most funding programmes receive scientific, technical and administrative support from project management agencies; such agencies are called on especially to advise applicants, to prepare funding decisions, to manage business details of projects and to monitor projects' success (including commercialisation of their results).

Institutional funding

Institutional funding, by contrast, is not oriented to individual research projects; instead, it is oriented to the overall operations and investments of research institutions, in a long-term framework. It is provided by the Federal Government or by the Federal Government and the *Länder*, acting jointly. The purpose of this funding is to safeguard the research infrastructure, excellence and strategic orientation of the German research system. Important examples of such funding include the allocations that the Federal Government and the *Länder* provide in the context of joint research funding pursuant to Art. 91 b Basic Law – for example, funding for the research organisations Helmholtz Association, Leibniz Association, Max Planck Society and Fraunhofer-Gesellschaft.

Basic funding provided to institutions is subject to stringent requirements and strict accountability.

Fig. 8 Federal Government expenditure for research and development as direct project funding and departmental research (by departments), as well as R&D expenditure of the EU that is effective in Germany



Including expenditure, as of 2001, for contracts in the framework of departmental and defence research and development, for the development of the higher education and science sectors and for the achievement of equal opportunity for women in research and teaching.

[1] Target figures for 2013

[2] Since the budget for FP7 (running from 2007 to 2013) grows exponentially over the years concerned, and thus the annual tranches of the EU's R&D expenditure that is effective in Germany grow annually, it makes little sense to select a base year for the German allocation shares of EU project funding. For this reason, the average value over the term to date is given.

Database: Table 8 (cf. long version only); EU data: ECORDA contracts database for FP7

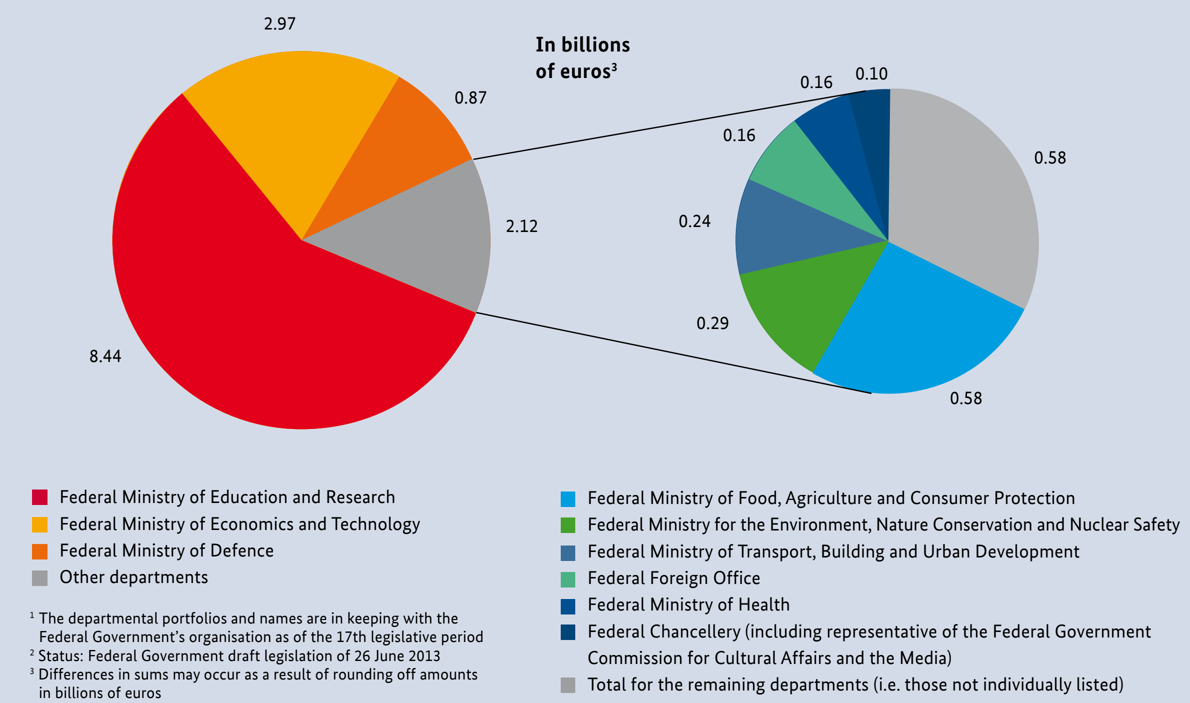
2 The Federal Government's research and innovation policy

Much of the funding for research, development and innovation in Germany is provided by the Federal Government. In the process, the Federal Government coordinates its research and innovation policy with the *Länder*. The aims of such funding include providing impetus and targeted support for research and development in companies.

The Federal Government's research and innovation policy is oriented to the guidelines of the *High-Tech Strategy (HTS)*. Since 2006, the Federal Government has been using the *HTS* format to consolidate its research and innovation activities across departmental boundaries. Instead of concentrating separately on individual technologies or research topics, the *High-Tech Strategy* covers the entire value-creation chain from basic research to applications. The *High-Tech Strategy* formulates specific research-policy models and objectives for major societal challenges, in the research emphases health/nutrition, climate/energy, mobility, communications and security. It is aimed at making Germany a leader in efforts to solve global challenges in these research areas – and, thus, at helping to provide convincing answers to the urgent issues of the 21st century. As a result, it is helping to strengthen innovation and growth potential in industry, and to protect high-quality jobs with a real future. The Federal Government's research and innovation policy also focuses on promoting key technologies, on creating and shaping innovation-friendly framework conditions and on addressing important cross-cutting issues such as research for the future of work and for innovations in education.

Federal expenditure of 14.4 billion euros is planned (target) for research and development in 2014. Figure 9 shows the Federal Government's expenditure for research and development in 2014, by departments.

Fig. 9 Federal Government expenditure on research and development, by departments[1], 2014 (target[2])



[1] The departmental portfolios and names are in keeping with the Federal Government's organisation as of the 17th legislative period
[2] Status: Federal Government draft legislation of 26 June 2013
[3] Differences in sums may occur as a result of rounding off amounts in billions of euros
Database: Table 4

The following section provides an overview of the Federal Government's research emphases, thereby outlining the aforementioned *HTS*. In addition, it takes account of supporting key technologies and a range of other priorities, such as research into demographic change and measures to promote young scientists and researchers. The Federal Government's research funding also includes funding for education research and research in the humanities.

The "health/nutrition" research priority

All of us want to live long and healthy lives – and more and more of us are fulfilling this wish. But even intensive research has been unable to answer a number of fundamental issues pertaining to health. As demographic change progresses, growing numbers of people are contracting diseases associated with modern society – such as type 2 diabetes mellitus, cardiovascular diseases, musculoskeletal disorders and cancer. The numbers of people requiring nursing care are also increasing. What is more, a number of communicable diseases remain undefeated or have begun spreading again as a result of globalisation. Health and prevention research seeks to address these challenges.

To be able to identify relevant risk factors in time, and to take suitable measures for prevention and treatment, one must truly understand diseases – and the interrelationships between genetic disposition, environmental influences and lifestyle factors such as diet and exercise. Health research helps to produce fundamental new findings regarding ways of staying healthy and of effectively combating diseases. Suitable studies that are carefully planned, both methodologically and conceptually, can yield evidence-based conclusions regarding the effectiveness, benefits and risks of new treatment methods and preventive measures. As a result, health and prevention research contributes significantly to the development of a health system with lasting viability.

A healthy diet, based on safe foods, is an important part of any healthy life. For a long time in the past, having an adequate food supply was a key concern. Today, issues of food quality and safety are also of central importance. At the same time, sustainability issues have to be considered: The world's limited area of arable land has to be used to produce food – and biomass for energy production and raw materials. At the same time, we need to protect biological diversity.

Our agricultural, forestry, fisheries and food-industry sectors, and relevant research, must all contribute to the development of living regions that support both employment and recreation, that produce healthy foods and that protect the natural environment and its flora and fauna. The necessary foundations for sustainable development of rural areas, in an age of globalisation and demographic changes, need to be studied, and our agricultural and forestry production systems need to be adapted to future changes such as climate change. Furthermore, strategies for safeguarding the world's food supply have to be developed.

Safe, healthy food is one example of a key consumer protection issue. The realm of consumer protection of course includes many more areas, in addition to food, our digital economy – for example, in connection with Internet purchases – is becoming more and more important. Transparency and better information about product characteristics and relevant services benefit consumers. Quality management systems assure the high quality of products and help to minimise risks for everyone.

The "climate/energy" research priority

The earth's climate has already changed, and now we have to be prepared for it to change still further: scientists have confirmed that average global temperatures are increasing, that sea levels are rising, that glaciers are melting and that the frequency of extreme weather events is increasing, including such events as heat waves, droughts, torrential rainfall and severe, destructive storms. We need to strive to keep such climate changes to a minimum – especially by reducing emissions of climate-harming substances, by expanding use of high-efficiency technologies and by converting our energy supply to a renewables-based system. The Federal Government is taking precautions in this area. It is implementing comprehensive protective and adaptation measures designed to enhance all sectors' ability to withstand the impacts of climate change.

Germany requires a climate-friendly, secure and affordable energy supply. As long as conventional energy systems are still needed, they have to be operated with the greatest possible efficiency, also with the help of new technologies. At the same time, use of renewable energies is being expanded, to produce a broad-based energy mix that will make it possible to achieve the Federal Government's climate-policy and energy-policy objectives. Efficiency technologies are supporting this strategy, which is designed to achieve a paradigm change toward a sustainable economy. And efficiency-oriented strategies are needed more urgently than ever with regard to utilisation of raw materials. Since the beginning of the 21st century, the demand for raw materials has grown enormously, fuelled by growing imports from newly industrialised countries such as China and India. We need to find strategies for producing and extracting such materials in socially and environmentally compatible ways, enhancing utilisation efficiency and finding substitutes for limited and scarce raw materials. Bio-economics, i.e. replacing fossil fuels with renewable resources, is one possible answer. Since the demand for agricultural products is growing worldwide, massive productivity gains are of vital importance, both in biomass utilisation for food production and bioenergy production.

The "mobility" research priority

Mobility is one of the great achievements of the modern industrial age. Today, we have an unprecedented broad range of options for covering considerable distances quickly and cheaply. Our entire economy is based on such mobility, and, in our globally connected world, the mobility demands of people, commerce and industry are constantly increasing. The resulting sharp growth in transports is placing heavy demands on transport infrastructures, logistics systems and relevant technologies – and climate change and demographic change are exacerbating such demand problems.

Mobility is an indispensable basis for economic growth, public services and quality of life. In light of the costs of mobility for the environment and society, the task of meeting growing mobility demands and necessities in a globalised, work-sharing world will call for enormous R&D efforts. To be able to make mobility safer and more efficient, while also reducing transport-related stresses and emissions, we need new, innovative solutions that involve low-emissions or even zero-emissions ways of moving from A to B. The Federal Government's climate-protection strategies thus also aim specifically at transports. They are designed to lower greenhouse-gas emissions, improve energy efficiency and increase reliance on renewable energies.

At the same time, the Federal Government is aiming to make the country's transport infrastructure and systems climate-resistant. In this regard, it is implementing a clear adaptation strategy in the framework of the *German Adaptation Strategy (DAS).* Mobility solutions cannot be achieved without the people they are designed to benefit. Relevant new technologies have to go hand-in-hand with new, holistically oriented mobility planning and new mobility patterns – for example, in keeping with the Federal Government's showcase projects for real-world tests of electromobility.

The "communications" research priority

The Internet and mobile communications have had a profound impact on our everyday lives and our workplaces. The world's knowledge is available via the Internet. Navigation without ICT is virtually inconceivable. Infrastructures such as our energy systems can no longer be managed without information technology. Information and communications technologies (ICT) have produced one of the largest technological revolutions of all time. They have changed the world in countless ways. Globalisation, along with its opportunities and challenges, would not have been possible without ICT.

In an astoundingly short time, ubiquitous networking has generated enormous databases – databases that need to be handled with the greatest of care. Information and communications technologies themselves have become growing sectors that generate employment and prosperity, contributing significantly to Germany's productivity and economic growth.

What is more, information and communications technologies have been driving innovation and growth in many other sectors. ICT now accounts for considerable shares of all productivity gains in Germany. Information technology can now be found almost anywhere one cares to look. Over 90 percent of all computer processors are not located in our office or home computers – they are hidden away in automobiles, machine-control units and medical equipment.

The very future of Germany's industrial sector could hinge on ever-growing networking of production systems and on intelligent production like "Industry 4.0", both of which would be inconceivable without progress in ICT.

The "security" research priority

People in Germany today live more safely than ever before. At the same time, active precautions must be taken. Risks and threats must be correctly assessed, and preventive strategies developed, to ensure that people can continue to live in safety and security. Dangers and threats can vary widely in terms of their impact. They can affect either individual persons or a society as a whole. Large-scale technological accidents can never be completely ruled out, since natural and environmental disasters remain a potential threat – also for Germany. The key tasks of the state include safeguarding security in cyberspace, and protecting against crime, terrorism and extremist attacks. The performance of such tasks is supported by security research and innovative strategies.

Germany's highly efficient, automated and interlinked infrastructures react very sensitively to interventions. Even relatively small factors, completely unrelated to terrorism, can lead to major negative impact. Without electricity, Germany's transport systems, health sector and public food supply would soon break down. Such infrastructures of vital importance for our society thus have to be protected against risks and threats. In addition, our communication systems are central lifelines. Not only do they greatly facilitate interpersonal communication, they are a key basis for movements of goods and money transactions. They thus also have to be safeguarded against dangers and threats. Sensitive personal data must be protected against unauthorised access, and companies have to be able to ward off industrial espionage. Events that draw large crowds, such as football matches and music festivals, need to be organised and structured in ways that prevent any onset of mass panic, which could endanger the lives of spectators and participants. Finally, pathogens and hazardous substances such as poisons and explosives, must be detected and dealt with whenever they pose a threat.

Key technologies

Germany has been able to cultivate and maintain a strong, globally competitive industrial base. Germany's success in this area will continue only if Germany is able to continue producing innovative, high-quality products. Key technologies are a main driver for innovation in industrial sectors in which Germany is strong, such as the automotive industry, medical technology, the mechanical engineering sector and logistics. In such areas, new products, processes and services hinge on key technologies. Germany's economic future thus depends decisively on its commitment to using the opportunities inherent in key technologies and to translating such technologies into commercial applications. German companies profit from Germany's strong research sector. They participate in a broad and diverse range of cooperative relationships, including arrangements that provide access to the latest research findings.

Research and development in key technologies not only strengthens German industry, it also makes essential contributions to the solution of societal challenges, especially in the focus areas of health, climate protection / resources conservation / energy, security and mobility. Without innovation driven by key technologies, it would be impossible to develop state-of-the-art drugs and new diagnostic procedures. Important mobility solutions – such as climate-friendly engine technologies, navigation systems and safety innovations such as airbags and ABS – depend on key technologies. Research in the area of key technologies is what has enabled renewable energies to reach market maturity, and to bring the transition to the post-oil age within reach.

Other research priorities

The Federal Government's research and innovation funding reaches far beyond the aforementioned activities. For example, it also includes priorities in research into innovation in education and in economics, the humanities and the social sciences. This is because, if they are to have a positive impact on society, research findings must reflect and take account of societal realities. When new technologies hold the potential for useful solutions, these solutions need to be tailored to people's real needs and have to be utilisable by people in real-world settings. And to be able to conduct research, people require extensive education and training.

Central societal trends determine the possibilities of, and the limits to, any successful research policy. Such trends determine the objectives and priorities for research and innovation strategies, and they shape the challenges for which research and innovation seek to find solutions. The future of work will be shaped profoundly by new information and communications technologies. Demographic change will create requirements for new technologies that can be adapted to the needs of an ageing society. Digital media are already having an enormous impact on teaching and learning in schools and universities. Researchers in economics, the humanities and the social sciences study the key factors that shape and affect social coexistence. Without their contribution, it will not be possible to develop and implement research and innovation policies that benefit people.

Promoting technologies in SMEs, and promoting start-ups

Among companies seeking to bring innovative products, processes and services to the market, small and medium-sized enterprises (SMEs) are especially in need of state support. This is why the Federal Government's funding programmes focus on targeted support for SMEs. Such support is aimed at inspiring SMEs to intensify their efforts in research, development and innovation, at reducing the risks inherent in research and development (R&D) projects, helping companies rapidly translate R&D findings into marketable innovations, expanding cooperation between SMEs and research institutions and increasing SMEs' involvement in R&D cooperation and innovative networks. The government also provides support, in the form of financing assistance and venture-capital facilitation, for technology-based start-ups and young technology companies.

Good, future-oriented ideas are the basis for innovative start-ups. Young companies and innovative start-ups often produce new forms of value creation and they often drive structural change in the economy, in important ways. And start-ups in research-intensive and knowledge-intensive sectors contribute disproportionately to growth and employment. Such start-ups often have difficulty in finding adequate private financing, however. This is significant in that such companies especially require adequate financing in their initial and growth phases. The Federal Government implements a broad range of support instruments in order to counter the structural disadvantages that such ventures face – lack of collateral, high risks in the areas of management, markets and technologies – in obtaining the capital they need.

Infobox

"Pilot service" for companies

Small and medium-sized enterprises (SMEs) that conduct research play a central role in innovation processes and in generating employment. One way in which they can rapidly obtain information about available support for research and innovation is to contact the "Lotsendienst" ("pilot service"), an advising service for companies that is part of the Federal "Research and Innovation" Funding Advisory Service. The "pilot service" for companies provides advisory services for all aspects of planned research projects and helps companies correlate their project ideas with potential support opportunities.
A service of the Federal "Research and Innovation" Funding Advisory Service:

- Tel.: 0800 2623009
- E-mail: beratung@foerderinfo.bund.de
- Internet: www.foerderinfo.bund.de/kmu

3 Research and innovation policy of the *Länder*

Germany's federal structure makes it possible for the regional strengths, resources and infrastructures of the country's 16 *Länder* (states) to be developed and utilised in accordance with the applicable circumstances and conditions in each case. In parallel with the relevant support activities of the Federal Republic of Germany, Germany's 16 *Länder* carry out numerous *Land*-specific support measures in the area of research, technology and innovation policy.

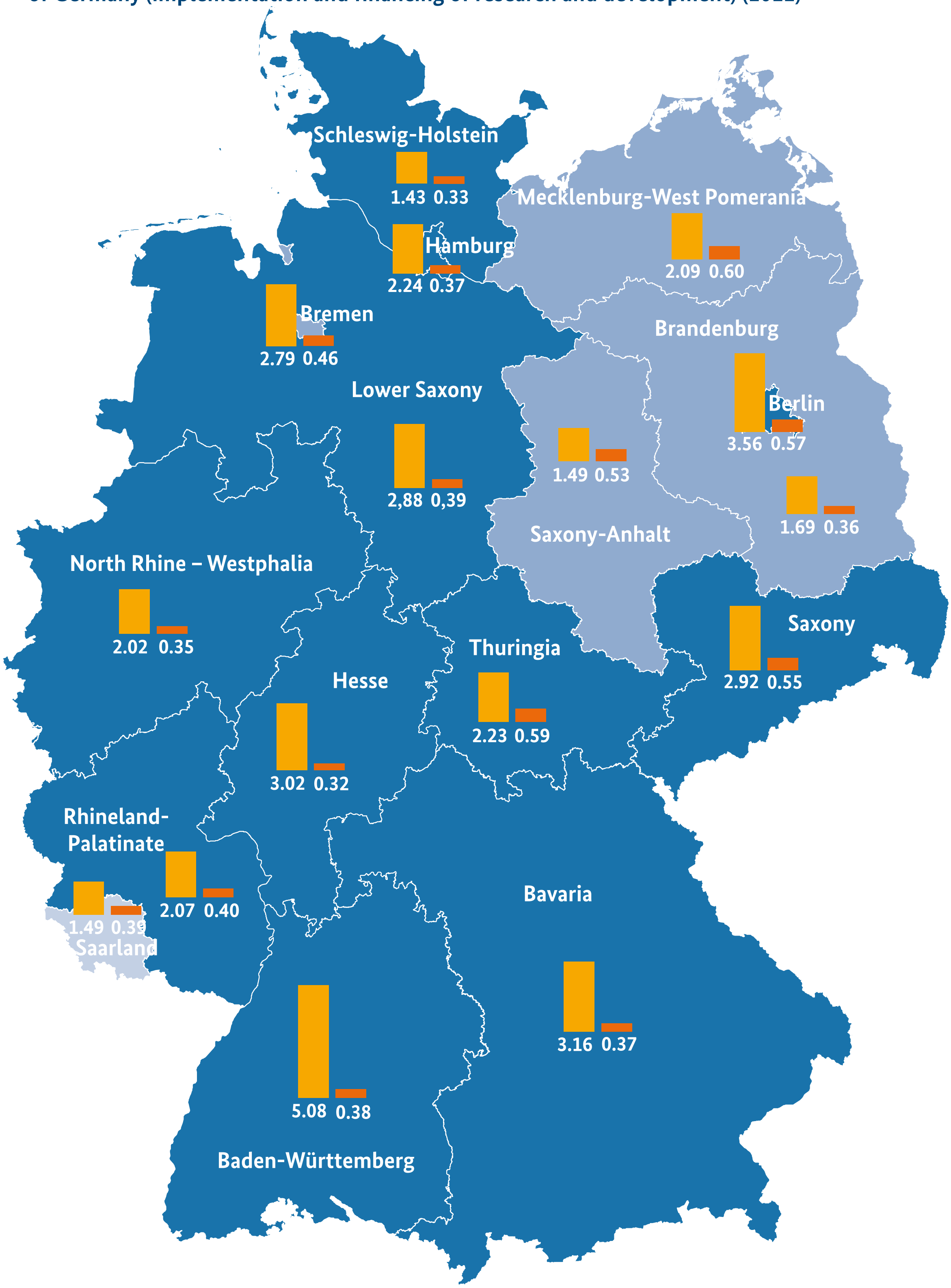
In the process, they focus on the specific strengths of the various regions involved, with regard to technological, economic and innovative competencies, and they take account of existing spatial structures and special circumstances. Such *Land*-specific support measures complement the overarching measures in place at the federal level. For example, while the *Länder* conduct funding measures in the same or similar technology contexts, their priorities and emphases can differ from those applied at the federal level.

And the *Länder* also differ among themselves in this regard. While all have initiatives in place in areas such as information and communications technologies, medical technology and environmental technologies, the emphases of such initiatives differ from *Land* to *Land*. Numerous *Land*-specific innovation programmes are especially important in cases of structural change in which traditional industrial centres develop into modern high-tech and services centres.

Overall, the regional differences seen in research and innovation funding as well as the specific emphases of the *Länder* contribute significantly to the strength of the German research and innovation system.

Please note the following: In keeping with their sovereignty in matters of *Land* (state) policy, the *Länder* are presenting their research, technology and innovation policies themselves, under their own responsibility, in the 2014 Federal Report on Research and Innovation. The following section presents consistently structured overview pages covering the research sectors of the *Länder*, the pertinent structural and innovation data and the priorities pursued in the relevant *Länder* measures.

Fig. 10 Regional distribution of expenditure for research and development in the Federal Republic of Germany (implementation and financing of research and development) (2011)



State R&D expenditure of the *Länder* (financing of R&D; 2011)

- Total expenditure in % of the GDP of the relevant Land (federal state) (implementation)
- Total expenditure in % of the GDP of the relevant Land (federal state) (financing)

Total expenditure for R&D, by *Länder* (implementation of R&D)

- < 500 million euros
- 500 - 1 000 million euros
- > 1 000 million euros

Abbreviations:
R&D = research and development
GDP = gross domestic product

Database: Stifterverband Wissenschaftsstatistik; Federal Statistical Office; calculations of the Federal Ministry of Education and Research

Source: BMBF, VDI/VDE-IT

Baden-Württemberg

Structural indicators

State capital: Stuttgart
Area: 35 751.36 km².
Population (in thousands): 10 569.10 (as of: 31 Dec. 2012)
Population density (per km²): 296 (as of: 31 Dec. 2012)
Gross domestic product, nominal (in millions of euros, 2012): 389 493
Gross domestic product, nominal (per capita, in euros, 2012): 36 019
Export ratio (foreign revenue as a share of revenue in the manufacturing sector, in %, 2012): 51.2

Innovation indicators

Total R&D expenditure (in millions of euros, 2011): 19 462
Total R&D expenditure (in % of the state's GDP, 2011): 5.08
Government R&D expenditure (in millions of euros, 2011): 1 466
Government R&D expenditure (in % of the state's GDP, 2011): 0.38
Patent applications (2012): 14 225
Patent applications per 100 000 inhabitants (2012): 135

Research and science sector

- 9 universities
- 23 state universities for applied sciences
- Baden-Wuerttemberg Cooperative State University (Duale Hochschule BW) (8 locations)
- 16 institutes/institutions of the Fraunhofer-Gesellschaft
- 12 institutes of the Max Planck Society
- 2 institutes of the Helmholtz Association (KIT, DKFZ)
- 2 locations of the German Aerospace Center (DLR)
- 10 locations of the German Centers for Health Research
- 7 institutes of the Leibniz Association
- Institute for Transuranium Elements
- European Molecular Biology Laboratory
- 12 institutes of the Innovationsallianz BW (Baden-Wuerttemberg innovation alliance)
- Heidelberg Academy of Sciences and Humanities
- 2 federal departmental research institutions (Federal Research Institute of Nutrition and Food (Max Rubner Institute) and the Federal Waterways Engineering and Research Institute (BAW))

Emphases of research and development measures

- Promoting sustainable science and research:
- Building and safeguarding an attractive, internationally competitive higher education and research sector
- Strengthening cutting-edge research at universities, for the long term
- Promoting scientific excellence
- Providing targeted support for young scientists and entrepreneurs
- Intensifying networking between science and industry
- Building the growth areas of sustainable mobility, environmental technologies, renewable energies and resources efficiency, health and care, information and communications technologies, green IT and intelligent products

Further information is available at:

www.baden-wuerttemberg.de

The freshly laminated SOFIA main mirror bearing the self portrait of two scientists. The German SOFIA (Stratospheric Observatory For Infrared Astronomy) Institute of Stuttgart University organises the NASA-DLR-project's German side.

Free State of Bavaria

Structural indicators

State capital: Munich
Area: 70 550.23 km².
Population (in thousands): 12 519.60 (as of: 31 Dec. 2012)
Population density (per km²): 177 (as of: 31 Dec. 2012)
Gross domestic product, nominal (in millions of euros, 2012): 465 502
Gross domestic product, nominal (per capita, in euros, 2012): 36 865
Export ratio (foreign revenue as a share of revenue in the manufacturing sector, in %, 2012): 51.3

Innovation indicators

Total R&D expenditure (in millions of euros, 2011): 14 403
Total R&D expenditure (in % of the state's GDP, 2011) 3.16
Government R&D expenditure (in millions of euros, 2011): 1 698
Government R&D expenditure (in % of the state's GDP, 2011): 0.37
Patent applications (2012): 14 340
Patent applications per 100 000 inhabitants (2012): 115

Research and science sector

- 9 state universities and 5 university hospitals
- 17 state universities for applied sciences / institutes of technology
- 6 state colleges of art
- 6 non-state universities and research universities
- 7 private and church-sponsored universities of applied science
- 3 private and church-sponsored colleges of art and music
- 1 university of public administration
- Numerous non-university research institutions (including 13 Max Planck institutes, 3 Helmholtz Centres and 1 Helmholtz Institute, 13 Fraunhofer institutes, 6 institutes of the Leibniz Association and numerous relevant state institutions)

Emphases of research and development measures

- Biosystems research, systems immunology, laser technologies in diagnostics
- Health research: neurodegenerative diseases; diabetes; cardiovascular, pulmonary and infectious diseases; cancer
- Energy research and clean technology, including environmental technologies, catalysis, hydrogen chemistry, resources management, renewable resources, electromobility
- Nanotechnology, new materials and hybrid materials, lightweight construction technologies, polymer research
- ICT, including supercomputing and computer simulations
- Production technologies, robotics
- Technology-based services
- Humanities and social sciences: antiquity, Africa, eastern Europe, transformation

Further information is available at:

www.bayern.de

Sites of universities and university-level institutions in the Free State of Bavaria (green = universities, orange = universities of applied science)

Berlin

Structural indicators

State capital: Berlin
Area: 891.70 km².
Population (in thousands): 3 375 20 (as of: 31 Dec. 2012)
Population density (per km²): 3 785 (as of: 31 Dec. 2012)
Gross domestic product, nominal (in millions of euros, 2012): 103 604
Gross domestic product, nominal (per capita, in euros, 2012): 29 455
Export ratio (foreign revenue as a share of revenue in the manufacturing sector, in %, 2012): 52.8

Emphases of research and development measures

- Health care system
- Energy technology
- Transport, mobility and logistics
- Optics
- ICT / media / creative industries
- Electromobility showcase (Schaufenster Elektromobilität)

Further information is available at:

www.berlin.de

Innovation indicators

Total R&D expenditure (in millions of euros, 2011): 3 606
Total R&D expenditure (in % of the state's GDP, 2011) 356
Government R&D expenditure (in millions of euros, 2011): 581
Government R&D expenditure (in % of the state's GDP, 2011): 0.57
Patent applications (2012): 855
Patent applications per 100 000 inhabitants (2012): 25

The Photonics Centre in Berlin Adlershof

Research and science sector

- 4 universities and Charité Universitätsmedizin Berlin (Charité university hospital)
- 4 state and 2 denominational universities of applied science
- 3 colleges of art
- 30 accredited state universities
- about 70 non-university research institutions
- over 20 technology and incubator centres

Brandenburg

Structural indicators

State capital: Potsdam
Area: 29 485.63 km².
Population (in thousands): 2 449.50 (as of: 31 Dec. 2012)
Population density (per km²): 83 (as of: 31 Dec. 2012)
Gross domestic product, nominal (in millions of euros, 2012): 57 774
Gross domestic product, nominal (per capita, in euros, 2012): 23 179
Export ratio (foreign revenue as a share of revenue in the manufacturing sector, in %, 2012): 28.5

Innovation indicators

Total R&D expenditure (in millions of euros, 2011): 954
Total R&D expenditure (in % of the state's GDP, 2011) 1.69
Government R&D expenditure (in millions of euros, 2011): 203
Government R&D expenditure (in % of the state's GDP, 2011): 0.36
Patent applications (2012): 296
Patent applications per 100 000 inhabitants (2012): 12

Research and science sector

- 3 universities
- 4 universities of applied science
- 1 college of art
- 3 institutes of the Fraunhofer-Gesellschaft
- 4 institutions / branches of the Helmholtz Association
- 10 institutes / branches of the Leibniz Association
- 3 institutes of the Max Planck Society
- 1 academy of sciences
- Other state and federal institutions
- Other private, state-accredited universities and vocational academies
- Over 20 technology and start-up incubators
- Other private research institutions

Emphases of research and development measures

- Climate, marine, energy and environmental research
- Research into key technologies; applied research, in areas including materials, medical technology and wireless microelectronics
- Life sciences and bio-economics; emphases in agriculture and landscape research, biotechnology and nutrition research
- Astrophysics
- Cognitive sciences
- Contemporary history
- Future-oriented areas of the Joint Innovation Strategy of Berlin and Brandenburg (cluster development): health care sector, energy technology, transport/mobility/logistics, ICT / media / creative industries, optics / microsystems technology; Brandenburg: food industry, plastics/chemistry, metallurgy, tourism

Further information is available at:

www.brandenburg.de

"Einsteintower" on the Potsdam Telegrafenberg
Picture: Leibniz Institute for Astrophysics Potsdam (AIP)

Free Hanseatic City of Bremen

Structural indicators

State capital: Bremen
Area: 419.24 km².
Population (in thousands): 654.80 (as of: 31 Dec. 2012)
Population density (per km²): 1 562 (as of: 31 Dec. 2012)
Gross domestic product, nominal (in millions of euros, 2012): 27 693
Gross domestic product, nominal (per capita, in euros, 2012): 41 897
Export ratio (foreign revenue as a share of revenue in the manufacturing sector, in %, 2012): 52.8

Innovation indicators

Total R&D expenditure (in millions of euros, 2011): 751
Total R&D expenditure (in % of the state's GDP, 2011) 2.79
Government R&D expenditure (in millions of euros, 2011): 125
Government R&D expenditure (in % of the state's GDP, 2011): 0.46
Patent applications (2012): 150
Patent applications per 100 000 inhabitants (2012): 23

Research and science sector

- 209 schools (primary schools, technical schools, grammar schools (Gymnasien), support centres, vocational schools, adult schools, Waldorf schools, school centres in secondary sector I, comprehensive schools, International School of Bremen)
- 2 universities (including 1 private university)
- 1 university of arts
- 4 universities of applied science (including 2 private ones)
- 1 university of public administration
- 20 non-university research institutions
- 2 technology and start-up incubators
- 1 technology park, with more than 400 companies

Emphases of research and development measures

- Oceanographic, polar and climate research; maritime technologies
- Materials science and technologies in the areas of aeronautics and space technology, wind energy
- Information, cognition and communications sciences / logistics / robotics
- Social sciences
- Epidemiology and health sciences

Further information is available at:

www.bremen.de

The Bremen "Glass hall" and "Falltower"

Free and Hanseatic City of Hamburg

Structural indicators

State capital: Hamburg
Area: 755.3 km².
Population (in thousands): 1 734.3 (as of: 31 Dec. 2012)
Population density (per km²): 2 296 (as of: 31 Dec. 2012)
Gross domestic product, nominal (in millions of euros, 2012): 95 815
Gross domestic product, nominal (per capita, in euros, 2012): 53 091
Export ratio (foreign revenue as a share of revenue in the manufacturing sector, in %, 2012): 22.1

Innovation indicators

Total R&D expenditure (in millions of euros, 2011): 2 098
Total R&D expenditure (in % of the state's GDP, 2011) 2.24
Government R&D expenditure (in millions of euros, 2011): 347
Government R&D expenditure (in % of the state's GDP, 2011): 0.37
Patent applications (2012): 758
Patent applications per 100 000 inhabitants (2012): 44

Research and science sector

- 3 universities
- 1 university hospital
- 2 universities of fine arts
- 1 university of applied science
- 2 universities of public administration
- 1 federal university
- 1 church-sponsored university of applied sciences
- 2 private universities
- 5 private universities of applied science with classroom instruction
- 2 private universities of applied science for distance learning
- 1 private vocational academy
- 11 applications centres
- 27 non-university research institutions (including federal, state, and jointly financed institutions)

Emphases of research and development measures

- Attraction of new non-university research institutions; for example, plans call for the establishment of a first Fraunhofer Institute in Hamburg
- Further development of clusters; the Renewable Energy Hamburg cluster and the Maritime Cluster Northern Germany were recently added
- Conclusion of long-term university agreements (for the period through 2020) to provide a reliable basis for planning
- Elimination of tuition fees as of the winter semester 2012/2013, with full compensation for the resulting funding shortfalls
- Beginning of funding in the new state research funding programme. Initial projects in this context have been receiving support since the beginning of 2013, and additional projects are to receive funding as of summer 2014.

Further information is available at:

www.hamburg.de

A research building of the Center for Free-Electron Laser Science (CFEL), a cooperation between Hamburg University (UHH), Deutsche Elektronen-Synchrotrons (DESY) and Max-Planck-Society (MPI) Center for Free-Electron Laser Science (Copyright: CFEL/J. M. Harms)

Hesse

HESSEN

Structural indicators

State capital: Wiesbaden
Area: 21 114.93 km².
Population (in thousands): 6 016.481 (as of: 31 Dec. 2012)
Population density (per km²): 285 (as of: 31 Dec. 2012)
Gross domestic product, nominal (in millions of euros, 2012): 229 747
Gross domestic product, nominal (per capita, in euros, 2012): 37 656
Export ratio (foreign revenue as a share of revenue in the manufacturing sector, in %, 2012): 50.2

Innovation indicators

Total R&D expenditure (in millions of euros, 2011): 6 827
Total R&D expenditure (in % of the state's GDP, 2011) 3.02
Government R&D expenditure (in millions of euros, 2011): 734
Government R&D expenditure (in % of the state's GDP, 2011): 0.32
Patent applications (2012): 2 293
Patent applications per 100 000 inhabitants (2012): 38

Research and science sector

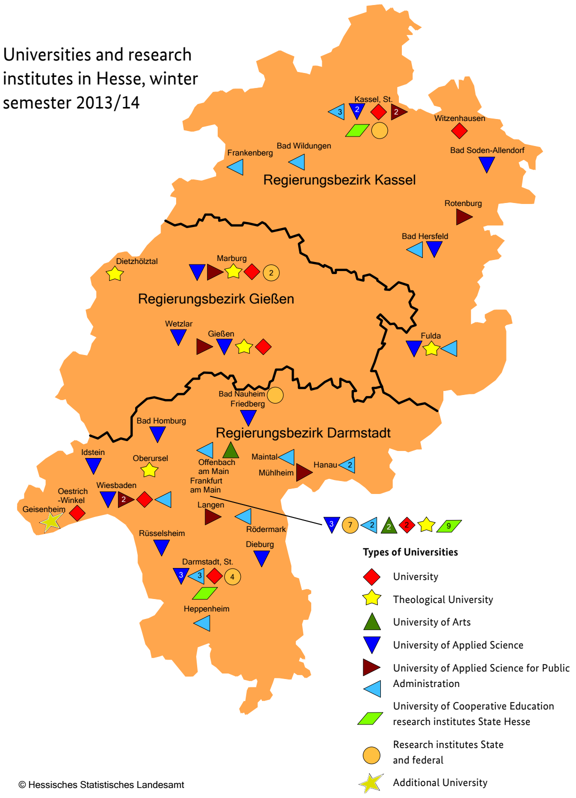
- 5 universities
- 5 universities of applied science
- 1 special university
- 2 colleges of art
- 3 universities of public administration
- 17 non-state universities
- 11 vocational academies
- 30 non-university research institutions, including:
  - 6 Max Planck institutes
  - 4 Fraunhofer institutes
  - 1 Helmholtz Centre
  - 4 research institutes of the Leibniz Association
  - (WGL)

Emphases of research and development measures

- Health / life sciences: basic and translational research on cardiovascular diseases, cancer and pulmonary diseases
- Pharmaceutical research, innovative biotechnologies (2 clusters of excellence, 4 LOEWE Centres, 12 LOEWE Research Focuses), 4 partner locations for the 4 new German Health Research Centres (DZL coordination for Hesse)
- Science/environment: climate change, particle physics (1 LOEWE Centre, 6 LOEWE Research Focuses)
- Engineering sciences / ICT: supercomputers and IT security, the future energy supply, resources-efficient utilisation of materials, mobility research (1 cluster of excellence, 2 LOEWE Centres, 6 LOEWE Research Focuses)
- Cultural studies / society / economics: normative orders, developmental and learning research, conflict research, financial market research (1 cluster of excellence, 2 LOEWE Centres, 7 LOEWE Research Focuses)

Further information is available at:

www.hessen.de



Mecklenburg – West Pomerania

Structural indicators

State capital: Schwerin
Area: 23 210.55 km².
Population (in thousands): 1 600.30 (as of: 31 Dec. 2012)
Population density (per km²): 69 (as of: 31 Dec. 2012)
Gross domestic product, nominal (in millions of euros, 2012): 36 885
Gross domestic product, nominal (per capita, in euros, 2012): 22 620
Export ratio (foreign revenue as a share of revenue in the manufacturing sector, in %, 2012): 28.8

Innovation indicators

Total R&D expenditure (in millions of euros, 2011): 741
Total R&D expenditure (in % of the state's GDP, 2011) 2.09
Government R&D expenditure (in millions of euros, 2011): 211
Government R&D expenditure (in % of the state's GDP, 2011): 0.59
Patent applications (2012): 180
Patent applications per 100 000 inhabitants (2012): 11

Emphases of research and development measures

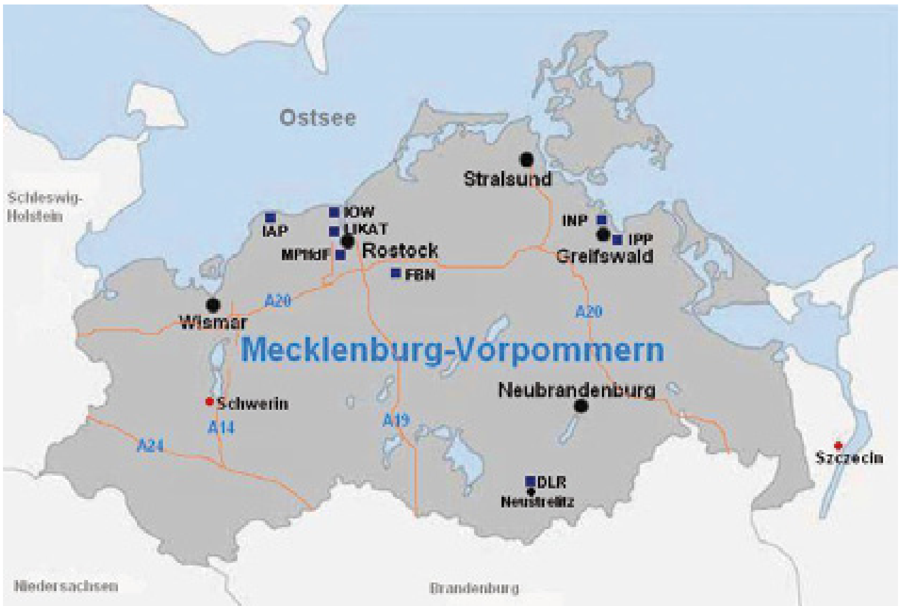
- Oceanographic, climate and atmospheric research; earth observation (also as integrated within environmental, transport and security research)
- Energy research, plasma research and catalysis research
- Health research (life sciences, regenerative medicine, drug research, biomedical technology and research into ageing)
- Mechanical engineering and production technologies, with an emphasis on maritime technologies and drive and propulsion system technologies
- Electrical engineering, automation and systems technology
- Humanities, with an emphasis on the Baltic Sea region

Further information is available at:

www.mecklenburg-vorpommern.eu

Research and science sector

- 2 universities (Rostock and Greifswald)
- 1 university of music and drama (Rostock)
- 4 universities of applied science (Wismar, Stralsund, Neubrandenburg and Güstrow)
- 1 state-accredited private university (Schwerin)
- 13 non-university research institutes (6 Leibniz, 4 HGF, 2 FhG, 1 MPG)
- 1 state research institute (Güstrow-Gülzow)
- 20 technology and start-up-incubator centres



Sites of research institutes in Mecklenburg-West Pomerania

Lower Saxony

Structural indicators

State capital: Hannover
Area: 47 613.78 km².
Population (in thousands): 7 779.00 (as of: 31 Dec. 2012)
Population density (per km²): 163 (as of: 31 Dec. 2012)
Gross domestic product, nominal (in millions of euros, 2012): 230 021
Gross domestic product, nominal (per capita, in euros, 2012): 29 032
Export ratio (foreign revenue as a share of revenue in the manufacturing sector, in %, 2012): 44.6

Innovation indicators

Total R&D expenditure (in millions of euros, 2011): 6 463
Total R&D expenditure (in % of the state's GDP, 2011) 2.88
Government R&D expenditure (in millions of euros, 2011): 874
Government R&D expenditure (in % of the state's GDP, 2011): 0.39
Patent applications (2012): 2,952
Patent applications per 100 000 inhabitants (2012): 38

Research and science sector

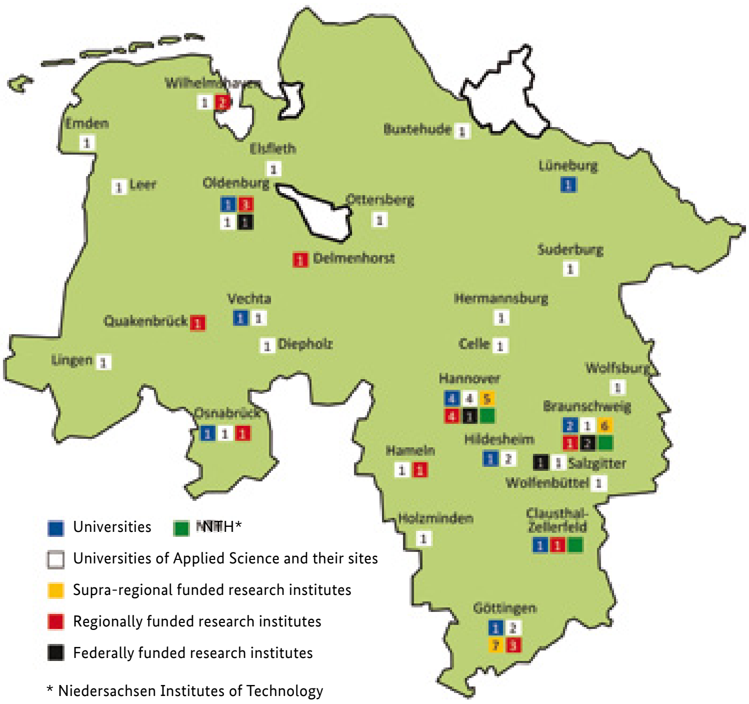
- 14 universities, including the Niedersachsen Institutes of Technology; 2 of the institutions are colleges of art and music
- 16 universities of applied science (universities) (state and private)
- 9 vocational academies
- 18 regionally financed research institutions
- 18 supra-regionally financed research institutions
- 5 federal research institutions

Emphases of research and development measures

- Energy research (electrical distribution networks and renewable energies: wind, solar, biomass, geothermal and high-performance drilling technology and fuel cell research)
- Mobility
- Aeronautics and space technology
- Microtechnology, nano and quantum engineering, gravitation physics
- Life sciences: translational research, genome analysis, infection research, cognition and neurosciences, molecular biosciences, hearing technology
- Nutritional science
- Climate and oceanographic research
- European and global studies

Further information is available at:

www.niedersachsen.de



Sites of universities and research institutes in Lower Saxony

North Rhine – Westphalia

Structural indicators

State capital: Düsseldorf
Area: 34 109.70 km².
Population (in thousands): 17 554.30 (as of: 31 Dec. 2012)
Population density (per km²): 515 (as of: 31 Dec. 2012)
Gross domestic product, nominal (in millions of euros, 2012): 582 054
Gross domestic product, nominal (per capita, in euros, 2012): 32 631
Export ratio (foreign revenue as a share of revenue in the manufacturing sector, in %, 2012): 41.9

Innovation indicators

Total R&D expenditure (in millions of euros, 2011): 11,543
Total R&D expenditure (in % of the state's GDP, 2011) 2.02
Government R&D expenditure (in millions of euros, 2011): 2 009
Government R&D expenditure (in % of the state's GDP, 2011): 0.35
Patent applications (2012): 6,758
Patent applications per 100 000 inhabitants (2012): 38

Research and science sector

- 14 public universities
- 16 public universities of applied science
- 7 state colleges of art and music
- 30 private and church-sponsored universities with their main location in NRW
- 5 universities of public administration
- 13 institutes of the Fraunhofer-Gesellschaft
- 12 institutes of the Max Planck Society
- 11 institutes of the Leibniz Association
- 3 centres of the Helmholtz Association
- 13 institutes of the Johannes-Rau-Forschungsgemeinschaft (Johannes Rau Research Association)
- Some 100 additional research institutes located at universities

Emphases of research and development measures

- Climate protection, resources efficiency and raw materials
- A reliable, clean and efficient energy supply
- Healthy foods from sustainable production
- Intelligent, environmentally friendly and integrated mobility
- Health and quality of life in an environment of demographic change
- Security, participation and social cohesion in an environment of societal change
- Key technologies

Further information is available at:

www.wissenschaft.nrw.de

Universities in North Rhine – Westphalia

Rhineland-Palatinate

Structural indicators

State capital: Mainz
Area: 19 854.10 km².
Population (in thousands): 3 990.30 (as of: 31 Dec. 2012)
Population density (per km²): 201 (as of: 31 Dec. 2012)
Gross domestic product, nominal (in millions of euros, 2012): 117 659
Gross domestic product, nominal (per capita, in euros, 2012): 29 431
Export ratio (foreign revenue as a share of revenue in the manufacturing sector, in %, 2012): 51.9

Innovation indicators

Total R&D expenditure (in millions of euros, 2011): 2 384
Total R&D expenditure (in % of the state's GDP, 2011) 2.07
Government R&D expenditure (in millions of euros, 2011): 459
Government R&D expenditure (in % of the state's GDP, 2011): 0.40
Patent applications (2012): 1 122
Patent applications per 100 000 inhabitants (2012): 28

Research and science sector

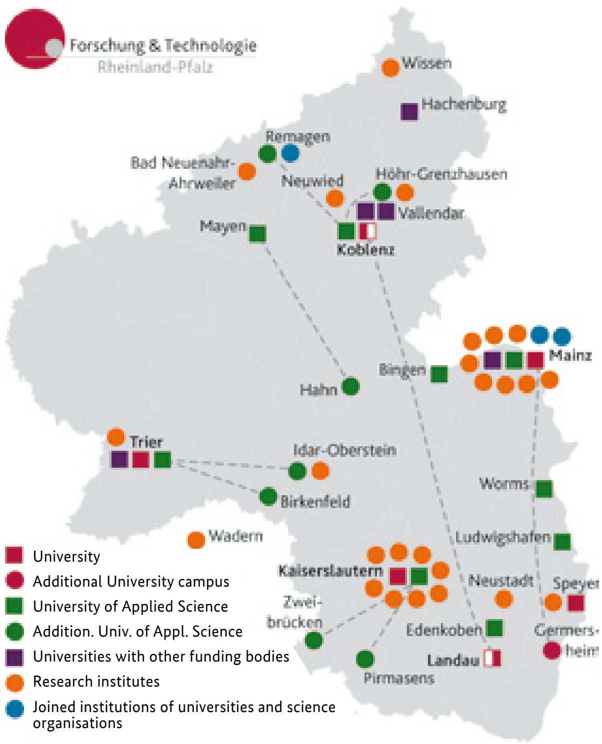
- 4 universities
- German University of Administrative Sciences
- 7 universities of applied science
- University of applied sciences for business administration and management
- University of applied sciences for finance
- 5 independently sponsored universities of applied sciences
- 3 institutes of the Max Planck Society
- 4 institutes of the Fraunhofer-Gesellschaft
- 4 institutes of the Leibniz Association
- Academy of Sciences and Literature
- A joint institution of the Helmholtz Association and the University of Mainz
- A joint institution of the Max Planck Society and the University of Mainz
- A joint institution of the Fraunhofer-Gesellschaft and the Koblenz University of Applied Sciences
- 12 non-university state research institutions

Emphases of research and development measures

- Energy, environmental technology, resources efficiency
- Life sciences and the health care sector
- Microsystems technology, sensors, automation
- Automotive and utility vehicle industry
- Information and communications technology, and Software systems
- Materials, surface technologies

Further information is available at:

www.rlp.de



Universities and science organisations in Rhineland-Palatinate

Saarland

Structural indicators

State capital: Saarbrücken
Area: 2 568.70 km².
Population (in thousands): 994.30 (as of: 31 Dec. 2012)
Population density (per km²): 387 (as of: 31 Dec. 2012)
Gross domestic product, nominal (in millions of euros, 2012): 31 709
Gross domestic product, nominal (per capita, in euros, 2012): 31 364
Export ratio (foreign revenue as a share of revenue in the manufacturing sector, in %, 2012): 48.5

Innovation indicators

Total R&D expenditure (in millions of euros, 2011): 471
Total R&D expenditure (in % of the state's GDP, 2011) 1.49
Government R&D expenditure (in millions of euros, 2011): 122
Government R&D expenditure (in % of the state's GDP, 2011): 0.39
Patent applications (2012): 249
Patent applications per 100 000 inhabitants (2012): 25

Research and science sector

- Universität des Saarlandes (Saarland University)
- Hochschule für Technik und Wirtschaft des Saarlandes (HTW Saar university of applied sciences)
- Hochschule der Bildenden Künste Saar (HBKsaar college of fine arts)
- Hochschule für Musik Saar (university of music)
- Franco-German University
- Deutsche Hochschule für Prävention und Gesundheitsmanagement (university of applied sciences for prevention and health management)
- Max Planck Institute for Informatics (MPI-Inf)
- Max Planck Institute for Software Systems (MPI-SWS)
- Leibniz Institute for New Materials (INM)
- Schloss Dagstuhl – Leibniz Center for Informatics (LZI)
- Helmholtz Institute for Pharmaceutical Research Saarland (HIPS)
- Fraunhofer Institute for Biomedical Engineering (IBMT)
- Fraunhofer Institute for Non-Destructive Testing (IZFP)
- German Research Center for Artificial Intelligence (DFKI)
- Korea Institute of Science and Technology Europe (KIST)
- Steinbeis-Forschungszentrum Material Engineering Center Saarland
- Zentrum für Mechatronik und Automatisierungstechnik (ZeMA; Centre for mechatronics and automation technology)
- Institut der Gesellschaft zur Förderung der Angewandten Informationsforschung (IAI; Institute of the society for promotion of applied information research)
- Institut für ZukunftsEnergieSysteme (IZES)

Emphases of research and development measures

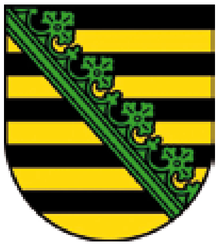
- Information and communications technology: software development, intelligent user interfaces, graphics and visualisation strategies, IT security, bioinformatics
- New materials: nanotechnology and nanoethics, boundary surfaces and materials, tribology, functional materials
- Automotive: processing and production procedures, automation and control technologies, drive concepts, materials and reliability, systems networking
- Medicine and biotechnology: pharmaceutical biotechnology, drug research, medical and biomedical technology, cryotechnology

Further information is available at:

www.saarland.de, www.willkommen.saarland.de

The Saarbruecken Campus – aerial view

Free State of Saxony



Structural indicators

State capital: Dresden
Area: 18 420.01 km².
Population (in thousands): 4 050.20 (as of: 31 Dec. 2012)
Population density (per km²): 220 (as of: 31 Dec. 2012)
Gross domestic product, nominal (in millions of euros, 2012): 96 608
Gross domestic product, nominal (per capita, in euros, 2012): 23 400
Export ratio (foreign revenue as a share of revenue in the manufacturing sector, in %, 2012): 35.7

Innovation indicators

Total R&D expenditure (in millions of euros, 2011): 2 785
Total R&D expenditure (in % of the state's GDP, 2011) 2.92
Government R&D expenditure (in millions of euros, 2011): 522
Government R&D expenditure (in % of the state's GDP, 2011): 0.55
Patent applications (2012): 1 056
Patent applications per 100 000 inhabitants (2012): 26

Research and science sector

- 4 universities and the International Graduate School Zittau
- 5 universities of applied science
- 5 colleges of art
- 2 universities of public administration
- 1 vocational academy (Berufsakademie Sachsen) with 7 faculties
- 6 private universities
- Several church-sponsored universities
- 5 Helmholtz institutions
- 16 Fraunhofer institutions
- 6 Leibniz institutions
- 6 Max Planck institutes
- 2 institutes of the Senckenberg Gesellschaft für Naturforschung
- 9 state research institutions
- Various associated institutes (An-Institute) of universities
- 3 research centres at universities of applied science

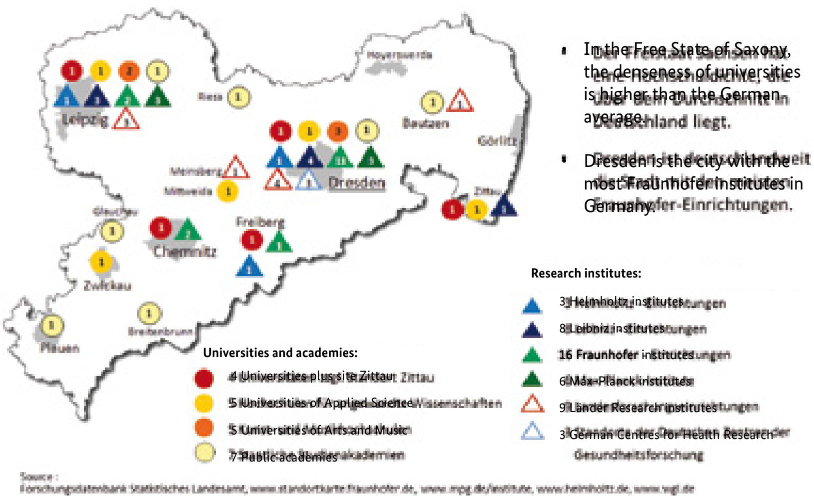
Emphases of research and development measures

- Micro-/nano- optoelectronics
- New mobility / electromobility
- Materials and raw materials technologies
- Health research and medical technology
- Energy research
- Resources technologies
- Environment
- Automotive / mechanical engineering
- Biotechnology
- Selected humanities

Further information is available at:

www.sachsen.de

Science and research landscape – Saxony



Saxony-Anhalt

Structural indicators

State capital: Magdeburg
Area: 20 450.64 km².
Population (in thousands): 2 259.40 (as of: 31 Dec. 2012)
Population density (per km²): 110 (as of: 31 Dec. 2012)
Gross domestic product, nominal (in millions of euros, 2012): 52 810
Gross domestic product, nominal (per capita, in euros, 2012): 22 933
Export ratio (foreign revenue as a share of revenue in the manufacturing
sector, in %, 2012): 26.5

Innovation indicators

Total R&D expenditure (in millions of euros, 2011): 769
Total R&D expenditure (in % of the state's GDP, 2011) 1.49
Government R&D expenditure (in millions of euros, 2011): 274
Government R&D expenditure (in % of the state's GDP, 2011): 0.53
Patent applications (2012): 246
Patent applications per 100 000 inhabitants (2012): 11

Research and science sector

- 2 universities
- 1 college of art
- 4 universities of applied science
- 1 police academy
- 2 privately sponsored universities
- 13 non-university research institutions

Emphases of research and development measures

- Center for Behavioral Brain Sciences / neurosciences
- Forschungszentrum Dynamische Systeme in Biomedizin und Prozesstechnik (research centre for dynamic systems in biomedical and process technology) / systems biology
- Automotive / engineering sciences
- Nanostructured materials / materials science
- Structures and mechanisms of biological information processing / life sciences
- Society and culture in motion / oriental studies
- Enlightenment, religion, knowledge – transformation of religion and rationality into their modern forms / humanities

Further information is available at:

www.sachsen-anhalt.de

The "Lion building" on Universitaetsplatz in Halle

Schleswig-Holstein

Structural indicators

State capital: Kiel
Area: 15 799.61 km².
Population (in thousands): 2 806.50 (as of: 31 Dec. 2012)
Population density (per km²): 178 (as of: 31 Dec. 2012)
Gross domestic product, nominal (in millions of euros, 2012): 77 275
Gross domestic product, nominal (per capita, in euros, 2012): 27 220
Export ratio (foreign revenue as a share of revenue in the manufacturing sector, in %, 2012): 39.3
Innovation indicators
Total R&D expenditure (in millions of euros, 2011): 1 078
Total R&D expenditure (in % of the state's GDP, 2011) 1.43
Government R&D expenditure (in millions of euros, 2011): 248
Government R&D expenditure (in % of the state's GDP, 2011): 0.33
Patent applications (2012): 516
Patent applications per 100 000 inhabitants (2012): 18

Research and science sector

- 3 universities
- 4 universities of applied science
- 1 college of art
- 1 college of music
- 1 university of applied sciences for public administration
- 3 private state-accredited universities
- 10 non-university research institutions
- 1 state research institution
- 18 technology and start-up incubator centres
- 12 centres of competence

Emphases of research and development measures

- Oceanography and geosciences
- Applied life sciences / medicine
- Materials science, nanoscience and surface science
- Humanities, social sciences and cultural studies

Further information is available at:

www.schleswig-holstein.de
www.wissenschaft.schleswig-holstein.de
www.wirtschaft.schleswig-holstein.de

Materials researcher of the Helmholtz Centre for Materials and Coastal Research in Geesthacht test a laser-welded seam for aircraft construction.

Free State of Thuringia

Structural indicators

State capital: Erfurt
Area: 16 172.46 km².
Population (in thousands): 2 170.50 (as of: 31 Dec. 2012)
Population density (per km²): 134 (as of: 31 Dec. 2012)
Gross domestic product, nominal (in millions of euros, 2012): 49 250
Gross domestic product, nominal (per capita, in euros, 2012): 22 241
Export ratio (foreign revenue as a share of revenue in the manufacturing sector, in %, 2012): 30.2

Innovation indicators

Total R&D expenditure (in millions of euros, 2011): 1 081
Total R&D expenditure (in % of the state's GDP, 2011) 2.23
Government R&D expenditure (in millions of euros, 2011): 287
Government R&D expenditure (in % of the state's GDP, 2011): 0.59
Patent applications (2012): 590
Patent applications per 100 000 inhabitants (2012): 27

Research and science sector

- 4 universities
- 4 universities of applied science
- 1 college of music
- 2 private state-accredited universities
- 2 vocational academies
- 5 institutes of the Fraunhofer-Gesellschaft
- 1 Helmholtz institutes
- 5 institutions of the Leibniz Association
- 3 institutes of the Max Planck Society
- 4 state-financed non-university research institutions
- 8 industry-oriented research institutions

Emphases of research and development measures

- Cultural and social change
- Media and communications
- Health research and medical technology
- Microbiology and biotechnology
- Optical technologies, photonics
- Micro-/nano- technologies, microelectronics
- Information and communications technologies
- Materials and production technology
- Environmental and energy technology, infrastructure

Further information is available at:

www.thueringen.de

TU Ilmenau's campus

4 International cooperation in research and innovation

4.1 Internationalisation of science and research

It is only natural for science to have an international orientation. While this has long been the case, the development of communications technologies has considerably accelerated transnational exchange and cooperation. Guiding the rapid ongoing globalisation of the innovation system has thus become a central political task. The success of the German education and research system depends on policy-makers' ability to create a framework for relevant international action that is conducive to science and education and that facilitates development of global knowledge resources. Today, internationalisation is an indispensable basis for excellent research and innovation in Germany. This relationship is substantiated, for example, in that about half of all publications of German scientists are now international co-publications.

The Federal Government has addressed these challenges via its 2008 *Strategy for the internationalisation of Science and Research*. The internationalisation strategy is a core element of German research policy, along with the *High-Tech Strategy*, the *Pact for Research and Innovation* and the *Excellence Initiative*. The Federal Government is making special efforts to integrate German research within a European context, since the creation of the European Research Area (ERA) has made Europe the decisive factor in orientation of the country's international research policy. Joint, concerted action on the part of important EU Member States enhances Europe's visibility and increases its weight with regard to the world's other major regions for innovation. Among programmes that complement national research programmes, the *7th European Framework Programme for Research and Technological Development (Seventh Framework Programme; FP7)* has been the world's largest programme to date. In the programme that has succeeded it, *Horizon 2020* (term: 2014–2020), the total funding volume has been increased to about 77 billion euros.

In addition, Germany has been strengthening its bilateral cooperation with important partner countries around the world. This applies especially to countries with strong growth and significant emerging markets, and it is of strategic importance with regard to access to excellent science and technology resources.

4.2 Objectives and priorities in international cooperation in research and innovation

Over the past few years, the stakeholders in the German science and innovation system have been making special efforts to respond to the continuing growth of global networks linking science, industry and other policy fields and to adapt cooperation with international partners to the applicable new requirements. Such efforts have included both defining concrete objectives and priorities in international cooperation and developing new instruments and forms of cooperation. The Federal Government's 2008 *Strategy for the Internationalisation of Science and Research* has provided an orientational framework for such efforts.

4.3 Germany's role in Europe

Science, research and innovation are key preconditions for the emergence of new ideas addressing major societal challenges and for developing products, services and processes that can succeed in world markets. Innovative solutions safeguard prosperity and create jobs and security for Europe's citizens. With its national funding programmes and organisations, the German science sector makes important contributions to the enhancement and enlargement of research capacities in Europe. The continual growth in the BMBF's expenditures for education and research has significantly supported such contributions.

The EU Member States continue to work for the full realisation of the European Research Area, with the aim of improving competitiveness and increasing employment. As a dynamic partner with an excellent research sector in many areas, Germany is a driving force for such efforts.

The political framework

The Treaty of Lisbon restructured the foundations of European research policy by providing for a first-ever division of responsibility for such policy between the European Union and its Member States. In this context, the *Treaty on the Functioning of the European Union*

(TFEU), which is a part of the Treaty of Lisbon, has readjusted the interrelationships between the national and the European policy-making levels, thereby having a significant impact on integration of research policy at the regional, national and European levels. In addition, the European Union has enshrined the following objective in its primary legislation: to strengthen its scientific and technological foundations by creating a European Research Area in which researchers, scientific knowledge and technology circulate freely. The creation of the European Research Area in particular makes Europe a central determinant for the orientation of the Federal Government's international research policy.

Further information in the Internet
- EU – Treaty of Lisbon: http://europa.eu/lisbon_treaty/full_text/index_de.htm
- Treaty on the Functioning of the European Union: http://dejure.org/gesetze/AEUV/179.html

The Europe 2020 strategy

The *Europe 2020 strategy* provides a strategic framework for European policy. It includes three priorities for growth: smart growth, sustainable growth and inclusive growth. The strategy's central elements, along with resources efficiency and social justice, are innovation and competitiveness. The seven flagship initiatives of the *Europe 2020 strategy* are binding for the EU and its Member States. They define the EU's priorities and objectives in this area through 2020. To support implementation of the flagship initiatives, a system of regular country reports, with country-specific recommendations, has been introduced. The European Commission monitors progress made toward the strategy objectives and promotes relevant exchanges at the political level.

The *Europe 2020 strategy* defines five headline targets and provides suitable indicators for measurement of pertinent progress. One such target is for investment in research and development to reach three percent of GDP.

Further information in the Internet
- European Commission – Europe 2020 strategy: http://ec.europa.eu/europe2020/index_de.htm
- BMBF – Europe 2020 strategy: http://eubuero.de/eu2020.htm

In September 2013, the European Commission introduced an innovation indicator that complements the three-percent target. It measures performance in the Member States in moving "from idea to market". The innovation indicator covers aspects such as technological innovation; the competitiveness of knowledge-intensive goods and services; and employment in knowledge-intensive sectors and in rapidly growing companies in innovative sectors. The new indicator is designed to complete the options available for assessing progress within the Innovation Union flagship initiative. The Innovation Union Scoreboard (IUS) is used to measure progress in implementation of the Innovation Union flagship initiative (cf. Figure 12).

Germany's contribution to the European Research Area

The European Research Area is more than the sum of the relevant activities of the EU's Member States. In an approach driven by the Member States themselves, the EU's organs work to improve the framework conditions for the transnational functioning of the European research sector. With effect as of December 2009, the Treaty of Lisbon (Art. 179 TFEU) enshrines the goal of establishing the European Research Area (ERA) in the EU's primary legislation. The European Research Area will guarantee a number of freedoms similar to the fundamental freedoms of the internal market – freedom of movement for researchers, and the free exchange of scientific findings and technologies.

The EU's multi-year framework programmes for research and innovation, known as *Horizon 2020* as of 2014, are an important instrument in this connection.

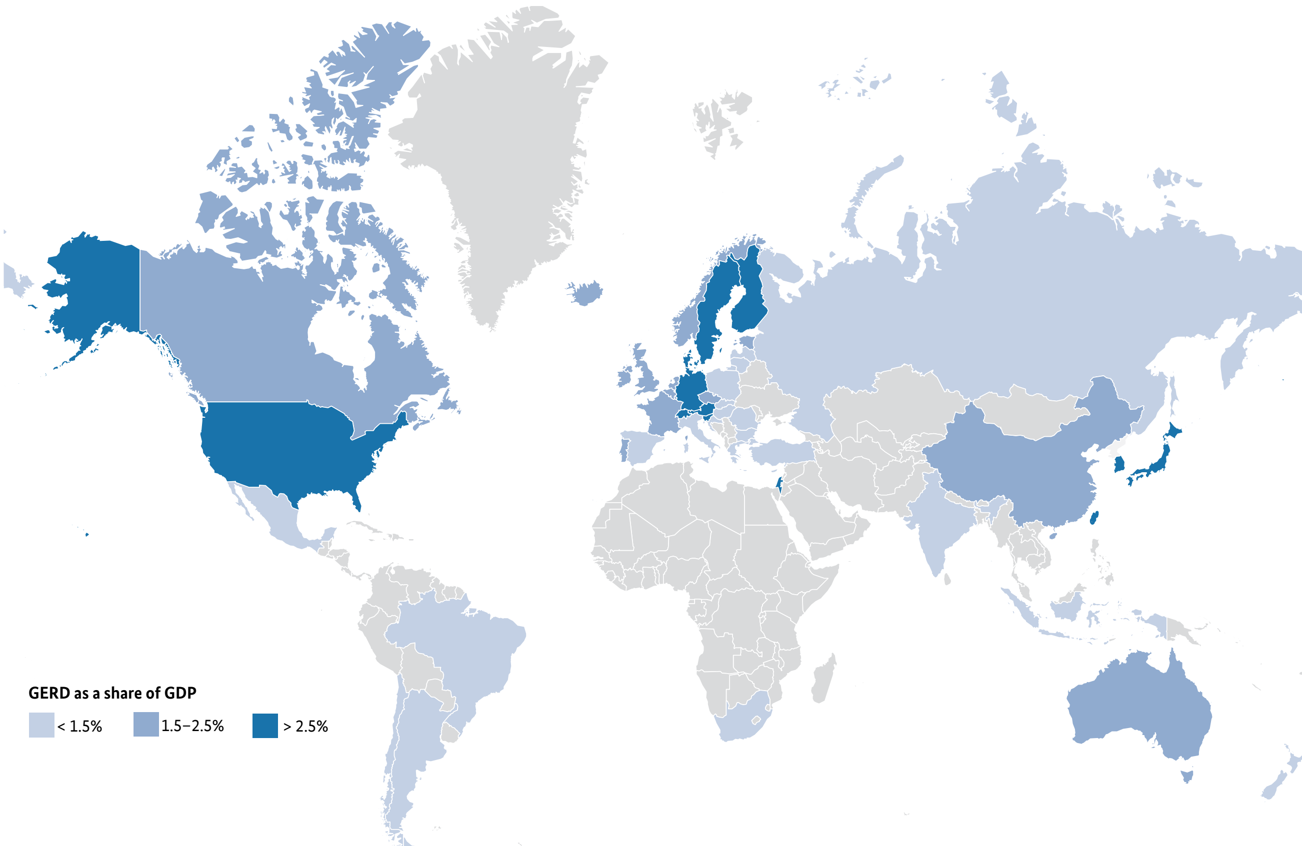
Further information in the Internet
- BMBF – the European Research Area: http://eubuero.de/era.htm
- European Commission – European Research Area: http://ec.europa.eu/research/era/index_en.htm (available only in English)

Horizon 2020 – Strength and resources for Germany's research sector

The new European framework programme for research and innovation, *Horizon 2020*, which was launched in 2014, places the existing Framework Programme for Research, the *European Institute for Innovation and Technology (EIT)*, the Member States' joint programmes and technology initiatives (measures pursuant to Articles 185 and 187 TFEU) and parts of the existing framework programme for innovation and competitiveness within a unified funding programme. For this effort, a funding volume of about 77 billion euros (current prices) is planned for a term of seven years (2014–2020).

The programme's priorities are oriented to benefits for science, industry and society. The programme's main instrument consists of funding of transnational European collaborative research alliances.

Fig. 11 Gross domestic expenditure on research and development (GERD) as a percentage of gross domestic product (GDP) of selected countries, 2012



< 1.5%	
Indonesia[1]	0.08
Chile[2]	0.42
Mexico[3]	0.43
Cyprus	0.47
Romania	0.49
Bulgaria	0.64
Argentina[3]	0.65
Latvia	0.66
Greece	0.69
Croatia	0.75
India[4]	0.76
South Africa[2]	0.76
Slovakia	0.82
Malta	0.84
Turkey[3]	0.86
Poland	0.90
Lithuania	0.90
Russian Federation	1.12
Brazil	1.16
Italy[5]	1.27
New Zealand[3]	1.27
Hungary	1.30
Spain	1.30

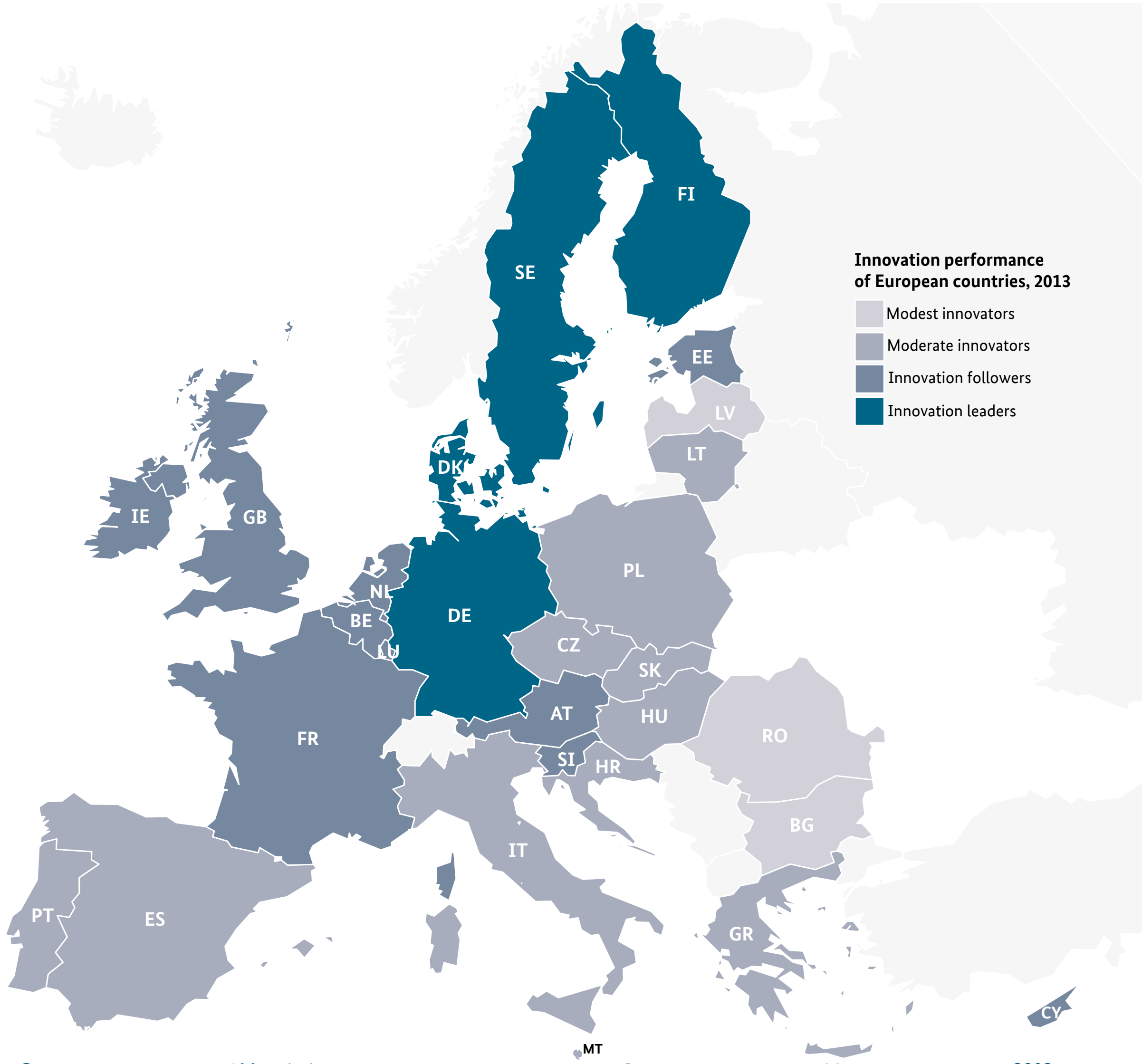
1.5–2.5%	
Portugal[5]	1.50
Luxembourg[2]	1.51
Norway	1.65
United Kingdom[5,6]	1.72
Ireland[6]	1.72
Canada[5]	1.73
Czech Republic[5]	1.88
China	1.98
Netherlands[5]	2.16
Estonia[5]	2.18
Australia[2]	2.20
Singapore[3]	2.23
Belgium[5]	2.24
France[5]	2.26
Iceland[3]	2.40

> 2.5%	
United States	2.79
Slovenia[5]	2.80
Austria[5,6]	2.84
Switzerland[7]	2.87
Germany[6]	2.98
Denmark[5,6]	2.98
Taiwan	3.07
Japan[8]	3.34
Sweden[6]	3.41
Finland	3.55
Israel[9]	4.20
Korea[8]	4.36

[1] Information for Indonesia from 2009
[2] Information for Chile, South Africa, Luxembourg and Australia from 2010
[3] Information for Mexico, Argentinia, Turkey, New Zealand, Singapore and Iceland from 2011
[4] Information for India from 2007
[5] Provisional
[6] National estimate or projection
[7] Information for Schwitzerland from 2008
[8] Estimate by the secretary's office or projection based on national sources
[9] Israel: not including defence expenditure

Database: OECD Main Science and Technology Indicators 2013/2, Eurostat Statistics Explained (2014/1/1), DESTATIS Länderprofile, Weltbank Länderdaten zu Science & Technology, VDI/VDE-IT

Fig. 12 Innovation performance of European countries, 2013



Country	Abbreviation	2013
Belgium	BE	0.63
Bulgaria	BG	0.19
Denmark	DK	0.73
Germany	DE	0.71
Estonia	EE	0.50
Finland	FI	0.68
France	FR	0.57
Greece	GR	0,38
Ireland	IE	0.61
Italy	IT	0.44
Croatia	HR	0.31
Latvia	LV	0.22
Lithuania	LT	0.29
Luxembourg	LU	0.65

Country	Abbreviation	2013
Malta	MT	0.32
Netherlands	NL	0.63
Austria	AT	0.60
Poland	PL	0.28
Portugal	PT	0.41
Romania	RO	0.24
Sweden	SE	0.75
Slovakia	SK	0.33
Slovenia	SI	0.51
Spain	ES	0.41
Czech Republic	CZ	0.42
Hungary	HU	0.35
UK	GB	0.61
Cyprus	CY	0.50

Comment: The 2013 indicator value for a country is calculated based on a total of 25 R&D-relevant individual indicators and refers to the years 2011/2012. The best possible value is 1 and the lowest-possible value is 0. The innovation leaders are the countries with values at least 20% higher than the EU-27 average. Innovation followers have values in the range from 10% below the average to 20% above the average. Moderate innovators have values in the range from 10% below the average to 50% below the average. Modest innovators have values that are more than 50% below the EU-27 average.
Database: Innovation Union Scoreboard 2014, Annexe E; VDI/VDE-IT

Further information in the Internet

- BMBF – Horizon 2020: www.horizont2020.de
- EU bureau of the BMBF: www.eubuero.de
- European Commission – Horizon 2020: http://ec.europa.eu/programmes/horizon2020/en/

4.4 Priorities in bilateral and multilateral cooperation in Europe

Cooperation with European countries is of central importance for Germany. This is seen in the country's international co-publications, for example. Over one-third of them are written together with European partners, while nearly 15% (second place) are written together with U.S. partners and far fewer are written with partners from Canada (3.1%) and China (also 3.1%).

Joint initiatives and identified topics of joint interest – especially in the context of the themes of the Federal Government's *High-Tech Strategy* and of the thematic priorities of the EU's *Horizon 2020* framework programme for research and innovation – strengthen European strategy development and promote the shaping of the European Research Area. In addition, such activities help promote the implementation of Germany's internationalisation strategy.

To strengthen cooperation with European partners, the BMBF promotes networking and research collaboration, takes part in international trade fairs and sponsors research and innovation forums in cooperation with partner countries (such as Poland, France and Switzerland).

France is Germany's most important European partner. At the government level, the two countries coordinate their bilateral cooperation via Franco-German Councils of Ministers. Germany also cooperates with Poland, Greece and Switzerland (one of the world's most innovative countries). Other relevant initiatives and programmes are oriented to the Danube region, the Baltic Sea region and to Central Eastern Europe and South Eastern Europe.

4.5 Worldwide cooperation

Germany's research policy is aimed at making Germany especially visible in countries with strategically significant science and technology resources. This applies especially to countries with vigorous growth and key emerging markets. In most cases, such bilateral cooperation is based on a jointly signed agreement on science and technology cooperation. Increasingly, however, it can also be founded on bilateral intergovernmental consultations in which education and research play an important role.

According to its shared global responsibility, Germany is also working to integrate its know-how and research / science capabilities within relevant international organisations (such as the OECD, G8, Carnegie Group and the UN), programmes and initiatives, and thereby to contribute to the solution of global problems.

4.5.1 Cooperation with industrialised countries and BRICS countries

In many research areas, Germany now cooperates with BRICS countries at the same level at which it cooperates with fully industrialised countries. The portfolios of instruments applied to such cooperation are similar for both groups, but they differ considerably from those used in cooperation with developing countries and other emerging countries, which tend to emphasise capacity-building.

Cooperation with industrialised countries

Germany has a long tradition of cooperation with industrialised countries. In most cases, such cooperation is carried out by the relevant players in science and research themselves. The role of policy-makers in such efforts mainly consists not of providing financial support, but of adapting the framework for cooperation to the applicable requirements in each case – for example, by signing, in the context of bilateral intergovernmental consultations, joint declarations of intent or by adopting suitable laws.

Such an approach applies especially to Israel. Israeli-German cooperation is especially diverse and dynamic, and of historically special significance. In addition, Germany cooperates with the United States, Canada, Japan (one of its most important cooperation partners worldwide), Australia and South Korea.

Cooperation with BRICS countries

Over the past decade, many newly industrialised countries have invested heavily in the expansion of their innovation systems and, at the same time, significantly increased their economic potential. This applies especially to the so-called BRICS countries (Brazil, Russia, India, China, South Africa).

The BMBF's largest investments in the area of cooperation with BRICS countries are aimed at the cooperation with China (18.5 million euros per year, as of 2012). Russia, at a level of about 10.1 million euros, ranks next in this category. On the other hand, India has registered the largest funding increases in this area over the past five years: investments in cooperation with India have grown more than sixfold since 2008 (from 1.4 to 8.7 million euros). The increases are due to the establishment of the *Indo-German Science & Technology Centre (IGSTC)*, which has brought a new dimension to the cooperation via the financing of major projects, as well as to the intensification of activities in thematic programmes. Over the same period, investments in cooperation with South Africa have nearly doubled (from 1.4 to 2.5 million euros) since the G8 summit in Heiligendamm intensified the global focus on Africa.

4.5.2 Cooperation with emerging and developing countries

Germany's science and research cooperation with emerging and developing countries builds on such countries' resources and strengths in light of Germany's interests – in the sense of mutual benefit, for example, capacity-building in such countries can go hand-in-hand with German access to resources and with global dissemination of accepted scientific standards.

By training researchers and improving their researchers' qualifications, and by strengthening their scientific infrastructures, emerging and developing countries become able to participate, as equal partners, in the global science community and in efforts to solve global challenges. They thus become able to contribute to achieving the United Nations' Millennium Development Goals.

While, for political reasons, such cooperation has tended to focus on Africa, Asia and Latin America becoming increasingly important.

Further information in the Internet

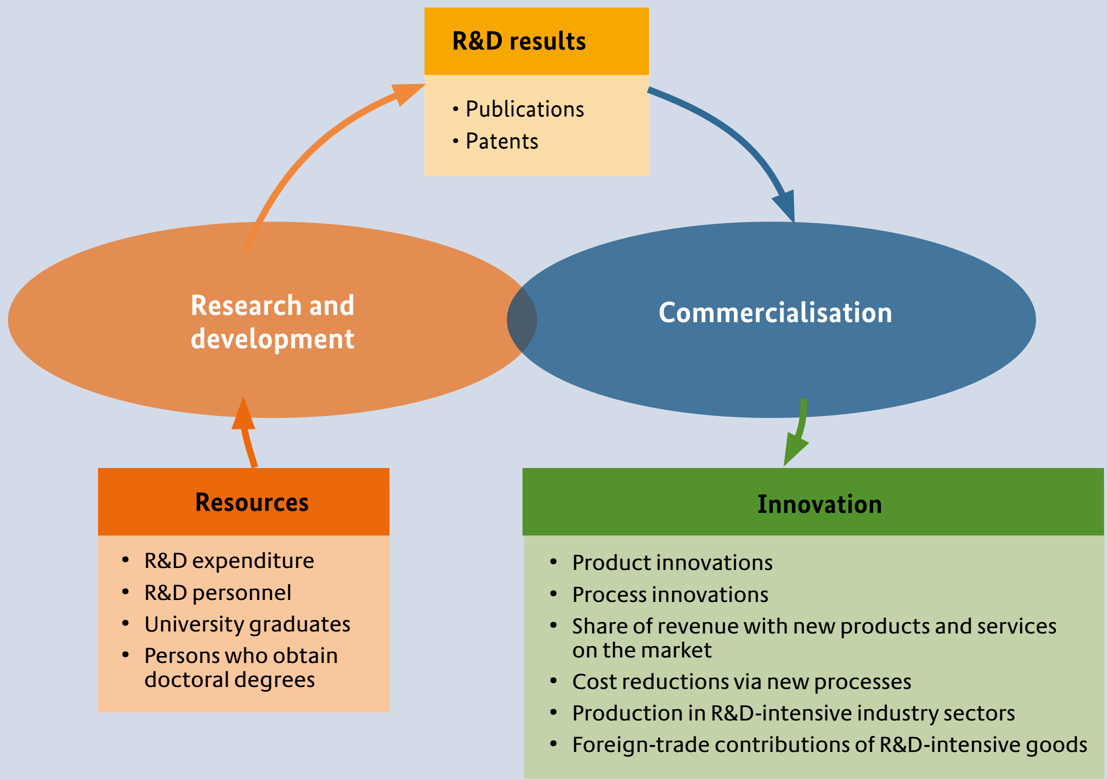
- BMBF – Cooperation with Mediterranean and African countries: www.bmbf.de/de/1563.php
- BMBF – Cooperation with Central and South America: www.bmbf.de/de/5281.php

5 Facts and figures about the German research and innovation system

The selected data on the German research and innovation system (R&I system) are oriented to three areas: 1) the resources invested in research and development (R&D) (funding, personnel); 2) the relevant R&D findings (publications, patents); and 3) the successes achieved through commercialisation of innovations.[1] If R&D is to be possible, suitable resources[2] – financial and/or human resources – must be provided to R&D institutions, such as R&D institutions at universities, science and research institutes, or R&D institutions of private industry. One key resource are graduates who complete technical or scientific courses of study, including courses leading to doctoral degrees.

The results of R&D processes are scientific findings and discoveries, and technical inventions. They can be commercialised. Usually (private) commercialisation tends to be the option considered for new products or production processes. In addition, such results can be used to generate value in a political, social or cultural context.

Fig. 13 Selected indicators for the German research and innovation system



Source: VDI/VDE-IT

In the case of scientific findings and discoveries, R&D results[3] can be described in terms of numbers of pertinent scientific publications. In the case of tech-

1 In the abstract innovation model shown in the figure, the areas "Research and development" and "Commercialisation" overlap slightly. This is intended to indicate that, in reality, the two process areas tend to meld. It is not always possible to determine whether a given substep (such as a step in prototype construction) is still "research and development" or should be assigned to the realm of "commercialisation".

2 In the international literature, such resources are also referred to as "inputs".

3 In the international literature, such R&D results are referred to as "throughputs", because they are neither inputs nor outputs.

nical discoveries, they can be described in terms of numbers of patents applied for or received. At the same time, it should be noted that not every finding or result leads to a publication or patent. In many cases, companies resort to other types of strategies for protecting their intellectual capital – for example, secrecy policies. Other forms of outputs, in addition to numbers of publications, are applied in describing the science sector. Nevertheless, intellectual property rights play a role here as well.

A successful R&D process terminates in successful innovation, in market-ready commercialisation of R&D results by industry and society. The indicators considered in this area include the percentage share of companies that have implemented product, process or other innovations within a certain period. They also include the ratio of innovation-related expenditure to revenue.

Info box

Availability of data

As a rule, this chapter uses data from the years 2011 and 2012. In some cases, it uses data and estimates for 2013. The primary data sources include the international statistics databases of the Organisation for Economic Co-operation and Development (OECD) and the statistical office of the European Union (Eurostat). These data are supplemented with data of the Federal Ministry of Education and Research (BMBF), the Federal Statistical Office, the German Central Bank (Bundesbank), the European Patent Office, the Wissenschaftsstatistik gGmbH within the Donors' Association for the Promotion of Sciences and Humanities in Germany and the Centre for European Economic Research (ZEW)). In addition, data from studies of the Commission of Experts for Research and Innovation (EFI) on the German innovation system are used.

Info box

The BMBF's data portal

The BMBF's new data portal, located at www.datenportal.bmbf.de, presents a wealth of facts and figures about science, research, development, innovation and education. Along with the tables found in Part II E of the Federal Report on Research and Innovation, it also includes extensive data on education and science. While the data portal presents the tables used in the Federal Report on Research and Innovation, the portal versions of the tables are considerably more detailed, and have longer time series.
The time series in the BMBF's data portal cover spans from current figures to historical data – in some cases, they go back to the 1960s. Additionally the figures are accompanied by international comparisons. The portal's database is updated at half-yearly intervals.
Along with specific information about the various education and research areas involved, the BMBF's data portal also presents data on pertinent expenditures of the Federal Government and the *Länder*. The portal's statistics on research and development include statistics on government and industry research expenditure, R&D personnel and patents. They also include indicators relative to innovation behaviour. The portal's education statistics include statistics on the primary school sector, kindergartens, daycare centres, other types of schools, universities (including students and staff), advanced training and relevant funding *(BAföG, Meister-BAföG)* for education and training.
The portal database is fully searchable by selected key words, and it can be navigated via its thematic structure. An alphabetically arranged glossary presents explanations of important terms and abbreviations. Search results can be output in various formats (HTML, PDF, Excel) and downloaded for further use.
All of the tables included in the Federal Report on Research and Innovation are available in the portal (www.datenportal.bmbf.de), in a range of different formats, and in their latest updated versions.

5.1 Resources

5.1.1 Financial resources

Basic data on expenditure for science, research and development

Research and development (R&D) expenditure consists of the financing of "creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications".[4] In contrast to "science expenditure", R&D expenditure does not include expenditures for science teaching and education and for other science-related activities (such as scientific and technical information services).

Gross Domestic Expenditure on Research and Development (GERD)[5] is a key indicator used in international comparisons of the R&D efforts of different countries. In absolute figures, between 2005 and 2011 Germany's GERD figures increased from 55.7 billion euros to 75.5 billion euros, or by approximately 36 %. A further increase, to 79.4 billion euros, is expected for 2012.

An especially important metric in this connection is GERD as a percentage share of gross domestic product (GDP). Since the formulation of the Lisbon strategy in 2000, the EU has been striving to reach an R&D-investment level of three percent of GDP.[6] The EU's three-percent goal has been explicitly enshrined in Europe 2020, the new European growth strategy. What is more, the core elements of the strategy, which was adopted in June 2010 by the European Council, include further improvement of conditions for R&D. (cf. also Chapter II 4.4, Europe 2020 strategy)

All in all, according to current calculations, GERD in Germany reached an estimated 2.98 %[7] of GDP in 2012. As a result, Germany has practically achieved the three-percent goal. This GERD/GDP figure is the highest ever measured since German reunification (Figure 2, p. 7). While in 2000, it amounted to 2.47 %, it has been markedly increasing especially since the year 2008. →Table 1

Contributions to GERD, in the individual sectors in which R&D is carried out, can differ widely. In 2011, the private sector's R&D funding accounted for 67.7 % of total GERD. This value refers to the total sum of all expenditure on R&D carried out in industry, including expenditure by domestic industry itself, the government, private non-profit institutions and by funding providers abroad.

With regard to the sectors that perform R&D, in 2011 the private sector, at a level of 51.1 billion euros, received the largest share of available R&D funding. Only comparatively small shares of that amount were provided by government and by funding providers abroad. The government sector (including private non-profit institutions) invested about 11.0 billion euros on research and development, while the higher education sector invested 13.5 billion euros. Basically, both sectors are financed by government (the state). →Table 1

The great importance of the private sector also becomes apparent when one considers the ways in which R&D is financed in the Federal Republic of Germany. In 2011, the private sector contributed about 49.6 billion euros, or about two-thirds of GERD. This figure refers to the total financial expenditure by the private sector, regardless of where the relevant R&D was performed: in the private sector itself, or in state, non-profit or public institutions such as universities. The figure is very high, when compared internationally, and is considered typical for the German research and innovation system.

After stagnating in the first half of the last decade, R&D expenditure by the private sector developed very briskly again from 2005 to 2012. A consideration by economic sectors shows that the automotive, electrical engineering (including IT equipment and optics) and the chemical and pharmaceutical industries have especially high R&D expenditures (Figure 14).

Federal expenditure on research and development

The Federal Government's financing of R&D expenditure increased from nine billion euros in 2005 to 13.5 billion euros in 2012. In 2013, federal R&D expenditure increased still further, to 14.5 billion euros (target), and R&D expenditure of about 14.4 billion euros (1st government draft budget) is planned for 2014.[8]

The Federal Ministry of Economics and Technology (BMWi)[9], the Federal Ministry of Defence (BMVg) and the Federal Ministry of Education and Research

4 Cf. Frascati Manual 2002, OECD, Art. 63, p. 30.

5 The term "Gross Domestic Expenditure on Research and Development (GERD)" is used internationally.

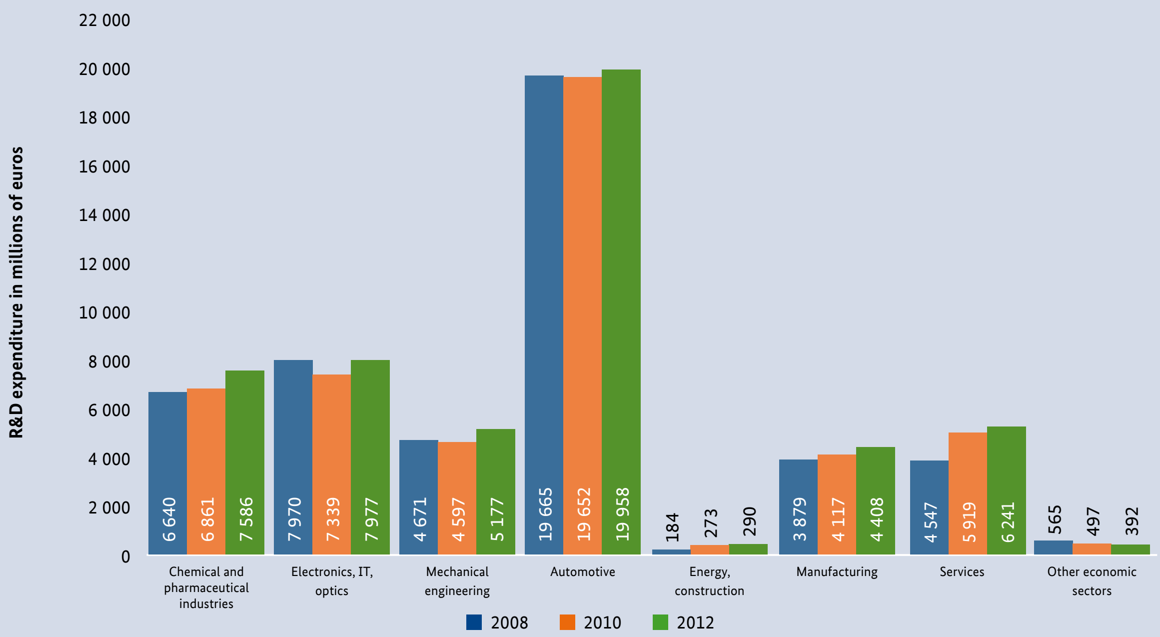
6 This goal was approved as part of the Lisbon Strategy, which was adopted by the European Heads of State and Government at a special summit held in Lisbon in March 2000. The strategy is aimed at lasting economic growth, including job growth and greater numbers of better quality jobs, and greater social cohesion.

7 Calculations of the BMBF

8 For 2010 and 2011, for the first time including the special investment and repayment fund *(Investitions- und Tilgungsfonds)* (not including *Länder* allocations). For 2011 and 2012, including the energy and climate fund *(Energie- und Klimafonds),* to which all electromobility-related expenditures of all departments (inter alia) are allocated as of 2012. The Federal Government's R&D expenditures also include the R&D expenditures of the Federal Government's departmental research institutions.

9 The departmental divisions and designations are in keeping with the Federal Government's organisational structures as of the 17th legislative period.

Fig. 14 Breakdown of intramural R&D expenditure by economic-activity classification, 2008–2012



Database: Data report of the Donors' Association for the Promotion of Sciences and Humanities in Germany, Table 23 (cf. long version, in German only); calculations of VDI/VDE-IT

(BMBF) together account for 85.3 % of the Federal Government's relevant total expenditures planned for 2014. The other departments account for the remaining 14.7 %. The BMBF accounts for about 59 % of the Federal Government's R&D expenditure. **→Table 4**

The breakdown of R&D expenditure by funding areas and funding priorities, in tables 5 to 7 , is based on the Federal Government's R&D planning system *(Leistungsplansystematik)*. It classifies R&D expenditure in terms of research topics, irrespective of the financing government department. For the first time, the institutional funding for non-university research institutions has also been distributed completely among R&D-planning system *(Leistungsplansystematik)* categories.[10] **→Table 5**

The Federal Government finances research and development primarily in the framework of institutional funding, project funding and departmental research. In 2012 (actual), institutional funding accounted for a 44.3 % share of the Federal Government's R&D expenditure (target for 2013: 43.1 %), while project funding, including departmental research, accounted for 46.2 % in 2012 (actual). Project funding, including departmental research, comprises both project-oriented funding and expenditure for contracts within the framework of departmental/ministerial and defence R&D. **→Table 6**

The breakdown of the Federal Government's R&D expenditure by recipient groups provides an overview of the way in which the funding is distributed among the relevant individual sectors – including government and municipal institutions, non-profit organisations and the private sector.[11]

- In 2012 (actual), non-profit organisations (including the DFG, Max Planck Society [MPG], Fraunhofer-Gesellschaft [FhG], Helmholtz Association of German Research Centres [HGF] and the Leibniz Association (WGL) [Leibniz]) received 53.3 %, or the largest share, of the Federal Government's R&D expenditure.
- The second largest share, 16.0 %, was allocated to the private sector.
- While regional authorities' share of the Federal Government's R&D expenditure amounts to 21.0 %, that figure consists of 8.1 % for the Federal Government[12] and 12.9 % for the *Länder* and municipalities. The majority of funding provided to the *Länder* goes to universities (11.4 %).

10 Previously, the institutional funding for the DFG, FhG and MPG was combined under category TA, "Basic financing of research institutions" ("Grundfinanzierung von Forschungseinrichtungen").

11 Financing includes both basic funding for institutions and other types of funding. Funding forwarded by institutions to third parties, for research purposes, is not included; i.e. the "initial recipient" principle is applied.

12 A 7.4 % share of the Federal Government's expenditure goes to federal institutions with research tasks.

Table E1 Project funding of the Federal Government that goes directly to, or for the benefit of, SMEs, pursuant to the national and EU definitions for SMEs (in millions of euros)

Year	Total for Federal Government	Technology-specific programmes of the Federal Government[1]	Technology-open programmes of the BMWi, not including additional funding from the stimulus package II (Konjunkturpaket II)[2]	Total for Federal Government
	to SMEs	to SMEs	for the benefit of SMEs	to, or for the benefit of, SMEs
	EU definition	nat. definition		
2007	249	306	477	783
2008	293	368	562	930
2009	366	455	646	1 101
2010	419	500	654	1 154
2011	456	543	693	1 236
2012	469	515	825	1 340
2013	491	564	862	1 426

1) Not including Federal Ministry of Defence (BMVg)
2) Of this funding, at least 50 % goes directly to SMEs. The remaining funding goes to research institutions – usually in the context of cooperation projects with SMEs that directly benefit the participating SMEs. As a rule, conformance with the EU's SME definition is required as a prerequisite for funding eligibility. The funding from the stimulus package II (Konjunkturpaket II) in the framework of the Central Innovation Programme for SMEs (ZIM), amounted to 53 million euros in 2009, 320 million euros in 2010 and 397 million euros in 2011.
Sources: The values for the category "to SMEs" have been taken from the "profi" project funding database.

Of the Federal Government's expenditure for research and development in the framework of project funding and departmental research, one-third goes to non-profit organisations, one-fifth goes to universities and more than one-third goes to recipients in the private sector. In the period 2009 to 2012, the share for recipients in the private sector decreased (from 41.4 % to 36.5 %), while the higher education sector experienced an increase in its share of the Federal Government's project funding and departmental research (from 17.3 % to 21.5 %).

In 2012, Federal Government R&D expenditure in the amount of 2,712.7 million euros was allocated to the private sector. This figure breaks down as follows:

- 532.2 million euros (23 %) were provided by the BMBF
- 496.6 million euros (22 %) were provided by the BMVg
- 918.4 million euros (40 %) were provided by the BMWi.

Small and medium-sized enterprises (SMEs) receive a disproportionately high share of the Federal Government's funding in this area. In 2013, the Federal Government's project funding that went directly to, or to the benefit of[13], small and medium-sized enterprises (SMEs)[14], in research and innovation, amounted to more than 1.4 billion euros (2012: more than 1.3 billion euros).

Of this amount, 862 million euros came from the BMWi's technology-open programmes for the benefit of SMEs, with about half of the funding going directly to SMEs. Taken together the funding programmes of all departments (not including the Federal Ministry of Defence (BMVg)) overall 564 million euros went directly to SMEs, with nearly 90% of that amount coming from the BMBF and BMWi. With regard to the BMBF's funding programmes, the amount involved here represents about half of the funding available for companies. As a result, the Federal Government's project funding directly to SMEs increased sharply with respect to the relevant 2007 levels. →Table E 1

The eastern German *Länder*, including Berlin, accounted for about one quarter (26 %, 3.2 billion euros)

13 The expression "to the benefit of SMEs" is a description of the actual results of the relevant BMWi allocation categories in so-called technology-open programmes (such as the Central Innovation Programme for SMEs (ZIM)). Of that funding, at least 50 % goes directly to SMEs. The remaining funding goes to research institutions – usually in the context of cooperation projects with SMEs that directly benefit the participating SMEs.

14 The term "SME" is commonly defined in various ways. For many years, the Federal Government has used a specific national definition for its own statistical purposes. That definition, while based on the criteria for the pertinent EU definition, applies additional restrictions: revenue of no more than 100 million euros (EU: 50 million euros) and no more than 50 % (EU: 25 %) ownership by other large companies.

of the R&D financed within Germany by the Federal Government in 2012.

Of the Federal Government's expenditures on science, research and development in 2012, amounting to about 13.47 billion euros, a full 91.3 % remained within the country. Of the funding that went abroad, an amount totalling about 1,176.8 million euros, the largest share, about 971.0 million euros, consisted of contributions to international scientific organisations and intergovernmental research organisations.

Länder expenditures on research and development

Länder expenditures on science, research and development primarily benefit the higher education sector, either as basic funding for university research and teaching or as third-party funding, via the *Länder* share of funding for the German Research Foundation (DFG) and for support of graduate students (Graduiertenförderung). In addition, joint Federal/*Länder* research funding plays a significant role. This includes funding for institutions of the Max Planck Society (MPG), the Fraunhofer-Gesellschaft (FhG), the Hermann von Helmholtz Association of German Research Centres (HGF), the Leibniz Association and the *Academies Programme*. Other beneficiaries of *Länder* science and research funding include *Länder* and local government institutions performing scientific and research activities and the private sector, which receives public funds under research, technology and innovation funding programmes. In 2011, *Länder* and municipalities spent some 23.5 billion euros on science, research and development. This value represents a slight increase over previous years. The share contributed by eastern German *Länder* (including Berlin) to total *Länder* science expenditures amounted to 21.4% in 2011.

The great majority – 86.3 % – of the science expenditures (more precisely: basic funding for the science sector) of the *Länder* and municipalities in 2011 went to the higher education sector, including university hospitals, while 13.7 % was allocated to science and research institutions outside of the higher education sector. The expenditure share for universities thus remained nearly constant in comparison to previous years.

The R&D expenditures of the *Länder* (not including the municipalities) in 2011 amounted to about 10.2 billion euros, up from about 9.7 billion euros in the previous year. The *Länder* share of the total R&D expenditures of the Federal Government and the *Länder* amounts to 43.3 %. The trend for this figure is slightly decreasing. At the end of the last decade, it was about 45.9 %. →**Table 2**

In 2011, the *Länder* that made the largest contributions to the *Länder* expenditures were North Rhine-Westphalia (19.8 % of the *Länder* share), Bavaria (16.7 %) and Baden-Württemberg (14.4 %).

Figure 3, p. 7 shows the changes in R&D expenditures of the Federal Government and the *Länder* over time. Considerable growth in the figures for both the Federal Government and the *Länder* is apparent, especially in the most recent data.

Joint research funding by Federal and *Länder* governments

In 2011, the Federal Government and the *Länder* jointly spent some 23.4 billion euros on research and development; as a result, government financed 31.2 % of all R&D expenditures in Germany. About one-third (33.3 %) of this government R&D expenditure consists of basic funding for institutions, which is shared by the Federal and *Länder* governments as joint research funding. →**Table 2**

Most of the funding provided via the joint research funding of the Federal Government and the *Länder* is allocated to the basic financing (institutional funding) of the science and research organisations MPG, HGF, Leibniz and FhG, and of the DFG, a research funding organisation. Total joint research funding for these institutions amounted to 7.8 billion euros in 2012. Of these total expenditures, two-thirds were made by the Federal Government. At the same time, it is important to note that Federal and *Länder* financing shares differ from institution to institution.

Resources of higher education institutions

Higher education institutions make up the third major sector – in addition to the private sector and non-university research institutions – that carries out research and development. A special aspect of higher education institutions is that their research and teaching are closely linked; as a result, it is sometimes difficult to consider these two task areas separately.[15]

In 2011, higher education institutions spent some 13.4 billion euros on R&D. This figure represents 44.6 % of higher education institutions' total expenditures on teaching and research (30.1 billion euros). From 2000 to 2011, R&D expenditure at higher education institutions increased by 65.4 %. Higher education institutions accounted for 17.8 % of R&D performance in Germany in 2011.

Higher education institutions' R&D expenditures are borne predominantly by the government sector (the Federal Government and the *Länder*) (in 2011, to

15 R&D expenditures of higher education institutions are determined using so-called R&D coefficients, on the basis of such institutions' total expenditures. Other factors to consider include numbers of students, numbers of examinations taken and work-time budgets of staff. Pursuant to the OECD's adopted criteria for R&D statistics, the higher education sector does not include so-called An-Institute (attached institutes), which are closely linked to the relevant universities in various ways, while still existing as legally autonomous institutions.

a degree of 81 %). Third-party funding, as a share of all R&D expenditures at higher education institutions, has increased considerably. In 2011, third-party funding accounted for a share of 47.8 % (corresponding to 6.4 billion euros), up from 36 % (3.1 billion euros) in 2001. As a result, third-party funding for higher education institutions more than doubled during that period. →Table 1

5.1.2 Personnel resources

R&D personnel

In 2011, a total of nearly 575 000 persons (full-time equivalents[16]) were employed in R&D in Germany. This figure represents an increase of about 90,000, or over 18 %, over the corresponding figure in 2000. →Table 9

In addition to researchers, the listed figures include groups of persons that carry out technical (such as facility management) or other supporting tasks (such as secretarial services) for the actual research work involved. In 2011, scientific R&D personnel – researchers – accounted for 59 % of total R&D personnel.[17] Following a slight increase at the beginning of the past decade, that percentage share has remained nearly constant since 2004. →Table 9

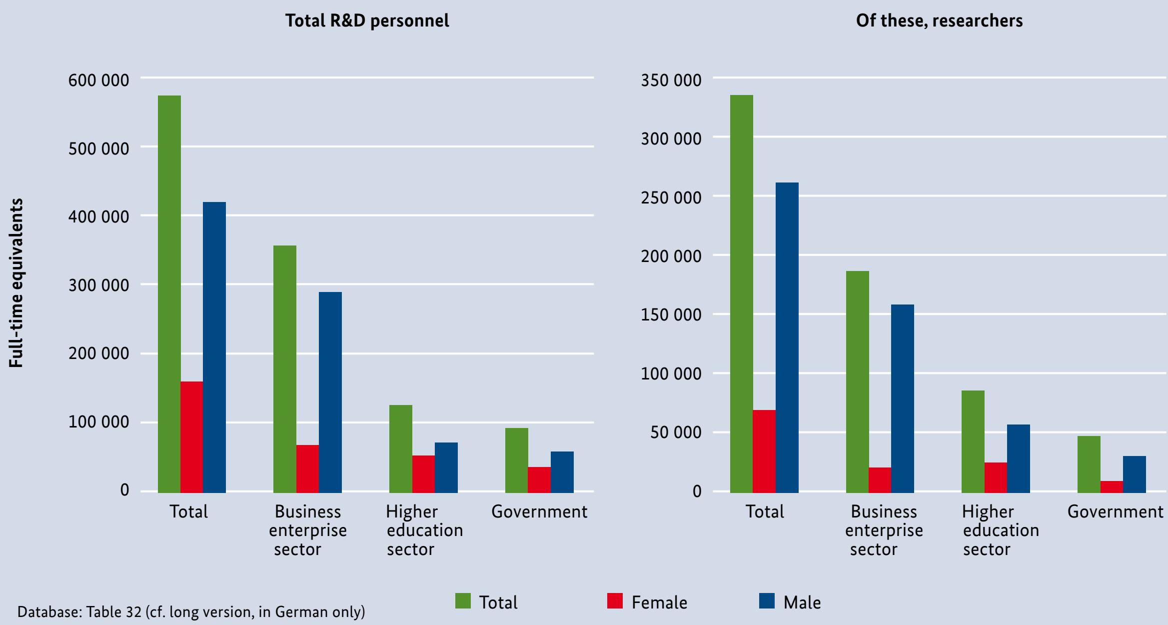
As Figure 15 clearly shows, women are underrepresented among R&D personnel. Of the nearly 575 000 persons employed in R&D in 2001, only about 157 000, or somewhat more than 27 %, were women. This means that numbers of women in R&D, as a percentage of total R&D personnel, have risen slightly since 2000 (24 %). Sectors differ markedly in terms of their levels of female staff, however. Whereas in 2011 women accounted for nearly 42 % of the total R&D workforce in higher education institutions, and for 39 % of R&D personnel in non-university research institutions, they only accounted for slightly more than 19 % of the private sector's R&D workforce.

The various sectors also differ markedly with regard to highly qualified persons. Of the some 339 000 researchers in Germany, about 75 000, or 22 %, are female. This percentage has thus increased considerably since 2000 (14 %). The largest percentage increases in this category have occurred in the higher education sector

16 One advantage this indicator has over R&D expenditure is that in comparisons over time, inflation effects do not play a role; likewise, in international comparisons differences in purchasing power do not have any impact. To eliminate the effects of part-time employment, numbers of R&D personnel are expressed as full-time equivalents. This method also reflects the fact that many persons included in "R&D personnel" perform both research and teaching, especially at higher education institutions. The proportion of work accounted for by research is determined by means of R&D coefficients, using a procedure agreed upon by the Federal Ministry of Education and Research (BMBF), the Standing Conference of the Ministers of Education and Cultural Affairs of the *Länder* in the Federal Republic of Germany, the Federal Statistical Office and the German Council of Science and Humanities *(Wissenschaftsrat).*

17 The applicable share for scientific R&D personnel is estimated on the basis of formal qualifications (higher education degrees). Qualification is not the decisive criterion in this classification of R&D personnel, by type of occupation. At the same time, researchers may generally be assumed to also be university graduates.

Fig. 15 R&D personnel by gender, broken down by sectors and personnel groups, 2011



Database: Table 32 (cf. long version, in German only)

(24 % to 34 %) and in the government sector (25 % to 31 %), while the corresponding percentage for women has changed only slightly in the private sector (an increase from 11 % to 14 %).

The various scientific fields within the higher education sector differ considerably in terms of the percentages of their researchers who are women. In 2011, the highest percentages of women, as shares of all highly qualified research personnel, were seen in the fields of medicine (51 %) and agricultural sciences (48 %). By contrast, the engineering sciences, in which women account for a total of only 18 % of all researchers, continue to be a male-dominated field. On the other hand, it is clear that in all scientific and academic areas the numbers of women in research at higher education institutions, expressed as percentages of all highly qualified research personnel, have increased continually since 2000. → Table 1.7.6 The BMBF's data portal

Young researchers: university degrees, including doctoral degrees

Graduates of higher education study programmes are of course a key resource with regard to the future of R&D. Over the past few years, the trend in this area has been positive, as Figure 16 illustrates. The number of such graduates increased from 198 000 in 2005 to a record level of 310,000 in 2012. In 2005, nearly 20 % of a given age cohort completed their education with a university degree. In 2012, the corresponding figure was nearly 31 %.

In the interest of overall technological progress, and the development of new and emerging markets, it is vitally important to ensure that enough young people complete studies in the areas of mathematics, information sciences, natural sciences and technology (also referred to as "MINT" fields).

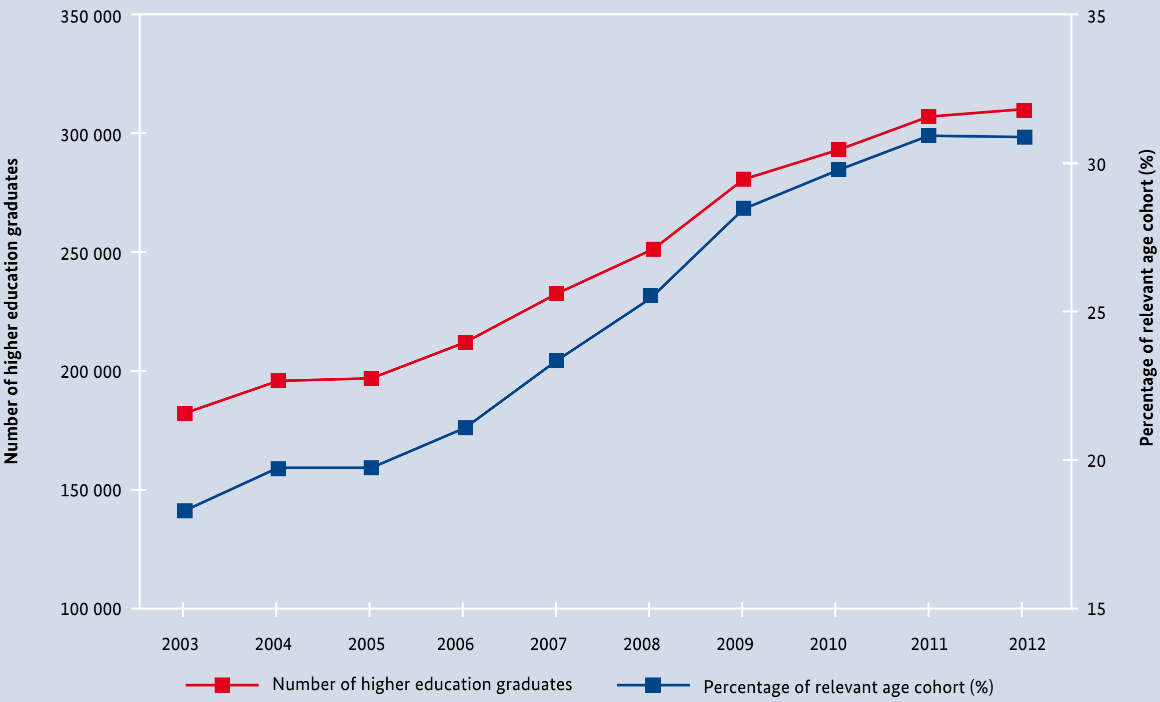
Figure 17 shows the numbers of MINT graduates as absolute numbers (left scale) and as percentages of the applicable age cohorts (right scale).

Since 2005, following a phase of stagnation, the number of graduates in engineering sciences has increased by a full 27 000 persons, or nearly 80 %.

During the same period, the increase in graduates in mathematics and natural sciences, expressed in absolute figures, was also highly pronounced – more than 18 000 persons, or about 60 %. This increase represented an intensification of a positive trend seen in earlier years.

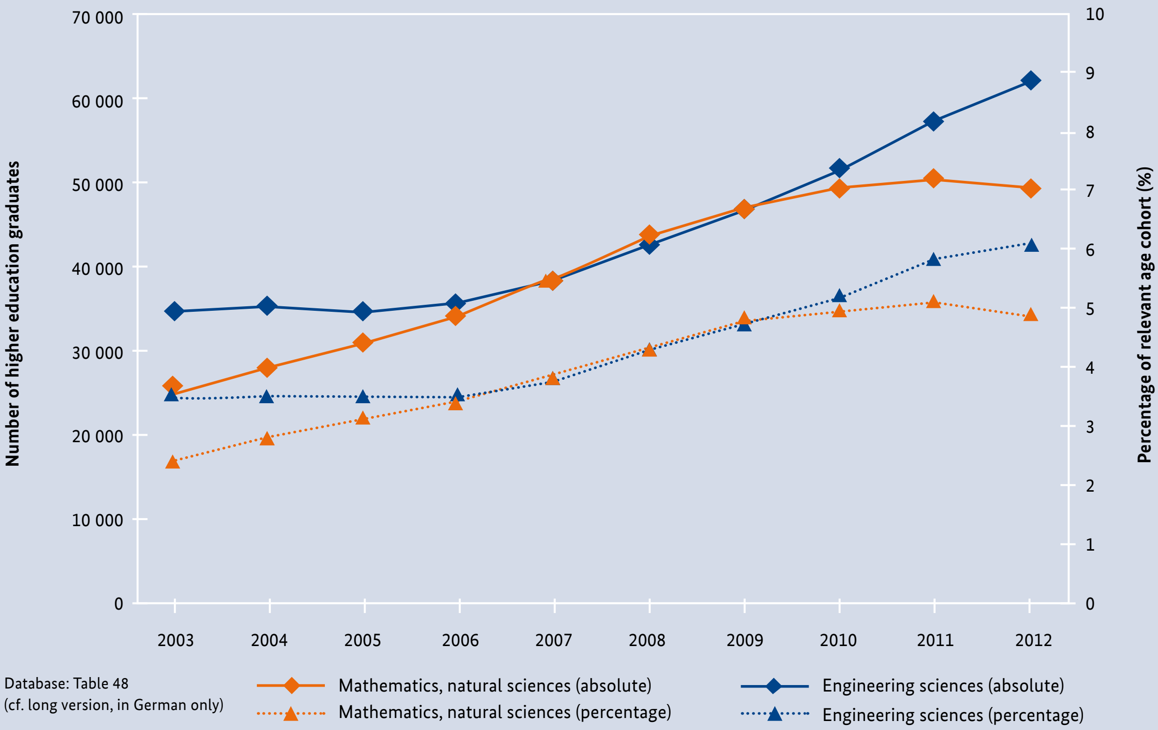
These positive trends in numbers of MINT graduates are welcome, not only in terms of the German research and innovation system's requirements for skilled manpower. They are also welcome in that programmes of studies in engineering sciences in particu-

Fig. 16 Higher education graduates, in absolute numbers and as age-cohort percentages, 2003–2012



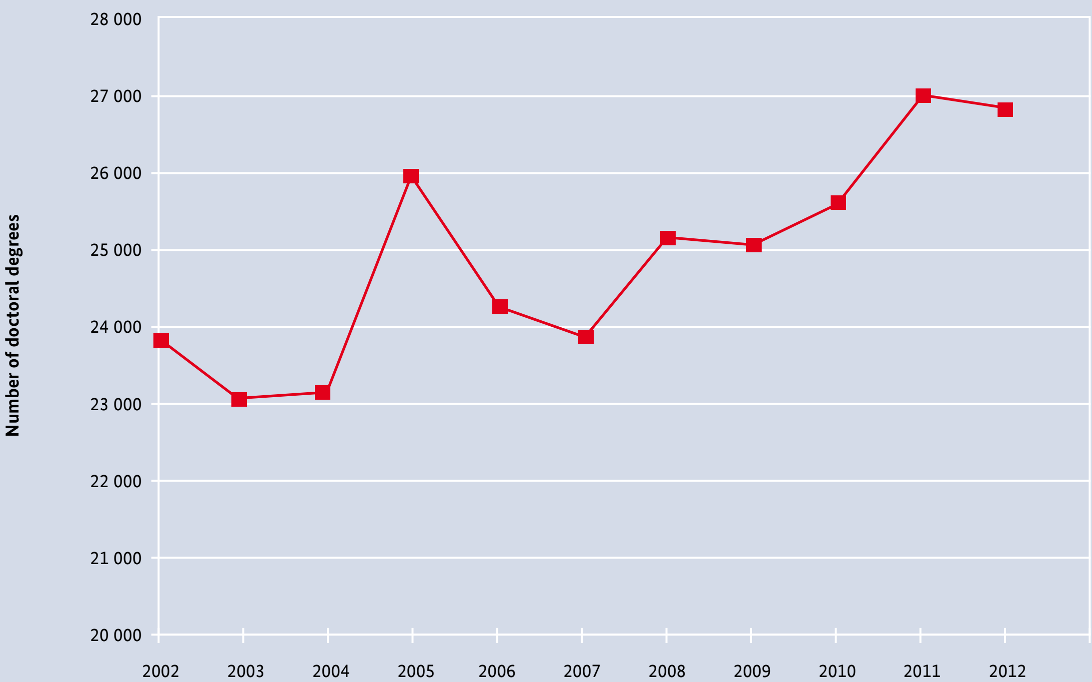
Database: Table 48 (cf. long version, in German only)

Fig. 17 **Graduates in MINT subjects, in absolute numbers and as age-cohort percentages, 2003–2012**



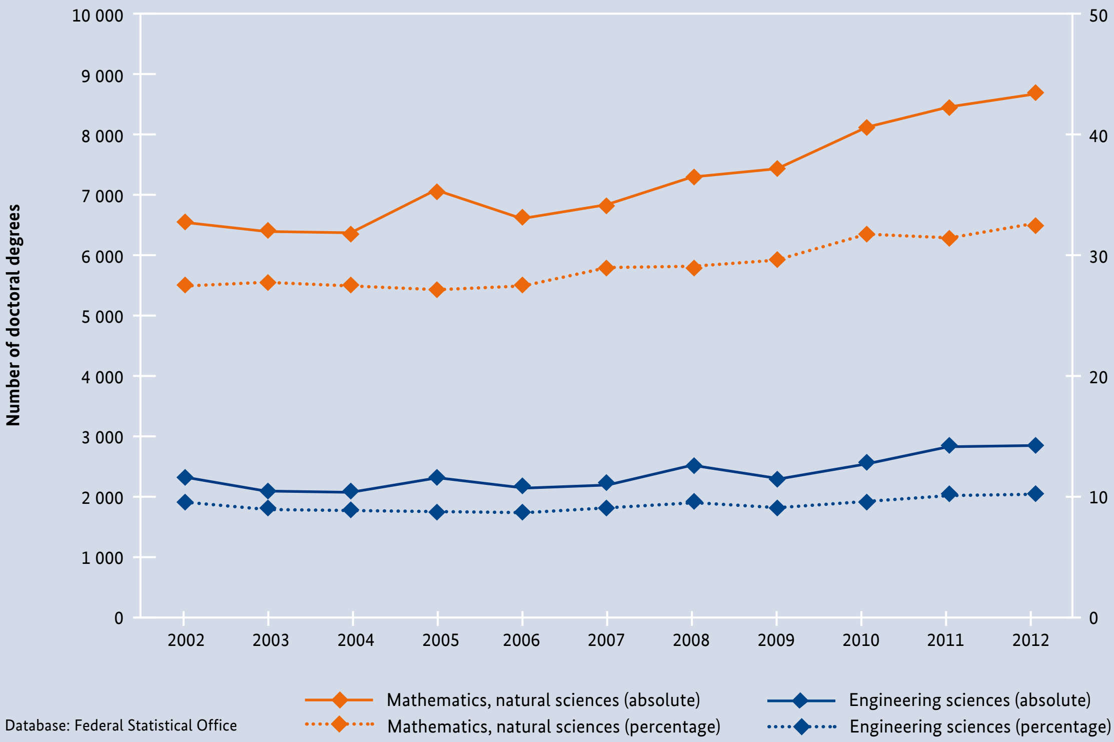
Database: Table 48
(cf. long version, in German only)

Fig. 18 **Number of doctoral degrees earned, 2002–2012**



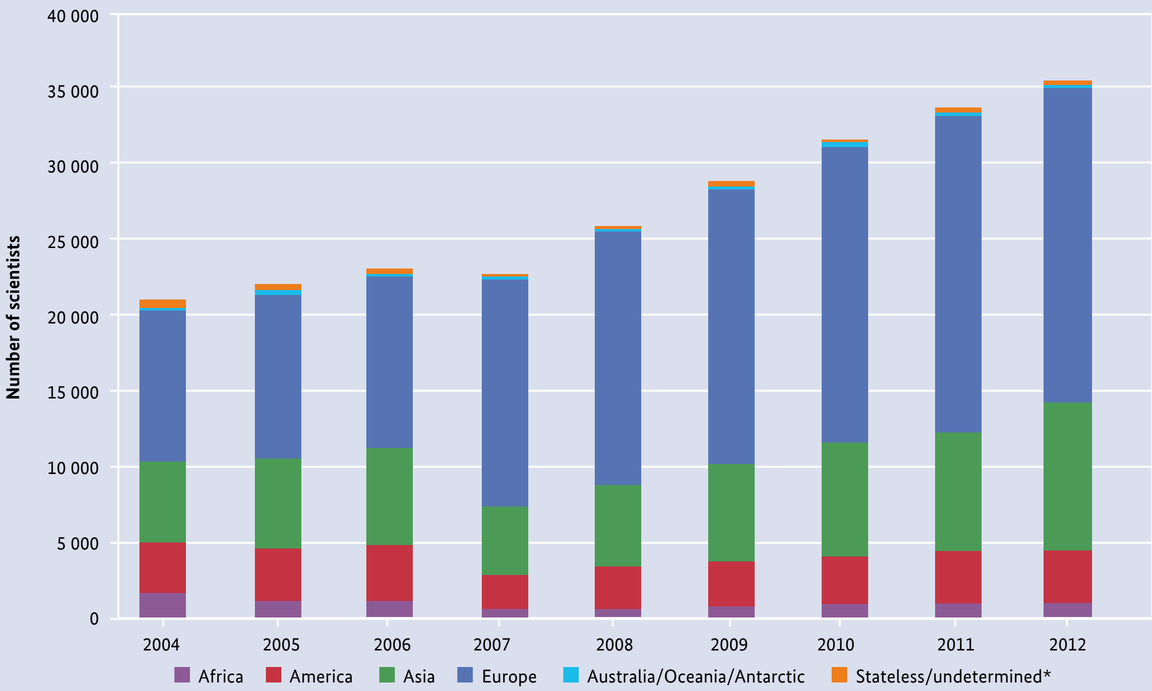
Database: Federal Statistical Office

Fig. 19 **Numbers of doctoral degrees in MINT subjects and doctoral degrees in MINT subjects as percentages of all doctoral degrees, 2002–2012**



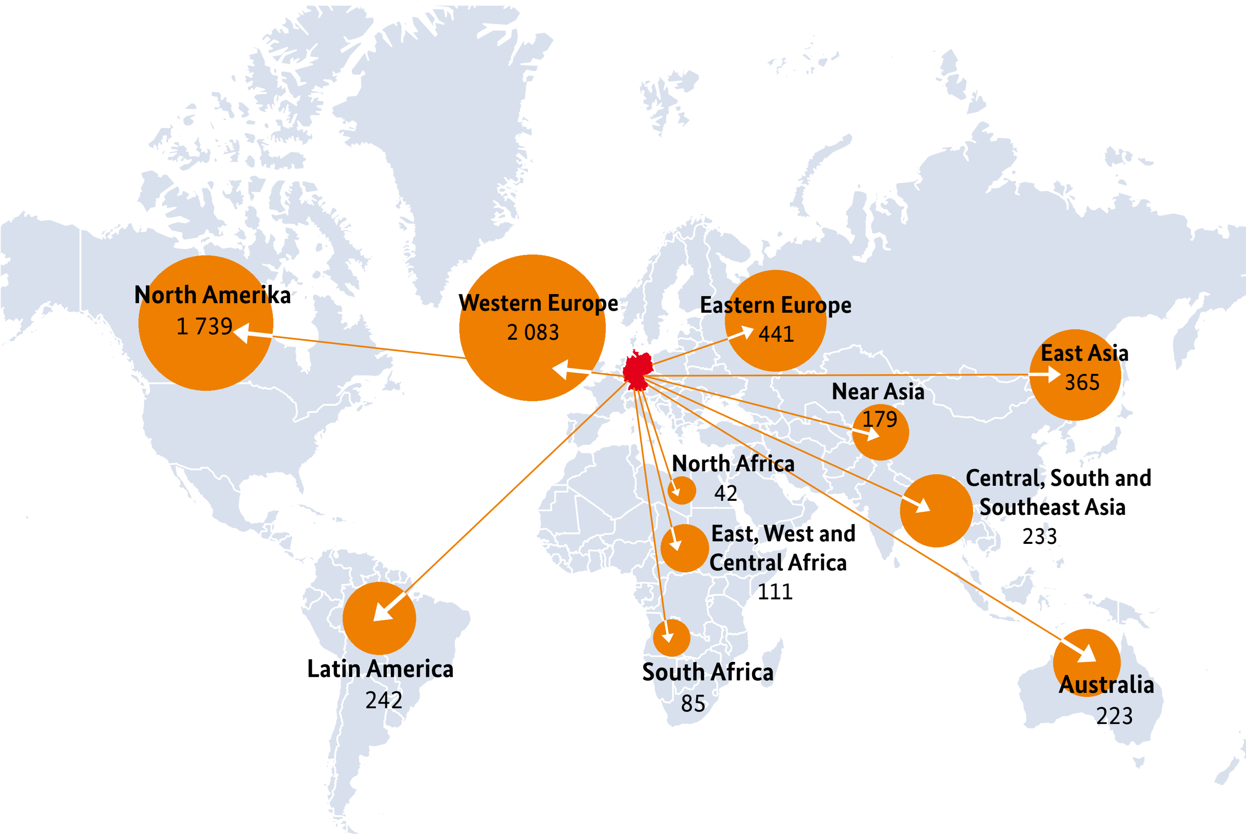
Database: Federal Statistical Office

Fig. 20 **Numbers of foreign scientists in Germany, by continents of origin, 2007–2011**



*Including persons of dual foreign nationality
Database: Federal Statistical Office, HIS calculations

Fig. 21 **Funded stays of German researchers abroad (by regions for stays, 2011)**



Source: Wissenschaft weltoffen (2013): Deutsche Studierende im Ausland. In DAAD; HIS-HF (ed.): Wissenschaft weltoffen: Daten und Fakten zur Internationalität von Studium und Forschung in Deutschland, Bielefeld: Bertelsmann

lar are typical paths to advancement for children of parents who are not university graduates.

Numbers of doctoral degrees are of particular importance with regard to the availability of especially highly qualified personnel for R&D work. In addition, numbers of doctoral degrees serve as a general indicator for R&D activities.

The numbers of doctoral degrees completed annually have remained relatively stable over time (Figure 18). Between 2000 and 2010, they averaged about 24 500, with a variability of plus/minus 1 500. Nearly 27 000 doctoral degrees were registered in 2012.

In the area of doctoral degrees, it makes sense to consider MINT subjects separately, as was done with regard to graduates in general. Between 2002 and 2009, the numbers of doctoral degrees in mathematics and natural sciences varied around a value of 7 000, with a variability of up to plus/minus 700. The trend in engineering sciences was also constant from 2002 to 2009. During those years, the number of doctoral degrees in engineering sciences averaged about 2 300, with variability of plus/minus 250. The most recent data show positive trends for both engineering sciences and mathematics and natural sciences (an increase of about 17 % in absolute figures, from 2009 to 2012, in mathematics and natural sciences, and of about 22 % in the engineering sciences). A significant aspect overall is that MINT subjects account for 43 % of all doctoral degrees earned. This high percentage highlights the special relevance of this subject group for research.[18]

Mobility of researchers

In 2012, about 35 000 researchers of foreign origin were employed at German higher education institutions (an increase of about 60 % with respect to 2006).[19] The largest group of foreign researchers involved comes from western Europe. It accounts for about 35 % of all research personnel of foreign origin. Eastern Europe and Asia are also important regions of origin in this

18 In this area, it must be noted that in certain natural science fields careers typically begin via a doctoral degree.

19 Destatis (Federal Statistical Office), Fachserie 11 Reihe 4.4, Bildung und Kultur. Personal an Hochschulen, Jahre 2012 und 2008.

regard; each accounts for about one quarter of the foreign research personnel in Germany.

Of the more than 32 000 guest scientists receiving support in 2011 in Germany, throughout all scientific institutions, 30 % came from China, Russia, the U.S., India or Italy. Significant growth has been seen especially in the numbers of scientists from Europe and Asia. The numbers in those categories are the highest ever seen since this survey was established. In 2011, they accounted for more than three quarters of all guest scientists receiving support in Germany.[20]

Funding organisations that support research stays abroad have been intensifying their programmes for exchanges of scientists. The regions most preferred by German scientists, who receive funding for their stays, are North America and Western Europe. For example, the U.S. accounts for about one-fifth of the German researchers staying abroad and registered by the relevant funding organisations. The UK, Switzerland, France and Italy are also popular destination countries. Eastern Europe and Asia are less frequently represented in this category, on the other hand. This distribution has remained relatively stable over the past few years.[21]

20 Wissenschaft weltoffen 2013. Daten und Fakten zur Internationalität von Studium und Forschung in Deutschland, 2013, p. 106, www.wissenschaftweltoffen.de/publikation/wiwe_2013_verlinkt.pdf.

21 Database: Wissenschaft weltoffen 2013

5.2 R&D results

Successful R&D leads to scientific findings, scientific discoveries or technical inventions. Scientific findings are reflected in scientific publications, while technical inventions are reflected in patents.[22]

A country's patents serve as an indicator for the country's technological performance in the narrower sense; publications, on the other hand, serve as a measure of its scientific capabilities. In innovation policy contexts, publications are viewed as indicators for science performance, due to the growing importance of "knowledge" as a production factor. At the same time, it must be remembered that scientific disciplines can differ considerably in terms of their typical publication patterns. Furthermore, absolute publication figures reveal nothing at all about how the relevant publications are received by the research community. This can only be learned by consulting citation data.

5.2.1 Scientific performance: Publications

The numbers of scientific publications (per million inhabitants) in Germany have increased continually over the past few years. Between 2000 and 2012, the relevant increase amounted to about 41 %. As a result, Germany has now moved ahead of the U.S. for the first time.[23] (Figure 22) In 2000, the figure for the number of German publications reached about 92 % of the American figure. In 2012, then, it reached about 102 % of that figure. In addition, Germany's lead over Japan increased during the same period (from about 143 % to about twice the relevant Japanese figures). Germany also remained well ahead of the European average, at a constant level (about 127 % of the relevant European level).

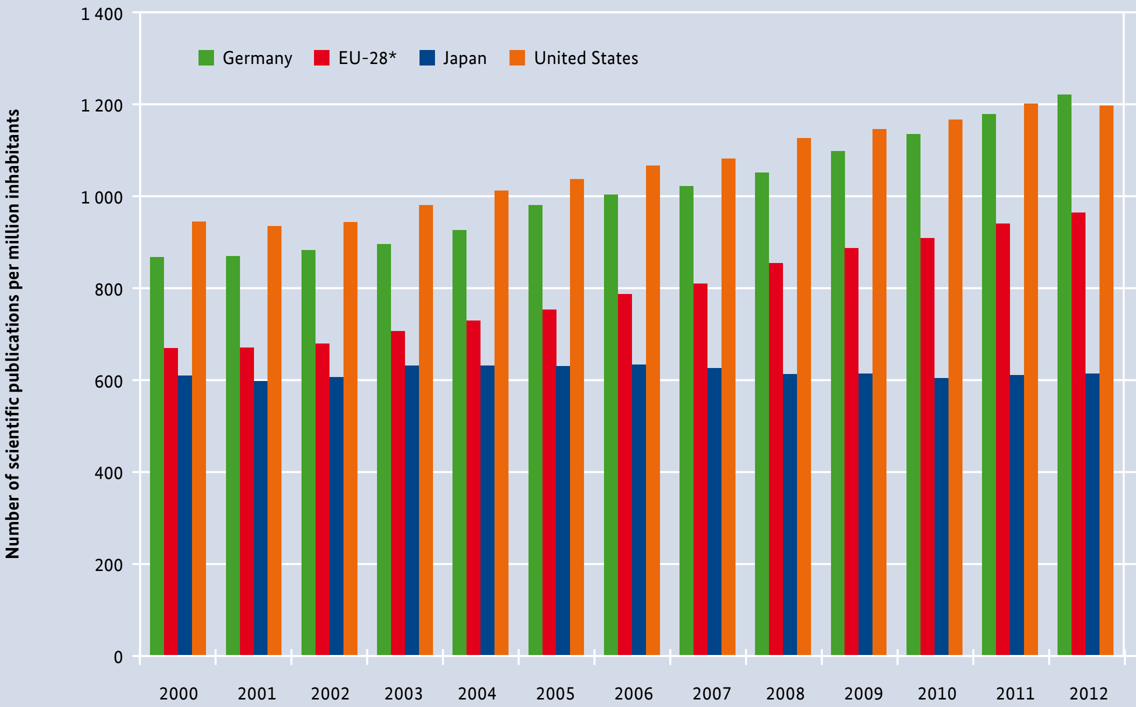
The various countries' shares of all international publications show decreases for several of the leading industrialised countries, such as the U.S., Japan and the UK. Germany, on the other hand, has maintained a stable share of 7 % over the past few years. A key reason for this is that publication activity by newly industrialised countries has intensified. This is especially the case for China, which increased its percentage share from 4.5 % to over 13 % within the space of a decade.[24]

22 Publications and patents can also be viewed as outputs of the R&D process. With respect to the entire innovation process, publications and patents are perhaps better understood as intermediate results that, for their part, serve as bases (inputs) for commercialisation of the relevant findings and inventions by the private sector and society. For this reason, the term "throughput indicators" is also used in this context.

23 With regard to the U.S., it must be remembered that researchers whose native language is English enjoy a considerable advantage with regard to international publications.

24 Cf. Michels/Fu/Neuhäusler/Frietsch: Performance and Structures of the German Science System 2013. Studien zum deutschen Innovationssystem Nr. 4-2014.

Fig. 22 Publications: Germany, EU-28, Japan and the United States, 2000–2012



* EU-28 adjusted to account for double-counting. Includes Croatia, a new EU Member State.
Database: Table 40 (cf. long version, in German only)

5.2.2 Technological performance: Patents

Patents are often used as indicators for technological performance. Data in this category, while easy to obtain, are not always easy to interpret with regard to R&D's effects on countries' economies. For example, in some sectors, inventions are patented either rarely or not at all, for reasons of secrecy.

Invention patents that are registered in Europe or with the World Intellectual Property Organization (WIPO) are referred to as "world-market relevant" or "transnational" patents[25]. For Germany's export-oriented industry, such patents are especially significant because they make it possible to protect inventions outside of the home market. With regard to this indicator, Germany has achieved high growth rates at a high absolute level. From 2000 to 2011, it registered growth of about 15 % in patents per million inhabitants. Germany's results in this category greatly surpass the EU-27 average, amounting to 250 % of the relevant European values.

Germany has about twice as many transnational patents per million inhabitants as the U.S. does. Japan has been catching up in this regard: in 2011, its patent intensity almost reached Germany's level. In addition, Korea's patent intensity has grown sharply since 2000. Along with Germany, the European countries with especially high patent intensities include Switzerland, Sweden and Finland. This overall picture has remained quite stable over time.

When differentiating patents by technological areas, an international comparison shows the following: In the U.S., Canada, Korea, Israel, Finland and Sweden, large shares of the patents applied for fall into the category of cutting-edge technology. On the other hand, Germany, like Switzerland, Denmark and Japan, has relatively low percentages of cutting-edge technology patents (in areas such as computers, electronics and pharmaceuticals), but it has pronounced strengths in the area of advanced technologies (in the automotive and mechanical engineering sectors, for example).[26]

25 The World Intellectual Property Organization is a specialised agency of the United Nations.

26 Cf. Neuhäusler, P.; Rothengatter, O.; Frietsch, R. (2014): Patent Applications – Structures, Trends and Recent Developments 2013, Studien zum deutschen Innovationssystem, Berlin, Nr. 4-2014.

Info box

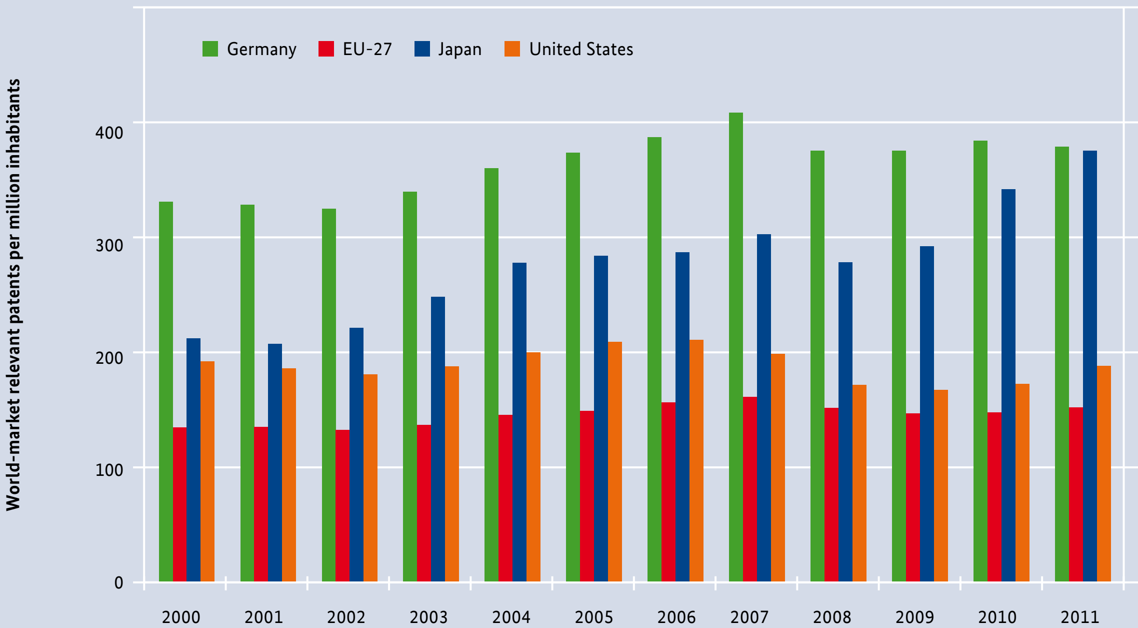
Differentiation between cutting-edge technology and advanced technology

Individual sectors are classified in accordance with relevant lists of the Fraunhofer Institute for Systems and Innovation Research (FhG-ISI) and the Lower Saxony Institute for Economic Research (NIW). Research-intensive industry consists of cutting-edge technology sectors and advanced technology sectors. The two sectoral categories are differentiated in terms of the ratio of internal R&D expenditures to revenue, i.e. R&D intensity. The following limits apply:

- Cutting-edge technology comprises goods for which the R&D intensity exceeds 9 %.
- Advanced technology comprises goods for which the R&D intensity is between 3 % and 9 %.

Applying these criteria to the manufacturing sector, it is clear that the pharmaceutical, IT, telecommunication, medical technology, measurement technology, aeronautical and space technology sectors belong to the realm of cutting-edge technology. The chemicals, mechanical engineering, electrical engineering, automotive and other vehicle-construction sectors are assigned to the area of advanced technology.

Fig. 23 **Transnational patents: Germany, EU-27, Japan and the United States, 2000–2011**



Database: Table 41 (cf. long version, in German only)

5.3 Innovation success

5.3.1 Innovation indicators for Germany

Investments in R&D, by the private sector and science sectors, have economic benefits when economic organisations (companies) implement R&D results to improve products or services or to realise productivity improvements. Two groups of indicators are now commonly used in empirical innovation research for assessing the extent to which, and the success with which, companies translate inventions (i.e. technical and scientific inventions) into innovations:[27]

The innovator rate expresses the percentage share of companies that have introduced new products or new processes within a given period of time. The innovation intensity expresses innovation expenditures as a fraction of revenue. In 2012, the innovator rate was 38.3 %. By comparison, in the pre-crisis year 2008, it was 47 %. These figures take account of companies that have introduced at least one product or process innovation within the previous three-year period. In each case, the innovation involved only need be an innovation in terms of the company's own perspective; i.e. the applicable definition includes innovations that are new for the company in question but have already been introduced by other companies. In 2012, about 48 % of all companies in the manufacturing sector were among the "innovators". The relevant innovator rate for knowledge-intensive business-related services[28] was about 45 %, while for other business-related services[29] it was about 26 %. Figure 24 shows the sector-specific differences by innovator rate category for 2012.

In 2012, even though the innovator rate had decreased, innovation expenditures reached a record level of 137.4 billion euros, or 5 % more than in the previous year. Innovation intensity, i.e. the ratio of innovation expenditures to revenue of the German private sector, increased from 2.58 % to 2.71 % in 2012. The resulting value was the highest seen since 2007. The increases in innovation expenditures occurred as the German private sector's revenue was stagnating (2012). Research-intensive industry reached a new record high in 2012: 8.3 %, up from 7.9 % in the previous year. By contrast, in knowledge-intensive services (not including financial services), the relevant value decreased slightly, from 4.8 % to 4.7 %.

27 Regarding the individual indicators and their definitions, cf. Rammer/Aschhoff/Doherr/Hud/Köhler/Peters/Schubert/Schwiebacher: Indikatorenbericht zur Innovationserhebung 2011. Mannheim: Zentrum für Europäische Wirtschaftsforschung, January 2012

28 Information and communication services, financial and insurance services, freelance services, scientific and technical services.

29 Wholesale, transport and storage, other business services (not including leasing of movable property).

Product innovators

Figure 25 shows the percentages of companies that have introduced at least one product innovation during the relevant period. The innovations in question may be either completely new items on the market or imitations of existing products (copycat innovations). The following should be noted in connection with this figure and the following figures: The relevant time series contains a break between 2005 and 2006, as a result of changes in the system for statistical classification of economic activities, changes in the survey methods used and changes in the definition of the "basic totality".[30] The highest product-innovator rate is seen in the manufacturing sector (including mining). Over the past 15 years, it has ranged between 40 % and 50 % in that sector. In the area of knowledge-intensive business-related services, it has ranged from 35 % to 40 %, while in other business-related services it has fluctuated from 15 % to 30 %. In 2008, following an inconsistent, generally decreasing trend in the early years of the consideration, the product-innovator rate reached rather high values (apart from a sudden drop in the 2009-2010 crisis year). In 2011, the product-innovator rate decreased in all three sectors – considerably, in some cases. In 2012, it remained stable, at a low level, in the manufacturing sector (including mining), and increased slightly in the area of services.

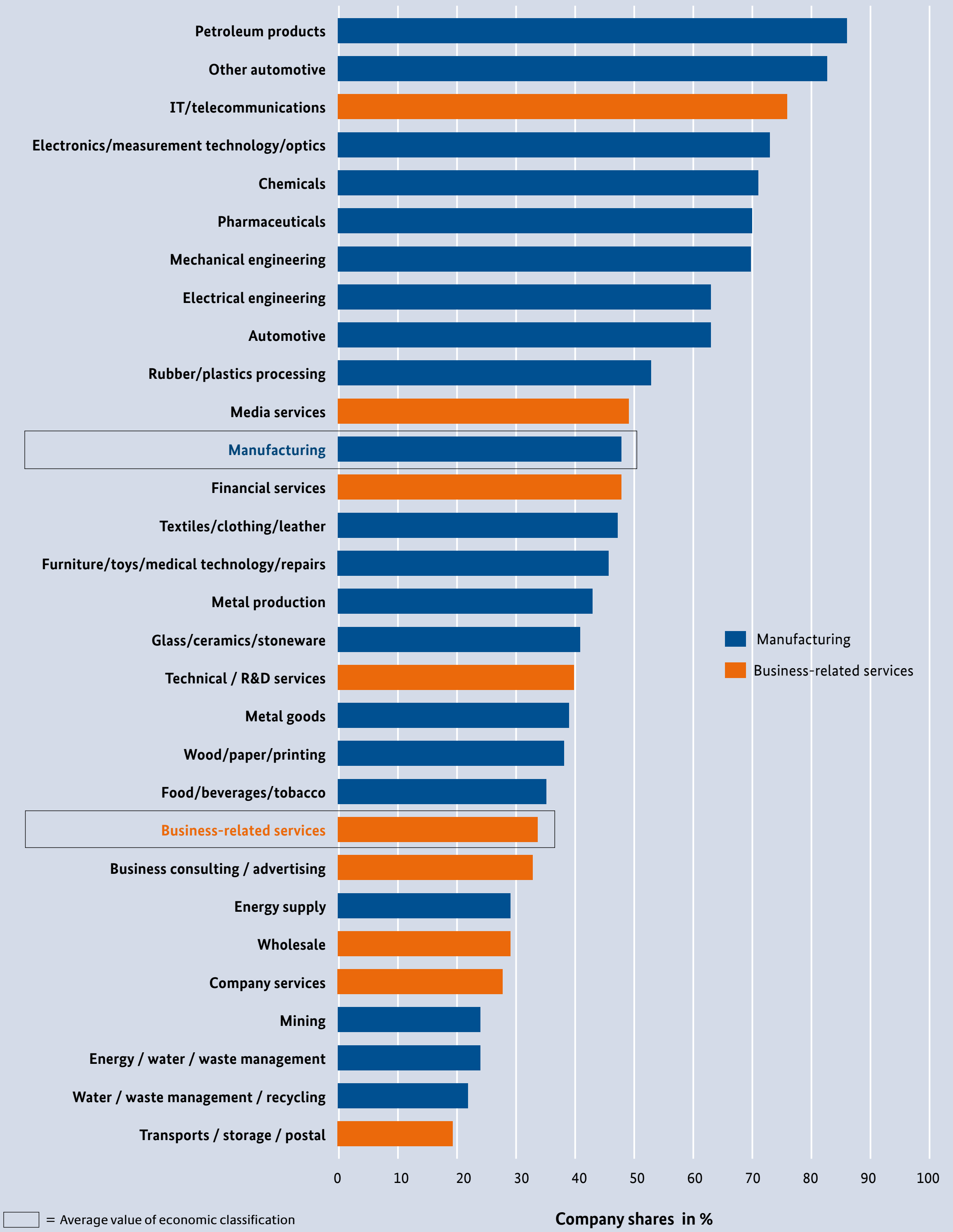
Process innovators

In addition to showing product-innovator rates, Figure 25 also presents the percentages of companies that introduced at least one process innovation during the period in question.

With regard to participating in process innovations, the manufacturing sector (including mining) and knowledge-intensive business-related services have process-innovation rates of 27 % and 26 % respectively, and thus considerably outperform other business-related services (15 %) in this category. In 2009 and 2010, the process-innovation rate decreased in all three sectors, after having reached relatively high levels in 2008. In 2011, it increased slightly in the area of business-related services. In 2012, a slight decrease was seen in all three sectors. Process innovations can lead to both cost reductions and quality improvements. In the manufacturing sector (including mining), the percentage of companies achieving cost reductions with process innovations is 15 %, or about the same as the percentage of companies that used such innova-

30 Cf. Rammer, C., B. Aschhoff, D. Crass, T. Doherr, M. Hud, C. Köhler, B. Peters, T. Schubert, F. Schwiebacher: Innovationsverhalten der deutschen Wirtschaft. Indikatorenbericht zur Innovationserhebung 2013, Mannheim: ZEW, January 2014.

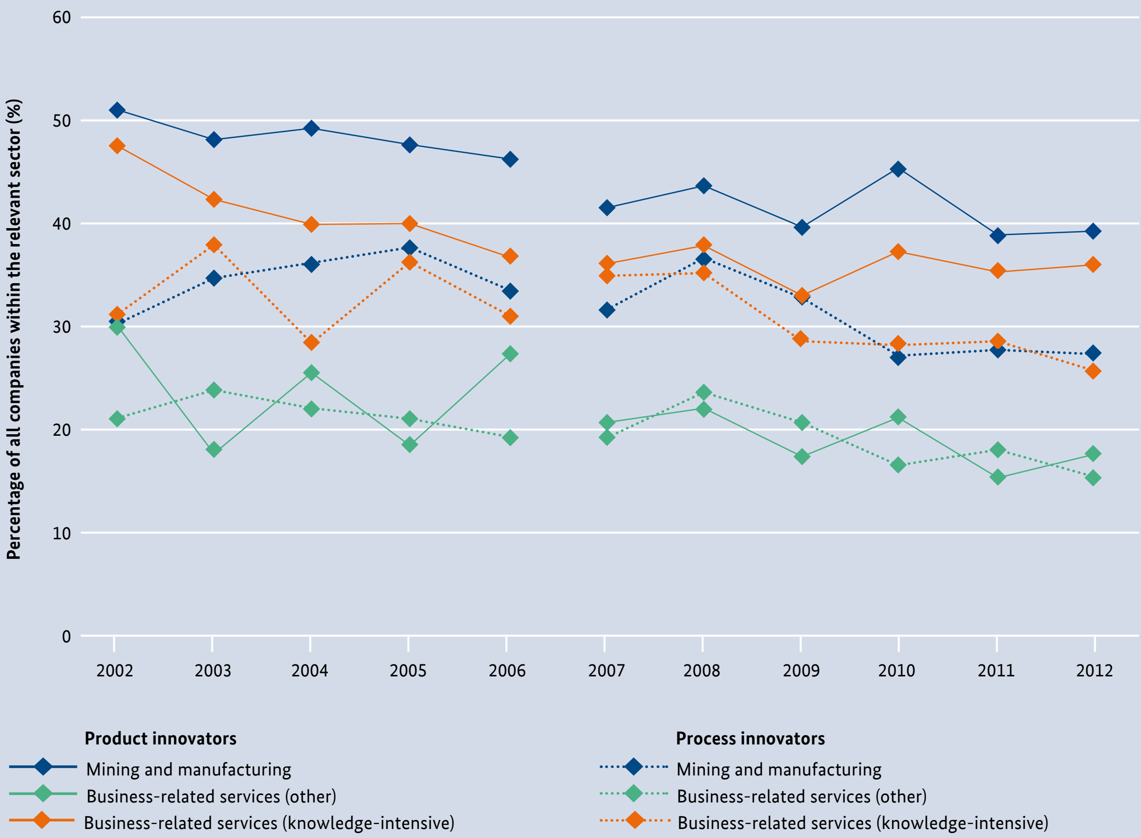
Fig. 24 **Innovator rate in 2012, by sector groups***



*Innovator rate: Companies with product or process innovations, in % of all companies.
Values for 2012 are provisional. All figures upwardly adjusted to the totality of companies with five or more employees in Germany.
Values for 2011 have been revised with respect to the previous year's report.

Source: ZEW – Mannheimer Innovationspanel, Table 38 (cf. long version, in German only)

Fig. 25 Product and process innovators, 2002–2012



Database: Tables 1.81 and 1.82 in www.datenportal.bmbf.de
The break between 2005 and 2006 is due to methodological changes.

tions to improve quality in production processes (17 %). In both sectors of business-related services, by contrast, quality objectives play the most prominent role within process-innovation activity.

Innovation performance of the German private sector in a European comparison

The German private sector's innovation performance is excellent when seen in a European comparison. The results of the Europe-wide innovation survey for 2010[31] confirm that German companies have high rates of participation in R&D and innovation – and that the participation rates are especially high for SMEs.[32] For example, the percentage of German companies that introduced new products or services, at a total of 42 %, is greater than the comparable figures in all other EU Member States. With regard to the percentage of companies that conduct research on an ongoing basis, Germany, at 18 %, comes out ahead of all other countries. By contrast, Germany's process-innovation rate, at 29 %, is in the middle of the spectrum. The German private sector's innovation activity, in comparison to the innovation activities of other European countries, is thus oriented more strongly to product innovations than to process innovations.

With regard to innovation expenditures, as a ratio of revenue, Germany ranks fourth, behind the three Scandinavian countries Denmark, Finland and Sweden. In 2010, the Europe-wide innovation survey found that the German private sector generated 16 % of its revenue with new products. That value was the third-highest among all European countries in this category. Only Slovakian and Spanish companies were found to have product portfolios of younger average

31 Eurostat, Community Innovation Survey 2010. – Calculations of the ZEW. More recent figures are not available.

32 The values for Germany in the Europe-wide innovation survey differ from the corresponding figures in national statistics, since the survey group in the Europe-wide innovation survey is more tightly restricted (only companies with at least 10 employees; fewer service sectors)

ages. 22% of companies in Germany are active in innovation and have received public innovation funding, which is an average level when seen in a European comparison.

5.3.2 Global trade in research-intensive goods

Trade in research-intensive goods is an important indicator for economic commercialisation of research and innovation. This indicator reveals the competitiveness of knowledge-based economies in international markets for innovative products and services. A consideration of the past two decades shows that global trade in research-intensive goods has continually increased throughout the entire period – with the exception of the financial and economic crisis (Table E2). During the period 2000 through 2008 in particular, trade in research-intensive goods registered an average annual growth of 9.1 %. In the subsequent period, 2008 through 2012, which was shaped by the economic crisis, growth was relatively sluggish – 3.4 %. From 2008 to 2009, a sharp decrease – nearly 20 % – occurred in the area of advanced technology and non-research-intensive goods, while trade in cutting-edge technology decreased by only 7.4 %, and thus was much less strongly affected by the temporary setback in global trade.[33]

Due to the increases in some newly industrialised countries' participation in world trade, the share of trade in research-intensive goods has been decreasing slightly over time. In 2012, the world-trade share of technology goods was nearly 43 %, or about 6 percentage points below the corresponding level in 2000. Cutting-edge technologies have been especially affected by the structural changes (2000: 18.6 %; 2012: 13.9 %). The world-trade share of advanced-technology goods, on the other hand, has remained relatively stable at about 30 %.

Growing newly industrialised countries have considerably increased their shares of trade in research-intensive goods since 2000. Whereas the EU-15, the U.S. and Japan now account for 55 % of world trade in this category, the corresponding figure in 2000 was nearly 70 %. The largest growth has been registered by China (including Hong Kong). In 2012, it had a share of more than 14 % and wound up in first place. Figure 26 shows the trends, for selected countries, for shares of world trade in research-intensive goods. As the figure shows, Germany – in contrast to other traditional

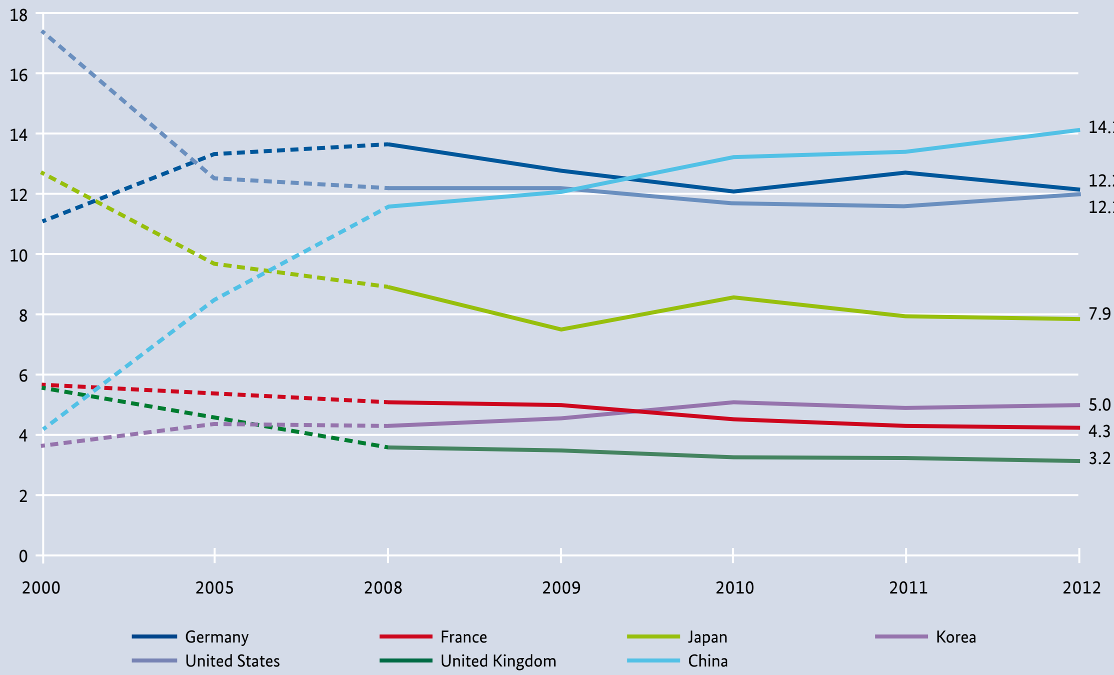
Table E2 World exports of research-intensive goods, 2000 to 2012 (in dollars)

World exports	Exports, 2012	Share in 2012	Average annual change, in %					
	in billions of US dollars	in %	2000–2008	2008–2012	2008–2009	2009–2011	2011–2012	2000–2012
R&D-intensive goods overall	5 758	42.9	9.1	3.4	-16.2	16.5	0.3	7.2
Cutting-edge technology	1 870	13.9	6.1	5.3	-7.4	13.8	2.6	5.8
Advanced technology	3 888	29.0	10.7	2.5	-19.9	17.9	-0.7	7.9
Non-R&D-intensive goods	7 658	57.1	12.7	4.5	-19.8	22.5	-0.8	9.5
Processed industrial goods	13 416	100.0	10.7	4.0	-18.2	19.8	-0.3	8.4

Source: Schiersch, A.; Gehrke, B. (2014): Die Wissenswirtschaft im internationalen Vergleich: Strukturen, Produktivität, Außenhandel, Studien zum deutschen Innovationssystem Nr. 6-2014, Berlin: EFI, S. 43
Database: UN Comtrade-Datenbank, Berechnungen des NIW

33 Schiersch, A.; Gehrke, B. (2014): Die Wissenswirtschaft im internationalen Vergleich: Strukturen, Produktivität, Außenhandel, Studien zum deutschen Innovationssystem Nr. 6-2014.

Fig. 26 **Shares of world trade in research-intensive goods for selected countries, 2000–2012**



Source: Schiersch, A., Gehrke, B. (2014): Die Wissenswirtschaft im internationalen Vergleich: Strukturen, Produktivität, Außenhandel, Studien zum deutschen Innovationssystem Nr. 6-2014, Berlin: EFI

industrialised countries – was able to keep its share of world trade in research-intensive goods largely stable over the past decade. In fact, it was able to slightly increase its share with respect to 2000 – from 11.1 % in 2000 to 12.2 % in 2012. The United States (from 17.4 % to 12.1 %) and Japan (from 12.7 % to 7.9 %) suffered decreases in this category.

5.4 International position

This section places the German research and innovation system in a larger context, on the basis of internationally comparable key indicators such as research expenditures and research personnel. Along with such individual indicators, the section also uses a composite indicator, the European Commissions' Innovation Union Scoreboard, for such positioning purposes. The Scoreboard indicator measures the performance of the EU Member States' innovation systems.

World expenditure on research and development

A number of EU Member States continue to be relatively far from reaching the three-percent goal, while other Member States have either already come close to it or have even surpassed it. Overall, the EU is nearly an entire percentage point away from the three-percent goal: the average R&D expenditures for the EU-28 amounted to 2.06 % in 2012.[34] Germany, on the other

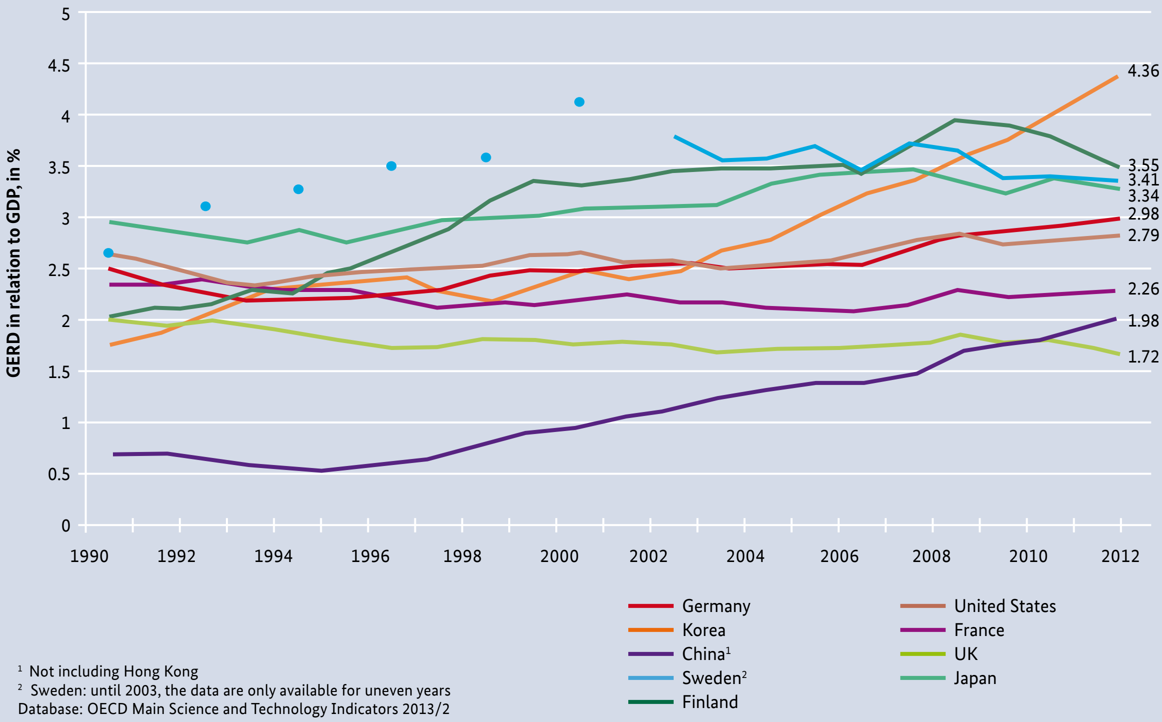
34 Database: Eurostat database

hand, reached the three-percent goal for the first time in 2012. With that result, Germany is among the EU-28 leaders in the area of R&D intensity. Denmark has reached a similar level in this category. Austria and Slovenia are at only slightly lower levels. On the other hand, the Scandinavian countries Finland and Sweden are now surpassing the three-percent goal significantly. All other EU countries are at least half of a percentage point below it.

In 2012, in a global comparison of OECD countries, Germany had a value of 2.98 %[35] (estimated), and was among the group of leading countries with R&D intensity levels greater than 2.5 %. Levels above 3 % were achieved only by Sweden (3.41 %), Finland (3.55 %), Japan (3.34 %), Israel (4.20 %) and Korea (4.36 %)[36]. The figures for Korea and Israel in particular are considerably higher than the figures for the other OECD countries. seen in that Korea's top-level figure is nearly twice the average for the OECD Member States, 2.4 % (Figure 27).

The trends for this indicator differ for different selected countries. For example, the European leaders Finland and Sweden have experienced decreases in R&D intensity in recent years. Considerable increases are seen on the part of Korea; its R&D intensity has increased continuously since the beginning of the 2000s. Since the middle of the decade, that country's substantiated R&D intensity has exceeded the corresponding figures for Germany and the U.S. In addition, since 2011 Korea has been the world leader. On the other hand, Germany has exhibited a continuously positive trend since 2008. By contrast, the R&D intensity levels of France and the UK have been stagnating. A look at the pertinent time series shows that R&D intensities in

Fig. 27 Gross domestic expenditure on research and development as a fraction of the gross domestic products of selected countries (R&D intensity), 1991–2012



[1] Not including Hong Kong
[2] Sweden: until 2003, the data are only available for uneven years
Database: OECD Main Science and Technology Indicators 2013/2

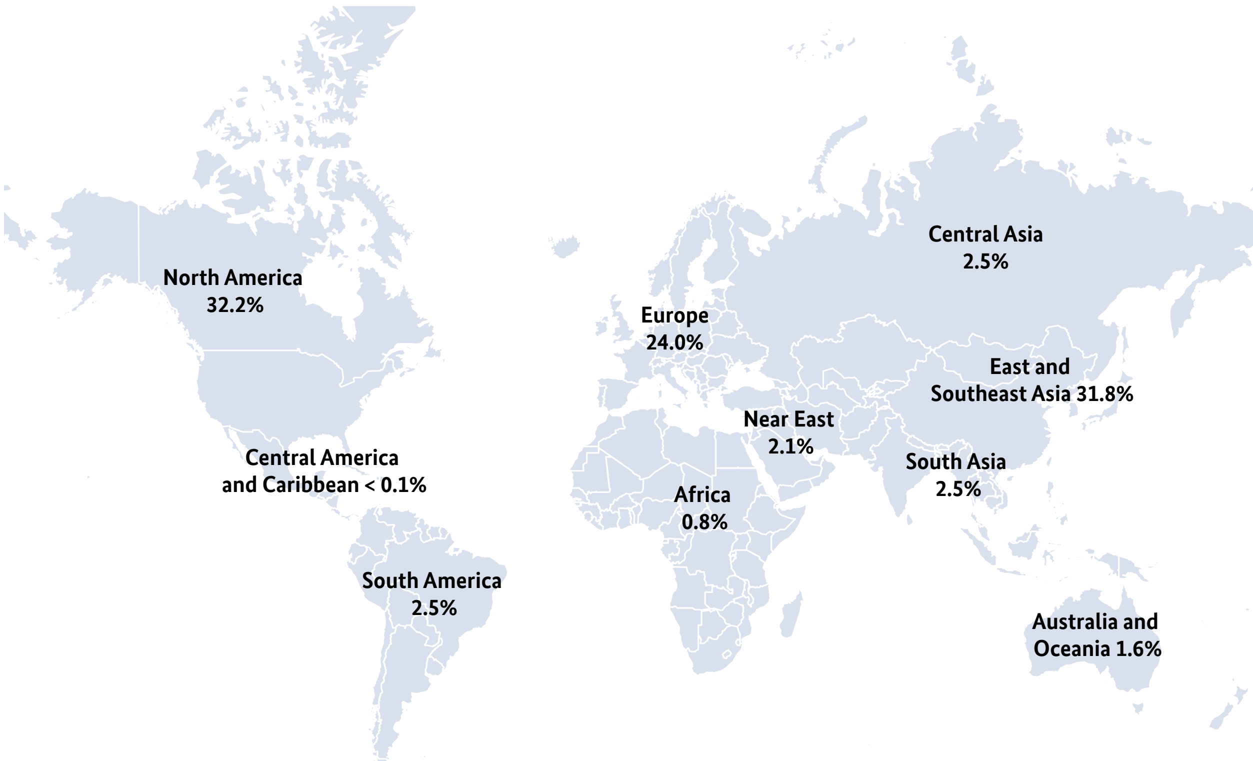
R&D intensity levels below 1.5 % are often registered by countries that are undergoing economic catch-up processes. On the other hand, countries such as Italy (1.27 %) and Spain (1.30 %) also failed to reach the 1.5 % mark. The extent of the country-specific differences is some countries either stagnated or decreased during the financial and economic crisis (after 2007) (Figure 27).

The presentation of the relative trends, in terms of R&D intensities, has to be seen in the context of absolute expenditures on research and development. Overall, global R&D expenditures have risen sharply since the turn of the millennium. The world's R&D

35 Calculations of the BMBF

36 Source: OECD-MSTI 2013/2

Fig. 28 **Worldwide R&D expenditures (by percentage shares per region, 2011)**



Remark: Foreign currencies have been converted to US dollars via purchasing-power parities. Some of the country indicators have been estimated. The countries have been grouped in keeping with the regions in The World Factbook (available at www.cia.gov/library/publications/the-world-factbook/index.html).

Source: The estimates were obtained from the National Science Foundation and the National Center for Science and Engineering (August 2013). Based on the data of the OECD Main Science and Technology Indicators (2013/1) and the UNESCO Institute for Statistics (http://stats.uis.unesco.org/unesco/ReportFolders/ReportFolders.aspx, Table 25, last accessed 2 August 2013)

expenditures in 2001 were estimated to be about 753 billion US dollars.[37, 38] The corresponding figure for the year 2006 is estimated to be 1 051 billion US dollars. As a result, an estimated 1 435 billion US dollars were spent worldwide on R&D in 2011.

Figure 28 shows that research and development takes place especially in three geographic regions: North America, Asia and Europe. In 2011, 32 % of worldwide R&D expenditures were registered in North America (U.S., Canada, Mexico). The corresponding figure for Europe was 24 %, while for East, Southeast and South Asia it rose to 34 %. The remaining 10 % of worldwide R&D expenditures are distributed among the regions Central and South America, the Near East, Australia and Oceania and Africa. As this indicates, the centre of gravity for R&D is clearly shifting toward Asia.

The geographic distribution of R&D expenditures tells an even clearer story when one looks at individual countries. A consideration by individual countries shows that the three largest R&D-performing countries (U.S., China and Japan) together account for more than half of the total worldwide R&D expenditures in 2011.[39] The U.S. is the clear leader in this category, with a share of nearly 30 % of all worldwide expenditures. On the other hand, its share has decreased noticeably over time. In 2001, it was 37 %. In 2011, China had already moved up to second place, with 15 % of all worldwide R&D expenditures. Japan ranked third, with a share of 10 %. Significantly, Germany accounts for a full 7 % of global R&D expenditures. It is followed in this regard by Korea (4 %), France (4 %) and the UK (3 %).

37 In terms of purchasing-power parities, in US dollars

38 Cf. National Science Foundation, Science and Engineering Indicators 2014, pp. 4-16

39 Cf. National Science Foundation, Science and Engineering Indicators 2014, pp. 4-17

Fig. 29 **R&D personnel intensity in selected countries, over time**[1]

[1] Limited data available for Sweden in 2000 and France in 2011
[2] OECD estimate: including Croatia
Database: OCED Main Science and Technology Indicators 2013/02

Development of R&D personnel worldwide

The trends in the area of R&D expenditures are substantiated by the trends for R&D personnel. R&D personnel is often a key factor in R&D expenditures. On the other hand, by-country comparisons of R&D personnel are subject to a degree of ambiguity. A key reason for this is that national education systems tend to differ widely in terms of structure and thus exhibit special characteristics with regard to the academic and vocational training of specialised personnel. In addition, in non-OECD countries (especially), methodological problems tend to hamper attempts to survey R&D personnel consistently.

Figure 29 shows levels of knowledge-intensive employment in various countries, in terms of "R&D personnel intensity"[40]. A trend toward a relative increase in R&D personnel intensity is plainly visible. Slightly different trends are seen in Japan and Finland. Overall, Japan has remained at a constant level. In Finland, R&D personnel intensity has been decreasing slightly. The starting levels in both countries were disproportionately high, however. Finland, for example, with more than 22 R&D employees per thousand members of the general workforce, continues to be among the OECD leaders. For its part, Germany has experienced an increase in R&D personnel intensity: from about 12 R&D employees per thousand members of the general workforce in 2000 to nearly 14 per thousand in 2011. Korea's high rates of growth in this category contrast with the low rates seen in Germany and the EU; from 2000 to 2011, it has gone from 6.5 to about 15 R&D employees per thousand members of the general workforce.

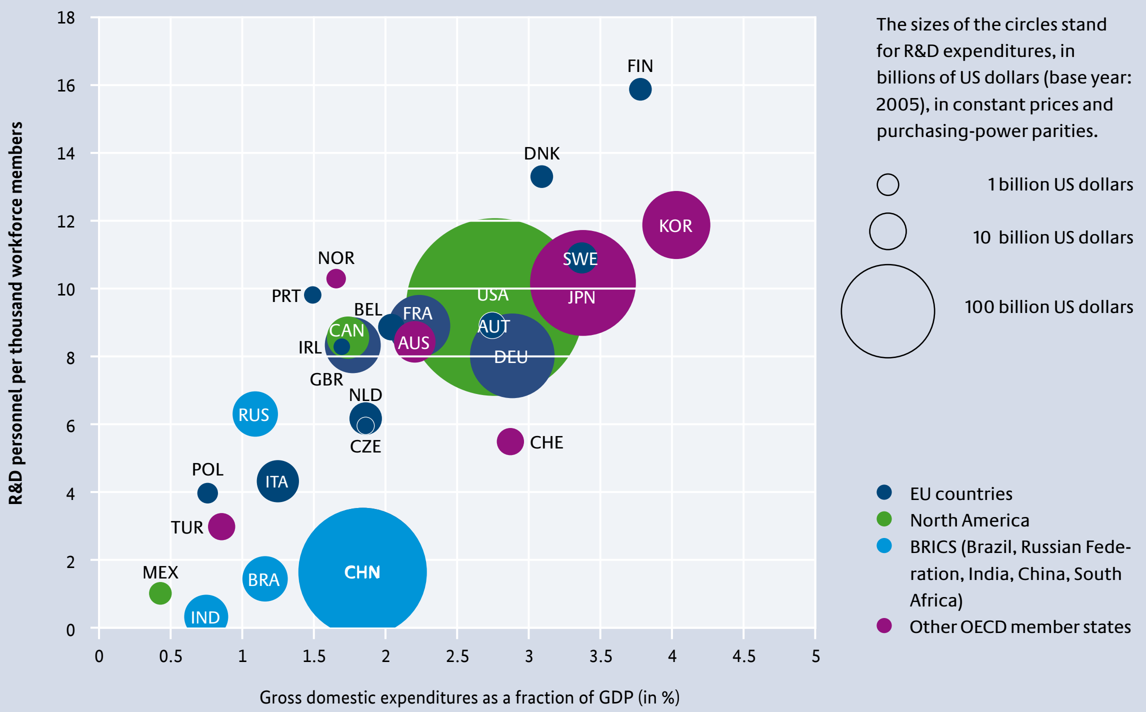
In a global context, the total numbers of R&D personnel (research personnel, technical personnel, other personnel) are more difficult to estimate, because the relevant statistical data are incomplete. The numbers of research personnel provide some orientation. Pursuant to the OECD's figures, the worldwide research-personnel workforce grew by about 42 % from 2000 to 2011 (reaching a level of about 6.3 million researchers worldwide[41] in 2011). During this period, the number of researchers rose from 695 000 to 1 318 000, an increase of about 90 %, in China alone.

Figure 30 provides an overview of global resources inputs in the area of R&D, in terms of the three di-

40 R&D personnel per thousand members of the general workforce, in full-time equivalents

41 Calculation pursuant to OECD-MSTI 2013/2, Table 7: Researchers in all OECD countries and in China, Argentina, Romania, the Russian Federation, Singapore, South Africa and Taiwan

Fig. 30 **Researchers and gross domestic expenditure on R&D (in % of GDP), in 2011**



Database: OECD STI Scoreboard 2013

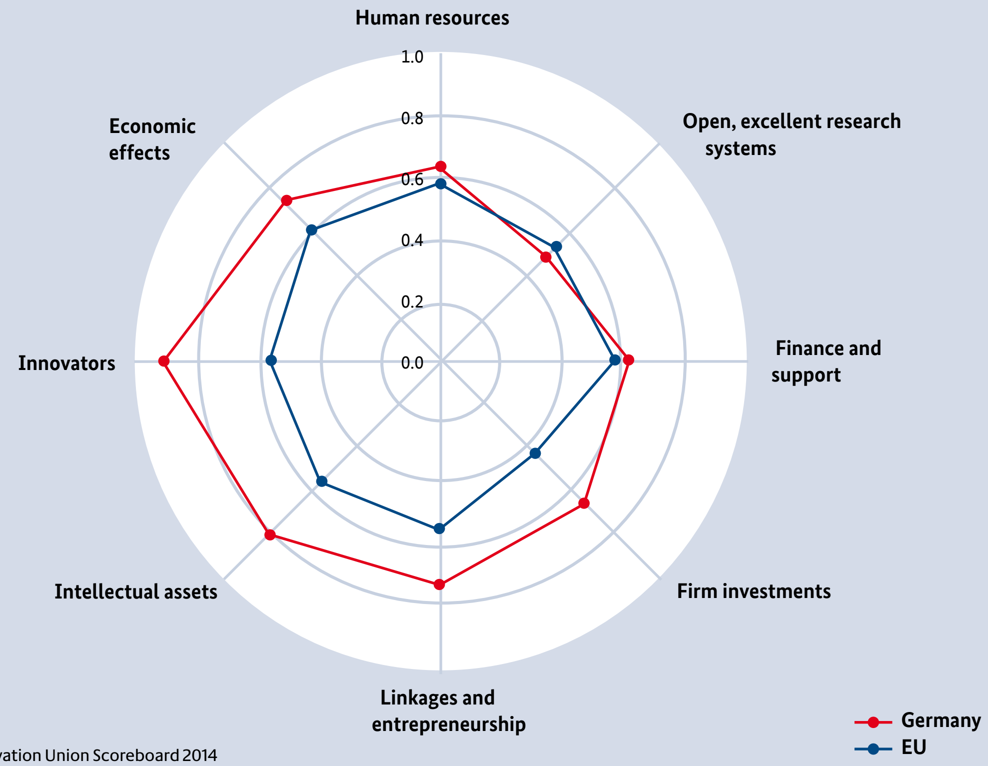
mensions R&D intensity, numbers of researchers in comparison to the general workforce and R&D expenditures in the base year 2011. In spite of the aforementioned data limitations – especially regarding data for BRICS countries – the relevant international positions are once again clear: The U.S. leads the rankings, with the highest R&D expenditures. It is followed in this regard by China, Japan, Germany and Korea. Korea has the world's highest R&D intensity and has registered high R&D growth rates over the past few years. The figure highlights the close connections between a) R&D expenditures and b) research personnel with respect to total workforce. In this perspective, Germany is relatively close to the U.S. and Japan and to other European countries. Significantly, the BRICS countries (still) show relatively low R&D intensity and R&D personnel-intensity levels. The variability in this overall interrelationship may be due to differences in R&D costs (especially costs for R&D personnel) or in patterns of R&D specialisation. The BRICS countries' rates of economic growth over the past few years give an indication of the growth they could experience in R&D categories, if they create the necessary basis for such growth.

Innovation Union Scoreboard

In the following considerations, individual indicators are supplemented with a composite indicator. Such indicators characterise countries' research and innovation systems in terms of a synthesis of multiple indicators. The Innovation Union Scoreboard (IUS) presented in the following is an instrument for monitoring implementation of the Innovation Union flagship initiative within the EU 2020 strategy. It measures the performance of EU Member States' innovation systems in terms of comparative data about innovation development. Specifically, the IUS takes account of 25 individual indicators, divided into three main groups:

- **Enablers:** Basic components for promotion of innovation (human resources, the openness and excellence of the research system, financing and support),
- **Firm activities:** Innovation-related efforts made by European companies (companies' R&D expenditures, linkages and entrepreneurship and intellectual assets and property),
- **Outputs:** Benefits for the economy as a whole (innovator rate and economic impacts of innovation efforts, including employment).

Fig. 31 **Innovation dimensions of the Innovation Union Scoreboard 2014**



Database: Innovation Union Scoreboard 2014

The IUS 2014 divides the Member States into four groups, in keeping with innovation performance:

- **Innovation leaders** have a level of performance that considerably exceeds the EU average.
- **Innovation followers** perform either slightly above or slightly below the EU average.
- **Moderate innovators** perform below the EU average.
- **Modest innovators** perform considerably below the EU average.

In the IUS 2014, Germany ranks third among all EU-28 countries and is thus within the group of innovation leaders. Overall, the IUS 2014, along with the indicators presented in the preceding sections, highlights the outstanding performance of the German innovation system and the current excellence of Germany's science sector. The IUS regularly places Germany among the top group of European innovation leaders.

The relative strengths of the German innovation system are found in the output dimensions "innovators", "intellectual assets", "economic effects" and "linkage". The largest increases in performance have been seen in cooperation by innovative SMEs and in Community trademarks.

Other strengths of the German innovation system are found in the science areas "international co-publications" and "new doctorate graduates". The relative weaknesses of the German innovation system, as identified by the IUS 2014, include a small number of non-EU doctorate students, a low level of venture capital investments and low licence and patent revenues from abroad.

– Access to the current IUS: http://ec.europa.eu/enterprise/policies/innovation/files/ius/ius-2014_en.pdf

5.5 Selected tables

(in brackets: the figure number in the long version of the Federal Report on Research and Innovation 2014)

Tab. 1 1/2 Gross domestic expenditure on R&D (GERD) of the Federal Republic of Germany by performing sectors

Performing sector[1, 2]	Millions of €					
	1981	1991	1995	2000	2005	2006
Private sector[3]						
Financed by						
Private sector	10 945	22 845	23 470	32 333	35 585	37 863
Government sector	2 260	2 640	2 742	2 448	1 723	1 854
Private non-profit sector	30	76	20	71	66	70
Abroad	159	685	584	748	1 278	1 361
Total	**13 394**	**26 246**	**26 817**	**35 600**	**38 651**	**41 148**
Government and private non-profit sector[4]						
Financed by						
Private sector	35	71	214	151	777	852
Government sector	2 601	5 214	5 890	6 444	6 524	6 680
Private non-profit sector	49	120	83	137	98	141
Abroad	27	53	79	141	469	483
Total	**2 712**	**5 457**	**6 266**	**6 873**	**7 867**	**8 156**
University sector						
Financed by						
Private sector	59	433	605	947	1 304	1 428
Government sector	3 255	5 713	6 694	7 001	7 575	7 645
Private non-profit sector	–	–	–	–	–	–
Abroad			78	198	342	402
Total	**3 313**	**6 145**	**7 378**	**8 146**	**9 221**	**9 475**
Gross domestic expenditure on R&D						
Financed by						
Private sector	11 039	23 348	24 289	33 431	37 666	40 143
Government sector	8 116	13 567	15 326	15 893	15 821	16 179
Private non-profit sector	78	196	104	208	164	211
Abroad	186	738	741	1 086	2 089	2 246
Total	**19 420**	**37 849**	**40 461**	**50 618**	**55 739**	**58 779**
GERD in % of BIP[5]	2.43	2.47	2.19	2.47	2.51	2.54

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 the private sector; until 1990 including non-apportionable government funding; as of 1992, government R&D funding for the private sector 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: (Research) institutions of the Federal Government, *Länder* and municipalities; 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 2005 modified calculation method.
5) Latest revision November 2013.

Source: Stifterverband Wissenschaftsstatistik Federal Statistical Office and Federal Ministry of Education and Research
Data portal of the BMBF: www.datenportal.bmbf.de/portal/1.1.1

Tab. 1 2/2 Gross domestic expenditure on R&D (GERD) of the Federal Republic of Germany by performing sectors

Performing sector[1, 2]	Millions of €				
	2007	2008	2009	2010	2011
Private sector[3]					
Financed by					
Private sector	39 427	42 211	41 662	43 183	46 659
Government sector	1 936	2 073	2 022	2 096	2 221
Private non-profit sector	74	79	39	40	133
Abroad	1 597	1 710	1 553	1 610	2 064
Total	**43 034**	**46 073**	**45 275**	**46 929**	**51 077**
Government and private non-profit sector[4]					
Financed by					
Private sector	923	865	973	927	1 019
Government sector	6 986	7 847	8 306	8 805	9 286
Private non-profit sector	143	128	137	124	131
Abroad	488	507	516	498	539
Total	**8 540**	**9 346**	**9 932**	**10 354**	**10 974**
University sector					
Financed by					
Private sector	1 532	1 682	1 680	1 766	1 877
Government sector	7 994	8 977	9 620	10 290	11 017
Private non-profit sector	–	–	–	–	–
Abroad	382	453	508	609	555
Total	**9 908**	**11 112**	**11 808**	**12 665**	**13 449**
Gross domestic expenditure on R&D					
Financed by					
Private sector	41 882	44 758	44 315	45 876	49 554
Government sector	16 915	18 897	19 947	21 191	22 525
Private non-profit sector	217	207	176	164	264
Abroad	2 468	2 670	2 577	2 716	3 158
Total	**61 482**	**66 532**	**67 015**	**69 948**	**75 500**
GERD in % of BIP[5]	2.53	2.69	2.82	2.80	2,89

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 the private sector; until 1990 including non-apportionable government funding; as of 1992, government R&D funding for the private sector 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: (Research) institutions of the Federal Government, *Länder* and municipalities; 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 2005 modified calculation method.
5) Latest revision November 2013.

Source: Stifterverband Wissenschaftsstatistik Federal Statistical Office and Federal Ministry of Education and Research
Data portal of the BMBF: www.datenportal.bmbf.de/portal/1.1.1

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

Year	Financed by: Territorial authorities[2] – Millions of €	Territorial authorities[2] – In % of the overall government budget[3]	Business enterprises[4] – Millions of €	Private non-profit institutions[5] – Millions of €	Total R&D expenditure – Millions of €
1981	8 981	3.2	11 154	78	**20 214**
1983	9 475	3.2	13 011	86	**22 571**
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**
2002	17 210	2.8	35 904	242	**53 356**
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	18 183	2.8	43 768	217	**62 168**
2008	19 874	2.9	46 890	207	**66 971**
2009	21 388	3.0	46 019	176	**67 583**
2010	22 480	3.1	47 409	164	**69 889**
2011	23 446	3.0	51 448	264	**75 158**

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 1: survey of performing sectors; Table 2: survey of financing sectors).
2) Federal Government and *Länder* governments. 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) Net expenditure without social insurance. As of 1998, does not include hospitals and university clinics with commercial accounting procedures.
4) 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 the private sector. Due to revision of the calculation method, figures as of 1991 are not comparable to data from earlier publications.
5) Financed from own funds. Some figures are estimates.

Source: Federal Statistical Office, Stifterverband Wissenschaftsstatistik and Federal Ministry of Education and Research
Data portal of the BMBF: www.datenportal.bmbf.de/portal/1.1.2

Tab. 3 Regional distribution of the total expenditure on research and development by the Federal Republic of Germany[1]

Federal *Land*	Performing of R&D							
	Total R&D expenditure							
	2003		2005		2010		2011	
	€ m	in %	€ m	in %	€ m	in %	€ m	in %
Baden-Wuerttemberg	12 322	22.6	13 702	24.6	17 039	24.4	19 462	25.8
Bavaria	11 348	20.8	11 458	20.6	13 608	19.5	14 403	19.1
Berlin	3 107	5.7	3 028	5.4	3 537	5.1	3 606	4.8
Brandenburg	550	1.0	572	1.0	795	1.1	954	1.3
Bremen	641	1.2	538	1.0	703	1.0	751	1.0
Hamburg	1 435	2.6	1 552	2.8	1 970	2.8	2 098	2.8
Hesse	5 107	9.4	5 204	9.4	6 769	9.7	6 827	9.1
Mecklenburg-West Pomerania	395	0.7	450	0.8	688	1.0	741	1.0
Lower Saxony	5 240	9.6	4 298	7.7	5 718	8.2	6 463	8.6
North Rhine-Westphalia	8 460	15.5	8 742	15.7	10 991	15.7	11 543	15.3
Rhineland-Palatinate	1 678	3.1	1 675	3.0	2 300	3.3	2 384	3.2
Saarland	277	0.5	289	0.5	390	0.6	471	0.6
Saxony	1 841	3.4	1 992	3.6	2 640	3.8	2 785	3.7
Saxony-Anhalt	531	1.0	550	1.0	731	1.0	769	1.0
Schleswig-Holstein	732	1.3	777	1.4	947	1.4	1 078	1.4
Thuringia	798	1.5	805	1.4	1 039	1.5	1 081	1.4
Total for all *Länder*	**54 462**	**.**	**55 631**	**100.0**	**69 865**	**100.0**	**75 416**	**100.0**
Of which: Eastern German *Länder* and Berlin	7 222	13.3	7 397	13.3	9 430	13.5	9 936	13.2
German institutions based abroad	56	.	57	.	83	.	84	.
Total[2]	**54 539**	**.**	**55 739**	**.**	**69 948**	**.**	**75 500**	**.**

1) Estimated in some cases.
2) Including non-apportionable government funding.
Source: Federal Statistical Office, Stifterverband Wissenschaftsstatistik and Federal Ministry of Education and Research

Tab. 4 1/3 Expenditure by the government for science, research and development by department[1]

Government departments[3]	Millions of €							
	ACTUAL							
	1991		1995		2000		2005	
	Total	Of which, R&D	Total	Of which, R&D	Total	Of which, R&D	Total	Of which, R&D
Federal Chancellor and Federal Chancellery[4]	177.8	79.8	228.6	63.0	232.5	69.2	282.8	91.0
Federal Foreign Office	176.5	123.0	181.3	122.9	177.8	121.7	179.3	123.2
Federal Ministry of the Interior	92.6	54.2	86.4	52.4	68.9	40.1	92.4	52.1
Federal Ministry of Justice	1.4	1.4	1.3	1.3	1.5	1.5	1.9	1.9
Federal Ministry of Finance	2.0	2.0	0.0	0.0	3.4	3.4	1.4	1.4
Federal Ministry of Economics and Technology	2 128.5	1 963.4	1 980.0	1 827.0	1 931.2	1 788.3	1 924.9	1 770.3
Federal Ministry of Labour and Social Affairs	48.1	17.6	49.9	21.1	59.0	27.9	70.6	39.5
Federal Ministry of Food, Agriculture and Consumer Protection	166.9	141.6	308.6	232.6	313.5	217.0	310.2	217.1
Federal Ministry of Defence	1 714.7	1 632.4	1 556.0	1 469.5	1 305.6	1 192.0	1 247.6	1 087.5
Federal Ministry for Family Affairs, Senior Citizens, Women and Youth	16.3	16.3	19.9	19.9	16.7	16.7	20.9	20.9
Federal Ministry of Health	262.3	156.1	168.6	94.7	246.0	91.5	228.7	99.6
Federal Ministry of Transport, Building and Urban Affairs	179.8	124.6	202.7	106.8	211.8	99.9	242.9	123.6
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety	276.4	196.3	300.2	176.4	280.9	163.1	337.9	183.1
Federal Ministry of Education and Research[5]	4 404.5	3 523.3	5 192.0	4 107.1	5 671.3	4 552.6	6 113.5	5 125.8
Federal Ministry for Economic Cooperation and Development	34.1	32.6	27.4	25.4	28.2	25.9	36.9	35.1
General Fiscal Administration[6]	606.7	567.3	79.5	79.5	68.3	68.3	56.2	56.2
Total expenditure	**10 288.5**	**8 631.9**	**10 382.5**	**8 399.7**	**10 616.6**	**8 479.2**	**11 148.2**	**9 028.3**

1) Divisions of departments and designation according to the organisational structure of the Federal Governemnt in the 17th legislative term.
2) Status: Federal Government's bill of 26 June 2013.
3) To facilitate comparison, expenditure for the new distribution of tasks has been applied retrospectively.
4) Including the expenditure by the Federal Government's representative for culture and media.
5) Planned expenditure, taking into account the proportional reduced global expenditure for science, R&D (2013: €239.2 million, 2014: €347.1 million).
6) Including payments for universities and projects in application-oriented research facilities in connection with the German reunification (1991 and 1995); from 2008 discontinuation of payments to the Volkswagen Foundation. 2010 and 2011 including investment and redemption fund without state allocations (economic stimulus package II), from 2011 including energy and climate funds. From 2012 research funding in the area of electro mobility is financed by the energy and climate fund.

Source: Federal Ministry of Education and Research
Data portal of the BMBF: www.datenportal.bmbf.de/portal/1.1.4

Tab. 4 2/3 Expenditure by the government for science, research and development by department[1]

Government departments[3]	Millions of €					
	ACTUAL					
	2010		2011		2012	
	Total	Of which, R&D	Total	Of which, R&D	Total	Of which, R&D
Federal Chancellor and Federal Chancellery[4]	308.6	87.0	288.8	79.2	303.3	89.4
Federal Foreign Office	255.0	183.4	248.1	164.6	263.5	171.6
Federal Ministry of the Interior	79.5	59.0	63.6	40.3	62.3	37.7
Federal Ministry of Justice	2.5	2.5	2.4	2.4	2.6	2.6
Federal Ministry of Finance	0.8	0.8	1.3	1.3	1.0	1.0
Federal Ministry of Economics and Technology	2 618.2	2 420.2	2 737.6	2 526.6	2 929.9	2 748.5
Federal Ministry of Labour and Social Affairs	71.1	33.1	79.3	36.9	84.8	36.9
Federal Ministry of Food, Agriculture and Consumer Protection	590.6	509.0	585.1	493.8	640.8	545.9
Federal Ministry of Defence	1 320.1	1 154.0	1 136.5	974.8	1 100.4	937.2
Federal Ministry for Family Affairs, Senior Citizens, Women and Youth	23.2	23.2	23.5	23.5	23.5	23.2
Federal Ministry of Health	272.0	124.4	271.0	120.4	300.1	132.1
Federal Ministry of Transport, Building and Urban Affairs	331.7	200.6	374.8	247.5	353.6	216.8
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety	404.9	234.5	435.5	243.8	482.4	274.1
Federal Ministry of Education and Research[5]	8 571.7	7 207.2	9 389.9	7 604.2	10 553.8	8 036.4
Federal Ministry for Economic Cooperation and Develop-ment	34.8	33.3	36.1	34.4	38.3	36.7
General Fiscal Administration[6]	509.6	492.9	715.0	692.3	185.0	185.0
Total expenditure	**15 394.3**	**12 765.1**	**16 388.6**	**13 285.8**	**17 325.3**	**13 474.8**

1) Divisions of departments and designation according to the organisational structure of the Federal Governemnt in the 17th legislative term.
2) Status: Federal Government's bill of 26 June 2013.
3) To facilitate comparison, expenditure for the new distribution of tasks has been applied retrospectively.
4) Including the expenditure by the Federal Government's representative for culture and media.
5) Planned expenditure, taking into account the proportional reduced global expenditure for science, R&D (2013: €239.2 million, 2014: €347.1 million).
6) Including payments for universities and projects in application-oriented research facilities in connection with the German reunification (1991 and 1995); from 2008 discontinuation of payments to the Volkswagen Foundation. 2010 and 2011 including investment and redemption fund without state allocations (economic stimulus package II), from 2011 including energy and climate funds. From 2012 research funding in the area of electro mobility is financed by the energy and climate fund.
Source: Federal Ministry of Education and Research
Data portal of the BMBF: www.datenportal.bmbf.de/portal/1.1.4

Tab. 4 3/3 Expenditure by the government for science, research and development by department[1]

Government departments[3]	Millions of €			
	Target		Government bill	
	2013		2014[2]	
	Total	Of which, R&D	Total	Of which, R&D
Federal Chancellor and Federal Chancellery[4]	311.6	95.5	310.5	95.6
Federal Foreign Office	282.7	174.5	272.4	164.2
Federal Ministry of the Interior	72.7	49.1	65.7	42.1
Federal Ministry of Justice	3.1	3.1	3.4	3.4
Federal Ministry of Finance	3.9	3.9	1.9	1.9
Federal Ministry of Economics and Technology	3 124.9	2 948.7	3 145.5	2 965.5
Federal Ministry of Labour and Social Affairs	94.4	45.2	93.9	45.4
Federal Ministry of Food, Agriculture and Consumer Protection	653.2	556.1	683.9	576.2
Federal Ministry of Defence	1 153.9	981.6	1 048.4	873.0
Federal Ministry for Family Affairs, Senior Citizens, Women and Youth	26.0	25.9	24.2	24.0
Federal Ministry of Health	345.7	166.3	345.9	163.8
Federal Ministry of Transport, Building and Urban Affairs	346.6	217.0	375.9	244.9
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety	515.1	297.6	509.5	293.7
Federal Ministry of Education and Research[5]	11 512.1	8 262.7	11 664.5	8 442.4
Federal Ministry for Economic Cooperation and Development	43.6	41.8	46.4	44.4
General Fiscal Administration[6]	589.4	589.4	424.8	423.4
Total expenditure	**19 079.2**	**14 458.5**	**19 017.0**	**14 404.0**

1) Divisions of departments and designation according to the organisational structure of the Federal Governemnt in the 17th legislative term.
2) Status: Federal Government's bill of 26 June 2013.
3) To facilitate comparison, expenditure for the new distribution of tasks has been applied retrospectively.
4) Including the expenditure by the Federal Government's representative for culture and media.
5) Planned expenditure, taking into account the proportional reduced global expenditure for science, R&D (2013: €239.2 million, 2014: €347.1 million).
6) Including payments for universities and projects in application-oriented research facilities in connection with the German reunification (1991 and 1995); from 2008 discontinuation of payments to the Volkswagen Foundation. 2010 and 2011 including investment and redemption fund without state allocations (economic stimulus package II), from 2011 including energy and climate funds. From 2012 research funding in the area of electro mobility is financed by the energy and climate fund.
Source: Federal Ministry of Education and Research
Data portal of the BMBF: www.datenportal.bmbf.de/portal/1.1.4

Tab. 5 1/6 Expenditure by the government for science, research and development by funding area and funding priorities[1]

Funding area / Funding priority		Millions of € ACTUAL 2011[2] Total	2011[2] Of which R&D	2012[2] Total	2012[2] Of which R&D
A	**Health research and health economy**	**1 869.1**	**1 706.0**	**1 989.6**	**1 811.9**
AA	Health research and health economy	1 852.4	1 694.1	1 971.4	1 794.4
AB	Radiation protection	16.7	11.8	18.2	17.5
B	**Bio-economy**	**225.7**	**225.6**	**261.8**	**261.8**
C	**Civilian safety research**	**97.6**	**92.6**	**101.7**	**97.0**
D	**Nutrition, agriculture and consumer protection**	**664.0**	**565.6**	**726.9**	**629.8**
DA	Nutrition	25.3	17.5	26.9	18.4
DB	Sustainable agriculture and rural areas	399.6	374.0	444.2	417.6
DC	Health-related and commercial consumer protection	239.1	174.1	255.8	193.9
E	**Energy research and energy technologies**	**1 182.6**	**857.1**	**1 387.6**	**1 021.2**
EA	Rational energy conversion	294.2	292.7	423.0	422.7
EB	Renewable energies	272.2	269.9	318.4	316.6
EC	Nuclear safety and disposal	255.9	122.0	273.7	130.0
ED	Disposal of nuclear plants	221.5	34.2	237.9	17.2
EF	Fusion research	138.9	138.3	134.7	134.7
F	**Climate, environment, sustainability**	**1 194.3**	**1 007.8**	**1 279.7**	**1 082.4**
FA	Climate, climate protection; global change	221.3	219.5	240.9	240.7
FB	Coast, marine and polar research, geosciences	362.9	312.1	387.7	337.0
FC	Environment and sustainability research	321.0	241.6	343.0	258.1
FD	Ecology, nature conservation and sustainable use	289.0	234.6	308.0	246.7
G	**Information and communication technologies**	**761.5**	**733.2**	**768.0**	**747.9**
GA	Software systems; science technologies	231.7	227.9	211.6	211.5
GB	Communication technologies and services	77.0	75.6	75.7	75.4
GC	Electronics and electronic systems	225.1	223.2	247.7	247.3
GD	Micro-systems engineering	125.8	125.1	125.5	125.4
GE	Multimedia – development of convergent ICT	101.9	81.4	107.6	88.2

1) According to the Federal Government's planning system 2009. Expenditure was implemented in accordance with the Federal Government's planning system 2009. Expenditures of non-university research institutes is distributed to individual funding areas and funding priorities. This applies for the first time for DFG, FhG and MPG.
2) 2010 and 2011 including investment and redemption fund without state allocations (economic stimulus package II), from 2011 including energy and climate funds. From 2012 research funding in the area of electro mobility is financed by the energy and climate fund.
3) Distribution of funding areas and funding priorities estimated or extrapolated in some cases.
4) Status: Federal Government's bill of 26 June 2013.
5) Including universities of the Federal Armed Forces and the Federal University of Applied Administrative Sciences.
6) The distribution of the global reduced expenditure of the BMBF to funding areas or funding priorities can only be carried out in the ACTUAL.
7) Slight differences compared to earlier publications due to subsequent amendments to the allocation to the funding areas/funding priorities.
Source: Federal Ministry of Education and Research
Data portal of the BMBF: www.datenportal.bmbf.de/portal/1.1.5

Tab. 5 2/6 Expenditure by the government for science, research and development by funding area and funding priorities[1]

Funding area Funding priority		Millions of €			
		ACTUAL			
		2011[2]		2012[2]	
		Total	Of which R&D	Total	Of which R&D
H	**Vehicle and traffic technologies including maritime technologies**	**605.5**	**514.1**	**300.9**	**217.9**
HA	Vehicle and traffic technologies	558.5	477.8	248.5	180.1
HB	Maritime technologies	47.0	36.3	52.4	37.8
I	**Aerospace**	**1 327.5**	**1 325.3**	**1 312.4**	**1 312.1**
IA	Aviation	234.0	233.5	225.2	225.2
IB	National space research and space engineering	453.1	452.4	446.8	446.6
IC	European Space Organisation ESA	640.5	639.3	640.5	640.3
J	**Research and development to improve the work conditions and in the service sector**	**146.1**	**98.0**	**140.6**	**91.8**
JA	Research to improve work conditions	103.5	59.5	107.4	59.2
JB	Research in the service sector	42.6	38.5	33.3	32.6
K	**Nanotechnologies and materials technologies**	**488.3**	**460.7**	**514.0**	**489.1**
KA	Nanotechnologies	195.3	189.9	191.0	188.8
KB	Materials technologies	293.0	270.8	323.0	300.3
L	**Optical technologies**	**172.7**	**168.5**	**184.8**	**184.2**
M	**Production technologies**	**208.9**	**207.0**	**199.3**	**199.0**
N	**Spatial planning and urban development; construction research**	**76.3**	**73.3**	**84.0**	**80.6**
NA	Spatial planning, urban development and living	18.4	18.1	19.9	19.6
NB	Construction research	58.0	55.2	64.1	61.0
O	**Innovations in education**	**703.7**	**417.1**	**749.6**	**434.5**
OA	Educational reporting, international assessments	405.3	238.9	425.6	247.7
OB	Education research	279.2	159.0	307.1	169.7
OC	New media in education	19.1	19.1	17.0	17.0
P	**Humanities; economic and social sciences**	**1 050.1**	**822.1**	**1 116.9**	**874.7**
PA	Humanities research	650.5	428.1	694.5	466.3
PB	Social science research	179.2	176.2	202.2	188.6
PC	Economic and financial science research	67.4	67.4	72.9	72.9
PD	Infrastructures	152.9	150.5	147.3	146.9

1) According to the Federal Government’s planning system 2009. Expenditure was implemented in accordance with the Federal Government’s planning system 2009. Expenditures of non-university research institutes is distributed to individual funding areas and funding priorities. This applies for the first time for DFG, FhG and MPG.
2) 2010 and 2011 including investment and redemption fund without state allocations (economic stimulus package II), from 2011 including energy and climate funds. From 2012 research funding in the area of electro mobility is financed by the energy and climate fund.
3) Distribution of funding areas and funding priorities estimated or extrapolated in some cases.
4) Status: Federal Government‘s bill of 26 June 2013.
5) Including universities of the Federal Armed Forces and the Federal University of Applied Administrative Sciences.
6) The distribution of the global reduced expenditure of the BMBF to funding areas or funding priorities can only be carried out in the ACTUAL.
7) Slight differences compared to earlier publications due to subsequent amendments to the allocation to the funding areas/funding priorities.
Source: Federal Ministry of Education and Research
Data portal of the BMBF: www.datenportal.bmbf.de/portal/1.1.5

Tab. 5 3/6 Expenditure by the government for science, research and development by funding area and funding priorities[1]

Funding area Funding priority		Millions of € ACTUAL 2011[2] Total	2011[2] Of which R&D	2012[2] Total	2012[2] Of which R&D
Q	**Innovation funding for small and medium-sized enterprises**	**1 253.8**	**1 243.2**	**1 012.9**	**998.8**
QA	Start-up funding	77.2	77.2	71.6	71.6
QB	Technology funding for small and medium-sized enterprises	825.8	821.6	565.8	565.2
QC	Technology transfer and innovation consulting	157.4	151.4	177.3	163.9
QD	Research infrastructure for small and medium-sized enterprises	193.5	193.1	198.3	198.2
R	**Innovation-relevant underlying conditions and other cross-cutting activities**	**407.9**	**330.9**	**447.0**	**368.5**
RA	Technology assessment	5.4	5.4	5.5	5.5
RB	Structural cross-cutting activities	73.3	54.7	66.5	45.6
RC	Demographic change	36.7	36.7	40.4	40.4
RD	Sport funding and sport research	18.7	18.7	19.1	19.1
RE	Other	273.8	215.4	315.4	257.9
T	**Funding organisations, restructuring of the research field in acceding areas; construction of universities and primarily university-specific special programmes[5]**	**1 987.5**	**539.3**	**2 749.7**	**634.5**
TA	Basic funding for research institutes	0.5	0.3	0.5	0.5
TB	Other	1 987.0	539.0	2 749.2	634.0
U	**Large appliances in the basic research field**	**946.2**	**946.0**	**1 024.4**	**1 024.4**
Z	**Global reduced expenditure; budget reserve[6]**	**0.0**	**0.0**	**0.0**	**0.0**
Civilian funding areas combined		**15 369.4**	**12 333.2**	**16 351.9**	**12 562.0**
S	**Military science research**	**1 019.2**	**952.6**	**973.4**	**912.8**
SA	Military medicine and military psychology research	45.0	14.9	42.7	13.4
SB	Defence research	951.0	932.0	909.6	893.9
SC	Social science research	1.6	1.0	1.6	1.0
SD	Military history research	8.1	3.5	8.3	3.5
SE	Geoscientific research	13.4	1.2	11.3	1.0
Total expenses[7]		**16 388.6**	**13 285.8**	**17 325.3**	**13 474.8**

1) According to the Federal Government's planning system 2009. Expenditure was implemented in accordance with the Federal Government's planning system 2009. Expenditures of non-university research institutes is distributed to individual funding areas and funding priorities. This applies for the first time for DFG, FhG and MPG.
2) 2010 and 2011 including investment and redemption fund without state allocations (economic stimulus package II), from 2011 including energy and climate funds. From 2012 research funding in the area of electro mobility is financed by the energy and climate fund.
3) Distribution of funding areas and funding priorities estimated or extrapolated in some cases.
4) Status: Federal Government's bill of 26 June 2013.
5) Including universities of the Federal Armed Forces and the Federal University of Applied Administrative Sciences.
6) The distribution of the global reduced expenditure of the BMBF to funding areas or funding priorities can only be carried out in the ACTUAL.
7) Slight differences compared to earlier publications due to subsequent amendments to the allocation to the funding areas/funding priorities.
Source: Federal Ministry of Education and Research
Data portal of the BMBF: www.datenportal.bmbf.de/portal/1.1.5

Tab. 5 4/6 Expenditure by the government for science, research and development by funding area and funding priorities[1]

Funding area Funding priority		Millions of €			
		Target		**Government bill**	
		2013[2, 3]		**2014[2, 3, 4]**	
		Total	Of which R&D	Total	Of which R&D
A	**Health research and health economy**	**2 116.4**	**1 928.1**	**2 176.1**	**1 984.9**
AA	Health research and health economy	2 096.9	1 909.3	2 154.3	1 963.8
AB	Radiation protection	19.5	18.8	21.8	21.1
B	**Bio-economy**	**277.6**	**277.6**	**281.2**	**281.1**
C	**Civilian safety research**	**104.5**	**100.5**	**102.8**	**98.4**
D	**Nutrition, agriculture and consumer protection**	**762.0**	**662.9**	**792.5**	**682.6**
DA	Nutrition	30.5	21.0	31.4	21.7
DB	Sustainable agriculture and rural areas	486.8	456.7	497.1	465.0
DC	Health-related and commercial consumer protection	244.7	185.2	264.1	195.9
E	**Energy research and energy technologies**	**1 562.1**	**1 230.0**	**1 566.5**	**1 239.1**
EA	Rational energy conversion	538.2	538.0	531.5	531.2
EB	Renewable energies	410.8	409.2	417.6	415.9
EC	Nuclear safety and disposal	278.5	124.7	276.0	127.3
ED	Disposal of nuclear plants	191.5	15.0	192.0	15.2
EF	Fusion research	143.1	143.0	149.4	149.4
F	**Climate, environment, sustainability**	**1 381.8**	**1 191.7**	**1 416.1**	**1 220.0**
FA	Climate, climate protection; global change	280.1	279.9	288.4	286.8
FB	Coast, marine and polar research, geosciences	449.9	402.7	462.8	415.5
FC	Environment and sustainability research	343.8	259.9	354.5	267.8
FD	Ecology, nature conservation and sustainable use	308.0	249.2	310.5	249.9
G	**Information and communication technologies**	**852.7**	**821.9**	**796.9**	**771.5**
GA	Software systems; science technologies	224.1	224.0	219.7	219.6
GB	Communication technologies and services	101.6	101.4	101.6	101.4
GC	Electronics and electronic systems	307.9	307.5	259.0	258.6
GD	Micro-systems engineering	118.8	118.7	123.6	123.5
GE	Multimedia – development of convergent ICT	100.3	70.4	93.0	68.4

1) According to the Federal Government's planning system 2009. Expenditure was implemented in accordance with the Federal Government's planning system 2009. Expenditures of non-university research institutes is distributed to individual funding areas and funding priorities. This applies for the first time for DFG, FhG and MPG.
2) 2010 and 2011 including investment and redemption fund without state allocations (economic stimulus package II), from 2011 including energy and climate funds. From 2012 research funding in the area of electro mobility is financed by the energy and climate fund.
3) Distribution of funding areas and funding priorities estimated or extrapolated in some cases.
4) Status: Federal Government's bill of 26 June 2013.
5) Including universities of the Federal Armed Forces and the Federal University of Applied Administrative Sciences.
6) The distribution of the global reduced expenditure of the BMBF to funding areas or funding priorities can only be carried out in the ACTUAL.
7) Slight differences compared to earlier publications due to subsequent amendments to the allocation to the funding areas/funding priorities.
Source: Federal Ministry of Education and Research
Data portal of the BMBF: www.datenportal.bmbf.de/portal/1.1.5

Tab. 5 5/6 Expenditure by the government for science, research and development by funding area and funding priorities[1]

Funding area Funding priority		Millions of € Target 2013[2, 3] Total	Of which R&D	Government bill 2014[2, 3, 4] Total	Of which R&D
H	**Vehicle and traffic technologies including maritime technologies**	**424.2**	**346.8**	**391.1**	**312.3**
HA	Vehicle and traffic technologies	367.1	303.9	333.8	269.1
HB	Maritime technologies	57.1	43.0	57.3	43.2
I	**Aerospace**	**1 435.1**	**1 434.8**	**1 459.1**	**1 458.8**
IA	Aviation	265.0	264.9	271.2	271.2
IB	National space research and space engineering	527.0	526.9	542.2	542.1
IC	European Space Organisation ESA	643.2	643.0	645.6	645.5
J	**Research and development to improve the work conditions and in the service sector**	**137.2**	**87.2**	**136.4**	**87.1**
JA	Research to improve work conditions	108.2	58.8	107.2	58.4
JB	Research in the service sector	29.0	28.4	29.3	28.7
K	**Nanotechnologies and materials technologies**	**565.1**	**542.1**	**546.9**	**523.0**
KA	Nanotechnologies	200.8	198.8	199.4	197.2
KB	Materials technologies	364.3	343.3	347.5	325.7
L	**Optical technologies**	**178.2**	**177.7**	**188.1**	**187.5**
M	**Production technologies**	**216.7**	**216.4**	**216.9**	**216.6**
N	**Spatial planning and urban development; construction research**	**84.8**	**81.9**	**92.2**	**89.1**
NA	Spatial planning, urban development and living	21.9	21.6	23.6	23.3
NB	Construction research	62.9	60.3	68.6	65.8
O	**Innovations in education**	**779.8**	**448.1**	**801.5**	**465.0**
OA	Educational reporting, international assessments	437.3	250.6	419.1	239.0
OB	Education research	332.5	187.5	372.6	216.3
OC	New media in education	10.0	10.0	9.8	9.8
P	**Humanities; economic and social sciences**	**1 213.0**	**957.8**	**1 231.4**	**977.3**
PA	Humanities research	741.8	510.6	751.7	521.7
PB	Social science research	235.1	211.5	240.1	216.4
PC	Economic and financial science research	79.6	79.6	83.0	83.0
PD	Infrastructures	156.4	156.1	156.6	156.3

1) According to the Federal Government's planning system 2009. Expenditure was implemented in accordance with the Federal Government's planning system 2009. Expenditures of non-university research institutes is distributed to individual funding areas and funding priorities. This applies for the first time for DFG, FhG and MPG.
2) 2010 and 2011 including investment and redemption fund without state allocations (economic stimulus package II), from 2011 including energy and climate funds. From 2012 research funding in the area of electro mobility is financed by the energy and climate fund.
3) Distribution of funding areas and funding priorities estimated or extrapolated in some cases.
4) Status: Federal Government's bill of 26 June 2013.
5) Including universities of the Federal Armed Forces and the Federal University of Applied Administrative Sciences.
6) The distribution of the global reduced expenditure of the BMBF to funding areas or funding priorities can only be carried out in the ACTUAL.
7) Slight differences compared to earlier publications due to subsequent amendments to the allocation to the funding areas/funding priorities.
Source: Federal Ministry of Education and Research
Data portal of the BMBF: www.datenportal.bmbf.de/portal/1.1.5

Tab. 5 6/6 Expenditure by the government for science, research and development by funding area and funding priorities[1]

Funding area Funding priority		Millions of €			
		Target		Government bill	
		2013[2, 3]		2014[2, 3, 4]	
		Total	Of which R&D	Total	Of which R&D
Q	**Innovation funding for small and medium-sized enterprises**	**1 143.1**	**1 128.3**	**1 107.7**	**1 093.3**
QA	Start-up funding	91.5	91.5	80.9	80.9
QB	Technology funding for small and medium-sized enterprises	616.4	615.9	620.3	619.8
QC	Technology transfer and innovation consulting	235.1	221.0	201.4	187.6
QD	Research infrastructure for small and medium-sized enterprises	200.0	199.9	205.0	205.0
R	**Innovation-relevant underlying conditions and other cross-cutting activities**	**475.7**	**399.4**	**490.7**	**410.7**
RA	Technology assessment	5.5	5.5	5.8	5.8
RB	Structural cross-cutting activities	64.9	43.3	65.3	43.9
RC	Demographic change	48.7	48.7	46.8	46.8
RD	Sport funding and sport research	21.0	21.0	20.0	20.0
RE	Other	335.6	280.9	352.7	294.1
T	**Funding organisations, restructuring of the research field in acceding areas; construction of universities and primarily university-specific special programmes[5]**	**3 469.0**	**586.6**	**3 545.8**	**689.0**
TA	Basic funding for research institutes	0.5	0.4	0.5	0.4
TB	Other	3 468.5	586.2	3 545.3	688.6
U	**Large appliances in the basic research field**	**1 122.2**	**1 122.2**	**1 117.7**	**1 117.7**
Z	**Global reduced expenditure; budget reserve[6]**	**−239.2**	**−239.2**	**−347.1**	**−347.1**
Civilian funding areas combined		**18 062.0**	**13 502.8**	**18 110.4**	**13 558.0**
S	**Military science research**	**1 017.2**	**955.7**	**906.6**	**846.0**
SA	Military medicine and military psychology research	45.5	15.9	43.2	14.9
SB	Defence research	948.1	934.9	839.7	826.1
SC	Social science research	4.7	1.6	4.9	1.9
SD	Military history research	5.0	2.0	5.0	1.9
SE	Geoscientific research	13.8	1.2	13.8	1.2
Total expenses[7]		**19 079.2**	**14 458.5**	**19 017.0**	**14 404.0**

1) According to the Federal Government's planning system 2009. Expenditure was implemented in accordance with the Federal Government's planning system 2009. Expenditures of non-university research institutes is distributed to individual funding areas and funding priorities. This applies for the first time for DFG, FhG and MPG.
2) 2010 and 2011 including investment and redemption fund without state allocations (economic stimulus package II), from 2011 including energy and climate funds. From 2012 research funding in the area of electro mobility is financed by the energy and climate fund.
3) Distribution of funding areas and funding priorities estimated or extrapolated in some cases.
4) Status: Federal Government's bill of 26 June 2013.
5) Including universities of the Federal Armed Forces and the Federal University of Applied Administrative Sciences.
6) The distribution of the global reduced expenditure of the BMBF to funding areas or funding priorities can only be carried out in the ACTUAL.
7) Slight differences compared to earlier publications due to subsequent amendments to the allocation to the funding areas/funding priorities.
Source: Federal Ministry of Education and Research
Data portal of the BMBF: www.datenportal.bmbf.de/portal/1.1.5

Tab. 6 1/2 Expenditure by the government for science, research and development by recipient group

Recipient group		Millions of € ACTUAL			
		2009[1]		2010[1]	
		Total	Of which R&D	Total	Of which R&D
1.	**Territorial authorities**	**4 075.8**	**2 191.9**	**4 315.9**	**2 312.7**
1.1	Federal Government	1 873.9	891.0	1 931.5	927.0
1.1.1	Federal Government-owned research institutions	1 631.2	832.5	1 680.4	866.4
1.1.2	Other institutions of Federal administration[2]	242.8	58.5	251.1	60.6
1.2	*Länder* and communities	2 201.8	1 300.9	2 384.4	1.385.7
1.2.1	Research institutions of the *Länder*	99.2	94.8	106.5	101.2
1.2.2	Universities and university hospitals[3]	1 338.7	1 144.2	1 494.3	1 214.9
1.2.3	Other institutions of the *Länder*	734.3	35.4	745.3	40.4
1.2.4	Communities, local authority and special-purpose associations	29.7	26.6	38.3	29.2
2.	**Private non-profit organisations[4]**	**6 738.1**	**6 351.4**	**7 085.9**	**6 668.8**
2.1	Research funding organisations	3 268.0	3 109.2	3 554.1	3 361.7
2.2	Helmholtz Association of German Research Centres (HGF)	2 379.8	2 332.9	2 399.3	2 345.4
2.3	Other non-profit science organisations	986.7	830.3	1 018.9	873.8
2.4	Other non-profit organisations	103.5	78.9	113.6	87.9
3.	**Private sector[6]**	**2 454.2**	**2 288.1**	**2 753.7**	**2 598.7**
3.1	Private sector	1 737.5	1 591.6	1 952.0	1 823.9
3.2	Services if rendered by companies and the professions	716.7	696.5	801.8	774.8
4.	**Abroad**	**1 188.8**	**1 138.3**	**1 235.0**	**1 182.6**
4.1	Payments to the private sector abroad	150.6	146.9	154.4	149.0
4.2	Contributions to international organisations and other payments to recipients abroad	1 038.2	991.4	1 080.6	1 033.6
5.	**Cross-group positions**	**3.9**	**2.7**	**3.7**	**2.2**
Total expenditure[7]		**14 460.8**	**11 972.4**	**15 394.2**	**12 765.0**
	For information:				
	Private sector[6]:	2 454.2	2 288.1	2 753.7	2 598.7
	Of which:[8]				
	Federal Ministry of Economics	863.8	857.5	822.3	814.8
	Federal Ministry of Defence	645.2	645.2	606.6	606.6
	Federal Ministry of Education and Research	701.6	542.7	729.6	587.6

1) 2009 and 2011 including investment and redemption fund without state allocations (economic stimulus package II), from 2011 including energy and climate funds. From 2012 research funding in the area of electro mobility is financed by the energy and climate fund.
2) Including Universities of the Federal Armed Forces. 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.
3) Not including basic funding for DFG and funding for collaborative research centres.
4) Without funds to international organisations situated overseas.
5) Including basic funding for DFG and funding for collaborative research centres.
6) Including funding to promote contract research; differentiation in keeping with the classification of economic activities; not including funding for the private sector abroad.
7) Minor discrepancies with regard to earlier publications are due to subsequent data collection and/or retroactive revision of the allocation to recipient groups.
8) Divisions of departments and designation according to the organisational structure of the Federal Government in the 17th legislative term.
Source: Federal Ministry of Education and Research
Data portal of the BMBF: www.datenportal.bmbf.de/portal/1.1.8

Tab. 6 2/2 Expenditure by the government for science, research and development by recipient group

Recipient group		Millions of €			
		ACTUAL			
		2011[1]		2012[1]	
		Total	Of which R&D	Total	Of which R&D
1.	**Territorial authorities**	**4 954.6**	**2 513.7**	**5 956.7**	**2 825.6**
1.1	Federal Government	1 985.8	934.7	2 168.0	1 087.9
1.1.1	Federal Government-owned research institutions	1 746.1	868.8	1 886.5	995.2
1.1.2	Other institutions of Federal administration[2]	239.7	65.9	281.5	92.8
1.2	*Länder* and communities	2 968.8	1 579.0	3 788.7	1 737.7
1.2.1	Research institutions of the *Länder*	121.9	116.4	126.9	121.1
1.2.2	Universities and university hospitals[3]	2 058.3	1 390.1	2 879.5	1 542.2
1.2.3	Other institutions of the *Länder*	742.0	36.9	736.4	38.0
1.2.4	Communities, local authority and special-purpose associations	46.7	35.5	45.8	36.4
2.	**Private non-profit organisations[4]**	**7 283.1**	**6 854.6**	**7 662.4**	**7 180.0**
2.1	Research funding organisations	3 536.5	3 363.5	3 721.3	3 524.2
2.2	Helmholtz Association of German Research Centres (HGF)	2 603.2	2 529.0	2 722.6	2 624.7
2.3	Other non-profit science organisations	1 032.6	878.4	1 095.0	945.3
2.4	Other non-profit organisations	110.7	83.7	123.5	85.7
3.	**Private sector[6]**	**2 937.2**	**2 759.0**	**2 446.6**	**2 271.7**
3.1	Private sector	2 108.1	1 957.4	1 731.9	1 584.4
3.2	Services if rendered by companies and the professions	829.1	801.6	714.6	687.4
4.	**Abroad**	**1 211.4**	**1 157.1**	**1 253.3**	**1 196.8**
4.1	Payments to the private sector abroad	128.9	122.8	104.9	96.8
4.2	Contributions to international organisations and other payments to recipients abroad	1 082.4	1 034.3	1 148.3	1 099.9
5.	**Cross-group positions**	**2.3**	**1.4**	**6.4**	**0.8**
Total expenditure[7]		**16 388.6**	**13 285.8**	**17 325.4**	**13 474.9**
	For information:				
	Private sector[6]:	2 937.2	2 759.0	2 446.6	2 271.7
	Of which:[8]				
	Federal Ministry of Economics	869.7	865.2	922.9	918.4
	Federal Ministry of Defence	557.7	557.7	496.9	496.9
	Federal Ministry of Education and Research	750.9	592.3	697.6	532.2

1) 2009 and 2011 including investment and redemption fund without state allocations (economic stimulus package II), from 2011 including energy and climate funds. From 2012 research funding in the area of electro mobility is financed by the energy and climate fund.
2) Including Universities of the Federal Armed Forces. 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.
3) Not including basic funding for DFG and funding for collaborative research centres.
4) Without funds to international organisations situated overseas.
5) Including basic funding for DFG and funding for collaborative research centres.
6) Including funding to promote contract research; differentiation in keeping with the classification of economic activities; not including funding for the private sector abroad.
7) Minor discrepancies with regard to earlier publications are due to subsequent data collection and/or retroactive revision of the allocation to recipient groups.
8) Divisions of departments and designation according to the organisational structure of the Federal Government in the 17th legislative term.
Source: Federal Ministry of Education and Research
Data portal of the BMBF: www.datenportal.bmbf.de/portal/1.1.8

Tab. 7 1/2 Gross domestic expenditure for research and development by funding and performing sectors in selected OECD states

Country	Year[1]	R&D expenditure		Financed by			Performed by			
		Millions of US $[2]	Share of GDP in %	Private sector	Govern-ment sector	Other domestic sources and abroad	Private sector	Govern-ment sector	Univer-sity sector[3]	PNP sector[4]
				Anteil in %						
Germany[5]	2008	81 970.7	2.69	67.3	28.4	4.3	69.2	14.0	16.7	.
	2009	83 133.7	2.82	66.1	29.8	4.1	67.6	14.8	17.6	.
	2010	87 831.8	2.80	65.6	30.3	4.1	67.1	14.8	18.1	.
	2011	96 971.5	2.89	65.6	29.8	4.5	67.7	14.5	17.8	.
	2012	100 247.6	2.92	.	.	.	66.9	14.8	18.3	.
Finland	2008	7 487.9	3.70	70.3	21.8	7.9	74.3	8.0	17.2	0.5
	2009	7 543.0	3.94	68.1	24.0	7.9	71.4	9.1	18.9	0.6
	2010	7 653.9	3.90	66.1	25.7	8.2	69.6	9.2	20.4	0.7
	2011	7 897.7	3.80	67.0	25.0	8.0	70.5	8.8	20.0	0.7
	2012	7 530.1	3.55	63.1	26.7	10.2	68.7	9.0	21.6	0.7
France	2008	46 547.8	2.12	50.8	38.9	10.3	62.7	16.0	20.0	1.2
	2009	49 944.2	2.27	52.3	38.7	9.0	61.7	16.3	20.8	1.2
	2010	50 735.6	2.24	53.5	37.1	9.4	63.2	14.0	21.6	1.2
	2011	53 310.7	2.25	55.0	35.4	9.6	63.9	13.9	21.0	1.2
	2012	54 679.9	2.26	.	.	.	64.2	13.7	20.8	1.2
Italy	2008	24 076.1	1.21	45.9	42.0	12.1	53.6	12.7	30.5	3.2
	2009	24 741.5	1.26	44.2	42.1	13.7	53.3	13.1	30.3	3.3
	2010	25 154.4	1.26	44.7	41.6	13.8	53.9	13.7	28.8	3.6
	2011	25 780.8	1.25	45.1	41.9	13.0	54.6	13.4	28.6	3.3
	2012	26 320.5	1.27	.	.	.	54.5	13.7	28.6	3.1
Sweden[6]	2008	13 496.1	3.70	.	.	.	74.1	4.4	21.3	0.2
	2009	12 647.1	3.62	59.1	27.3	13.6	70.6	4.4	24.9	0.1
	2010	12 586.8	3.39	.	.	0.0	68.7	4.9	26.3	0.0
	2011	13 366.3	3.39	57.3	27.7	15.0	68.8	4.3	26.5	0.3
	2012	13 899.3	3.41	.	.	.	67.8	4.8	27.1	0.3

1) Values have been revised in some cases and are preliminary or estimated or cannot be fully compared to previous years or include other areas (see original publication “Main Science and Technology Indicators”).
2) Nominal expenditures. Converted into US $ purchasing-power parities.
3) Including general funding for university research.
4) PNP: Private non-profit sector.
5) According to recent estimates from the Statistisches Bundesamt, the Stifterverband Wissenschaftsstatistik and the Federal Ministry of Education and Research from December 2013 the expenditure for research and development as share of the GDP in 2012 amounts to 2.98 %.
6) 2008, 2010 und 2012: National estimate and forecast. Total R&D expenditure 2010 underestimated. Perfomance shares of government, university and PNP sector in 2012 overestimated. Performance share of PNP sector 2009 underestimated.
7) Until 2011 funding contributions by the state sector have been modified by the secretary’s office to meet the standards of the Frascati Manual. 2008 break in series.
8) Predominantly without expenditure for investments; implementation proportions by the state sector only taken into account with federal expenditure. 2008 preliminary.
Source: OECD (Main Science and Technology Indicators 2013/2) and calculations by the Federal Ministry of Education and Research
Data portal of the BMBF: www.datenportal.bmbf.de/portal/1.3.1

Tab. 7 2/2 Gross domestic expenditure for research and development by funding and performing sectors in selected OECD states

Country	Year[1]	R&D expenditure		Financed by			Performed by			
		Millions of US $[2]	Share of GDP in %	Private sector	Govern-ment sector	Other domestic sources and abroad	Private sector	Govern-ment sector	Univer-sity sector[3]	PNP sector[4]
				Anteil in %						
United Kingdom	2008	39 396.9	1.75	45.4	30.7	23.9	62.0	9.2	26.5	2.4
	2009	39 581.2	1.82	44.5	32.6	22.9	60.4	9.2	27.9	2.5
	2010	38 143.5	1.77	44.0	32.3	23.7	60.9	9.5	27.0	2.5
	2011	39 217.4	1.78	45.9	30.5	23.7	63.6	8.6	26.0	1.8
	2012	39 109.8	1.72	45.6	28.9	25.4	63.4	8.2	26.5	1.8
Japan[7]	2008	148 719.2	3.47	78.2	15.6	6.2	78.5	8.3	11.6	1.6
	2009	137 016.8	3.36	75.3	17.7	7.1	75.8	9.2	13.4	1.6
	2010	140 656.9	3.25	75.9	17.2	6.9	76.5	9.0	12.9	1.6
	2011	148 389.2	3.39	76.5	16.4	7.1	77.0	8.4	13.2	1.5
	2012	151 837.2	3.34	.	.	.	.	.	.	.
Canada	2008	24 916.8	1.92	49.5	34.0	16.5	54.1	9.8	35.5	0.6
	2009	25 051.8	1.97	48.5	34.6	16.9	53.2	10.4	35.9	0.4
	2010	24 703.4	1.86	46.4	35.6	18.0	51.2	11.1	37.2	0.4
	2011	24 756.8	1.79	48.0	34.8	17.2	52.0	9.7	37.9	0.4
	2012	24 801.1	1.73	48.4	34.5	17.1	52.3	9.0	38.3	0.4
United States[8]	2008	407 238.0	2.77	63.5	30.4	6.1	71.4	11.3	13.2	4.0
	2009	406 000.0	2.82	60.9	32.6	6.4	69.6	11.9	14.0	4.5
	2010	409 599.0	2.74	57.2	32.6	10.2	68.1	12.6	14.7	4.5
	2011	429 143.0	2.76	58.6	31.2	10.2	68.5	12.7	14.6	4.3
	2012	453 544.0	2.79	59.1	30.8	10.1	69.8	12.3	13.8	4.0

1) Values have been revised in some cases and are preliminary or estimated or cannot be fully compared to previous years or include other areas (see original publication “Main Science and Technology Indicators”).
2) Nominal expenditures. Converted into US $ purchasing-power parities.
3) Including general funding for university research.
4) PNP: Private non-profit sector.
5) According to recent estimates from the Statistisches Bundesamt, the Stifterverband Wissenschaftsstatistik and the Federal Ministry of Education and Research from December 2013 the expenditure for research and development as share of the GDP in 2012 amounts to 2.98 %.
6) 2008, 2010 und 2012: National estimate and forecast. Total R&D expenditure 2010 underestimated. Perfomance shares of government, university and PNP sector in 2012 overestimated. Performance share of PNP sector 2009 underestimated.
7) Until 2011 funding contributions by the state sector have been modified by the secretary’s office to meet the standards of the Frascati Manual. 2008 break in series.
8) Predominantly without expenditure for investments; implementation proportions by the state sector only taken into account with federal expenditure. 2008 preliminary.
Source: OECD (Main Science and Technology Indicators 2013/2) and calculations by the Federal Ministry of Education and Research
Data portal of the BMBF: www.datenportal.bmbf.de/portal/1.3.1

Tab. 8 1/4 Employees, turnover and internal R&D expenditure of the private sector by business sector and workforce classes[1]

Industry sector[2]			2009						
			Employ-ees[3]	Turnover[3]	Internal R&D expenditure				
					Total	Per employee	Share of turn-over	For inform.: total Eastern German *Länder* and Berlin	
			Thousand	€ m	€ m	€ 1 000	in %	€ m	
A	01–03	**Agriculture, hunting and forestry; fishing**	**5**	**1 030**	**131**	**26.2**	**12.7**	**31**	
B	05–09	**Mining and quarrying**	**31**	**15 284**	**13**	**0.4**	**0.1**	**1**	
C	10–33	**Manufacturing**	**3 147**	**903 031**	**38 711**	**12.3**	**4.3**	**2 158**	
	10–12	Manufacture of food products and beverages	120	48 784	318	2.7	0.7	19	
	13–15	Manufacture of textiles and apparel	29	5 914	126	4.3	2.1	22	
	16–18	Manufacture of wood and wood products excluding furniture	56	15 074	176	3.1	1.2	29	
	19	Manufacture of coke, refined petro-leum products and nuclear fuel	9	38 975	93	10.3	0.2	1	
	20	Manufacture of chemicals and chemical products	246	84 595	3 198	13.0	3.8	114	
	21	Pharmaceutical industry	114	42 812	3 896	34.2	9.1	312	
	22	Manufacture of rubber and plastic products	144	29 690	847	5.9	2.9	26	
	23	Manufacture of glass, ceramics and non-metallic mineral products	68	13 021	288	4.2	2.2	29	
	24	Manufacture of basic metals; manu-facture of fabricated metal products	152	52 279	495	3.3	0.9	26	
	25	Metal products	187	34 266	712	3.8	2.1	66	
	26	DP equipment, electronic and optical goods	382	75 357	5 815	15.2	7.7	743	
	27	Electrical equipment	161	33 294	1 333	8.3	4.0	63	
	28	Mechanical engineering	551	116 632	4 499	8.2	3.9	340	
	29	Motor vehicles and parts	718	263 035	13 821	19.2	5.3	147	
	30	Other vehicle construction	104	26 741	2 056	19.8	7.7	51	
	31–33	Other goods manufacturing	105	22 562	1 039	9.9	4.6	169	
D, E	35–39	**Energy and water supply, disposal**	**148**	**139 235**	**216**	**1.5**	**0.2**	**35**	
F	41–43	**Real estate, renting and business activities**	**71**	**13 124**	**69**	**1.0**	**0.5**	**28**	
J	58–63	**Information and communication**	**229**	**50 241**	**2 564**	**11.2**	**5.1**	**483**	
K	64–66	**Financial and insurance services**	**72**	**57 671**	**335**	**4.7**	**0.6**	**0**	
M	69–75	**Other community, social and personal service activities**	**196**	**27 224**	**2 629**	**13.4**	**9.7**	**622**	
G–I, L, N–U		**Remaining categories**	**160**	**72 022**	**313**	**2.0**	**0.4**	**49**	
Total			**4 058**	**1 278 862**	**44 983**	**11.1**	**3.5**	**3 408**	

1) Not including institutions for cooperative industrial research and experimental development.
2) Classification of the economic sectors, issue 2008.
3) Employees and revenue of the companies with (internal and/or external) R&D expenditure.
Source: Stifterverband Wissenschaftsstatistik, Data portal of the BMBF: www.datenportal.bmbf.de/portal/1.5.2

Tab. 8 2/4 Employees, turnover and internal R&D expenditure of the private sector by business sector and workforce classes[1]

Employee size category	2009					
	Employees[3]	Turnover[3]	Internal R&D expenditure			
			Total	Per employee	Share of turnover	For information: total in the Eastern German *Länder* and Berlin
	Thousand	€ m	€ m	€ 1 000	in %	€ m
Companies with employees						
less than 100	232	38 316	2 372	10.2	6.2	816
100 to 249	315	64 063	2 335	7.4	3.6	458
250 to 499	337	81 129	2 330	6.9	2.9	180
Sub-total	**884**	**183 508**	**2 688**	**3.0**	**1.5**	**1 454**
500 to 999	348	99 355	9 725	27.9	9.8	262
1 000 to 1 999	430	119 763	4 101	9.5	3.4	131
2 000 to 4 999	505	168 463	5 766	11.4	3.4	479
5 000 to 9 999	387	180 942	5 640	14.6	3.1	123
10 000 and over	1 505	526 831	19 751	13.1	3.7	959
Sub-total	**3 175**	**1 095 354**	**35 258**	**11.1**	**3.2**	**1 954**
Total	**4 058**	**1 278 862**	**44 983**	**11.1**	**3.5**	**3 408**

1) Not including institutions for cooperative industrial research and experimental development.
2) Classification of the economic sectors, issue 2008.
3) Employees and revenue of the companies with (internal and/or external) R&D expenditure.
Source: Stifterverband Wissenschaftsstatistik
Data portal of the BMBF: www.datenportal.bmbf.de/portal/1.5.2

Tab. 8 3/4 Employees, turnover and internal R&D expenditure of the private sector by business sector and workforce classes[1]

Industry sector[2]			2011					
			Employ-ees[3]	Turnover[3]	Internal R&D expenditure			
					Total	Per employee	Share of turn-over	For inform.: total Eastern German *Länder* and Berlin
			Thousand	€ m	€ m	€ 1 000	in %	€ m
A	01–03	**Agriculture, hunting and forestry; fishing**	**5**	**856**	**126**	**26.6**	**14.7**	**21**
B	05–09	**Mining and quarrying**	**25**	**4 506**	**10**	**0.4**	**0.2**	**2**
C	10–33	**Manufacturing**	**3 240**	**1 169 180**	**43 733**	**13.5**	**3.7**	**2 441**
	10–12	Manufacture of food products and beverages	102	46 797	308	3.0	0.7	16
	13–15	Manufacture of textiles and apparel	29	6 752	119	4.1	1.8	17
	16–18	Manufacture of wood and wood products excluding furniture	54	15 894	183	3.4	1.2	36
	19	Manufacture of coke, refined petro-leum products and nuclear fuel	9	39 956	94	10.7	0.2	0
	20	Manufacture of chemicals and chemical products	245	102 038	3 297	13.5	3.2	105
	21	Pharmaceutical industry	120	39 754	4 070	34.0	10.2	313
	22	Manufacture of rubber and plastic products	146	33 529	943	6.5	2.8	31
	23	Manufacture of glass, ceramics and non-metallic mineral products	73	14 693	281	3.8	1.9	27
	24	Manufacture of basic metals; manu-facture of fabricated metal products	166	177 282	516	3.1	0.3	23
	25	Metal products	186	36 433	726	3.9	2.0	71
	26	DP equipment, electronic and optical goods	375	90 481	6 563	17.5	7.3	834
	27	Electrical equipment	173	37 031	1 602	9.3	4.3	70
	28	Mechanical engineering	562	139 006	4 902	8.7	3.5	333
	29	Motor vehicles and parts	777	331 415	16 312	21.0	4.9	164
	30	Other vehicle construction	104	28 813	2 602	25.0	9.0	188
	31-33	Other goods manufacturing	121	29 307	1 214	10.1	4.1	211
D, E	35–39	**Energy and water supply, disposal**	**161**	**193 720**	**197**	**1.2**	**0.1**	**19**
F	41–43	**Real estate, renting and business activities**	**67**	**14 111**	**66**	**1.0**	**0.5**	**22**
J	58–63	**Information and communication**	**250**	**60 421**	**2 990**	**12.0**	**5.0**	**559**
K	64–66	**Financial and insurance services**	**86**	**259 361**	**261**	**3.0**	**0.1**	**0**
M	69–75	**Other community, social and personal service activities**	**225**	**41 659**	**2 989**	**13.3**	**7.2**	**764**
G–I, L, N–U		**Remaining categories**	**444**	**143 630**	**432**	**1.0**	**0.3**	**42**
Insgesamt			**4 501**	**1 887 444**	**50 804**	**11.3**	**2.7**	**3 869**

1) Not including institutions for cooperative industrial research and experimental development.
2) Classification of the economic sectors, issue 2008.
3) Employees and revenue of the companies with (internal and/or external) R&D expenditure.
Source: Stifterverband Wissenschaftsstatistik, Data portal of the BMBF: www.datenportal.bmbf.de/portal/1.5.2

Tab. 8 4/4 Employees, turnover and internal R&D expenditure of the private sector by business sector and workforce classes[1]

Employee size category	2011					
	Employ-ees[3]	Turnover[3]	Internal R&D expenditure			
			Total	Per employee	Share of turn-over	For information: total in the Eastern German *Länder* and Berlin
	Thousand	€ m	€ m	€ 1 000	in %	€ m
Companies with employees						
less than 100	257	48 209	2 864	11.2	5.9	903
100 to 249	322	70 006	2 491	7.7	3.6	551
250 to 499	350	95 493	2 657	7.6	2.8	197
Sub-total	**928**	**213 708**	**8 012**	**8.6**	**3.7**	**1 653**
500 to 999	370	112 068	3 027	8.2	2.7	226
1 000 to 1 999	435	154 148	4 784	11.0	3.1	359
2 000 to 4 999	522	243 010	5 693	10.9	2.3	415
5 000 to 9 999	376	164 481	4 778	12.7	2.9	205
10 000 and over	1 870	1 000 029	24 509	13.1	2.5	1 012
Sub-total	**3 573**	**1 673 736**	**42 792**	**12.0**	**2.6**	**2 217**
Total	**4 501**	**1 887 444**	**50 804**	**11.3**	**2.7**	**3 869**

1) Not including institutions for cooperative industrial research and experimental development.
2) Classification of the economic sectors, issue 2008.
3) Employees and revenue of the companies with (internal and/or external) R&D expenditure.
Source: Stifterverband Wissenschaftsstatistik
Data portal of the BMBF: www.datenportal.bmbf.de/portal/1.5.2

Tab. 9 1/2 R&D personnel by personnel groups and sectors

Sector (OECD differentiation)	Year (ACTUAL)	Full-time equivalents Total	Of which: Researchers	Technicians	Others
1. Private sector[1, 2]	**1995**	**283 316**	129 370	78 155	75 791
	2000	**312 490**	153 026	81 654	77 810
	2005	**304 502**	166 874	76 256	61 372
	2008	**332 909**	180 295	86 433	66 181
	2009	**332 491**	183 214	88 002	61 275
	2010	**337 211**	185 815	89 251	62 145
	2011	**357 129**	190 693	115 495	50 941
2. Government sector[3,4]	**1995**	**75 148**	37 324	20 380	17 444
	2000	**71 454**	37 667	17 599	16 188
	2005	**76 254**	39 911	8 420	27 923
	2008	**83 066**	45 342	11 815	25 910
	2009	**86 633**	49 241	12 274	25 118
	2010	**90 531**	51 783	12 565	26 182
	2011	**93 663**	54 185	12 634	26 844
3. University sector[5]	**1995**	**100 674**	64 434	13 636	22 604
	2000	**100 790**	67 087	12 151	21 551
	2005	**94 522**	65 363	9 902	19 258
	2008	**106 712**	76 831	11 384	18 497
	2009	**115 441**	84 771	11 365	19 305
	2010	**120 784**	90 355	11 392	19 038
	2011	**123 910**	93 730	11 379	18 801
4. Total	**1995**	**459 138**	**231 128**	**112 171**	**115 839**
	2000	**484 734**	**257 780**	**111 404**	**115 549**
	2005	**475 278**	**272 148**	**94 578**	**108 553**
	2008	**522 687**	**302 468**	**109 632**	**110 588**
	2009	**534 565**	**317 226**	**111 641**	**105 698**
	2010	**548 526**	**327 953**	**113 208**	**107 365**
	2011	**574 701**	**338 608**	**139 508**	**96 586**

1) Even years have been estimated.
2) 2000 and 2010: in even years, distribution to personnel groups is the same as the respective previous year. Rounding differences.
3) State institutes and private non-profit scientific organisations primarily funded by the state.
4) From 2003 onwards, the difference between technical and other personnel was modified for methodical reasons. Therefore, expenditure from 2003 onwards cannot be fully compared to the previous years.
5) Information on the university sector based on the full-time personnel of the private and state universities (IST) and calculated in accordance with the procedure agreed by the Conference of Education Ministers, the German Council of Science and Humanities, the Federal Ministry of Education and Research and the Federal Statistical Office.
Source: Stifterverband Wissenschaftsstatistik and Federal Statistical Office
Data portal of the BMBF: www.datenportal.bmbf.de/portal/1.7.1

Tab. 9 2/2 R&D personnel by personnel groups and sectors

Sector (OECD differentiation)	Full-time equivalents				
	Year (ACTUAL)	Total	Of which:		
			Researchers	Technicians	Others
of which: Eastern German *Länder* and Berlin					
1. Private sector[1, 2]	**1995**	**32 611**	19 768	5 402	7 443
	2000	**36 220**	21 370	7 790	7 060
	2005	**29 525**	17 393	6 696	5 436
	2008	**32 591**	18 819	8 094	5 679
	2009	**33 190**	19 385	8 642	5 164
	2010	**33 662**	19 661	8 764	5 236
	2011	**36 126**	19 988	12 055	4 090
2. Government sector[3,4]	**1995**	**20 782**	11 481	4 894	4 407
	2000	**19 951**	11 641	4 372	3 938
	2005	**21 970**	12 012	2 018	7 940
	2008	**24 916**	14 477	2 989	7 451
	2009	**25 741**	15 421	3 096	7 224
	2010	**27 560**	16 458	3 475	7 628
	2011	**28 589**	17 234	3 424	7 931
3. University sector[5]	**1995**	**24 601**	15 484	3 214	5 901
	2000	**23 032**	15 415	2 494	5 122
	2005	**22 441**	15 579	1 896	4 966
	2008	**24 075**	17 695	2 212	4 168
	2009	**26 018**	19 533	2 360	4 126
	2010	**27 491**	20 840	2 369	4 282
	2011	**28 446**	22 286	2 214	3 946
4. Total	**1995**	**77 994**	**46 733**	**13 510**	**17 751**
	2000	**79 203**	**48 426**	**14 657**	**16 120**
	2005	**73 936**	**44 984**	**10 610**	**18 342**
	2008	**81 582**	**50 991**	**13 295**	**17 297**
	2009	**84 949**	**54 339**	**14 098**	**16 514**
	2010	**88 713**	**56 959**	**14 608**	**17 146**
	2011	**93 161**	**59 508**	**17 692**	**15 967**

1) Even years have been estimated.
2) 2000 and 2010: in even years, distribution to personnel groups is the same as the respective previous year. Rounding differences.
3) State institutes and private non-profit scientific organisations primarily funded by the state.
4) From 2003 onwards, the difference between technical and other personnel was modified for methodical reasons. Therefore, expenditure from 2003 onwards cannot be fully compared to the previous years.
5) Information on the university sector based on the full-time personnel of the private and state universities (IST) and calculated in accordance with the procedure agreed by the Conference of Education Ministers, the German Council of Science and Humanities, the Federal Ministry of Education and Research and the Federal Statistical Office.
Source: Stifterverband Wissenschaftsstatistik and Federal Statistical Office
Data portal of the BMBF: www.datenportal.bmbf.de/portal/1.7.1

Tab. 10 1/2 R&D personnel in EU Member States and selected OECD Member States by personnel groups and sectors[1]

Country	Year	Full-time equivalents						
		Research-ers	Techni-cians and other staff	Total R&D personnel		Of which, active in the		
						Private sector	University sector	Public and PNP[2] sector
		Number			per 1 000 labour force	Share in %		
Germany	**1995**	231 128	228 010	**459 138**	11,7	61.7	21.9	16.4
	2000	257 874	226 860	**484 734**	12.3	64.5	20.8	14.7
	2005	272 148	203 130	**475 278**	11.6	64.1	19.9	16.0
	2010	327 953	220 573	**548 526**	13.2	61.5	22.0	16.5
	2012	342 700	236 500	**579 200**	13.7	61.6	21.9	16.4
Finland[3]	**1995**	16 863	16 771	**33 634**	13.4	52.9	27.2	19.9
	2000	34 847	17 757	**52 604**	20.2	55.9	29.4	14.8
	2005	39 582	17 889	**57 471**	21.8	55.9	30.4	13.8
	2010	41 425	14 472	**55 897**	20.8	54.7	32.1	13.3
	2012	40 468	13 579	**54 047**	19.9	57.3	29.9	12.8
France	**1995**	151 249	167 135	**318 384**	12.6	50.9	25.3	23.8
	2000	172 070	155 396	**327 466**	12.5	54.3	27.5	18.2
	2005	202 507	147 174	**349 681**	12.8	55.8	28.2	16.0
	2010	243 533	154 223	**397 756**	14.0	59.2	26.8	14.0
	2012	.	.	**.**	.	.	.	.
Italy	**1995**	75 536	66 253	**141 789**	6.1	42.5	34.2	23.3
	2000	66 110	83 956	**150 066**	6.2	42.6	36.5	20.8
	2005	82 489	92 759	**175 248**	7.2	40.4	38.2	21.4
	2010	103 424	122 207	**225 632**	9.0	49.7	32.0	18.2
	2012	110 823	123 104	**233 927**	9.1	49.5	32.6	17.9
Sweden[4]	**1995**	33 665	28 970	**62 635**	13.8	66.5	27.6	5.9
	2000	.	.	**.**	.	.	.	.
	2005	55 090	22 614	**77 704**	16.5	72.2	22.8	5.0
	2010	49 312	28 106	**77 418**	15.7	70.8	25.2	4.1
	2012	49 280	31 992	**81 272**	16.1	68.7	26.8	4.5

1) Some values are only preliminary or estimated or cannot be fully compared to previous years (see original publication “Main Science and Technology Indicators 2013/2”).
2) PNP: Private non-profit sector.
3) 1995 and 2000 graduates instead of researchers.
4) 2010 and 2012 Total R&D personnel and researchers underestimated, personnel in economic sector overestimated.
5) 2005 and 2010 R&D personnel and personnel in the university sector underestimated, personnel in economic sector overestimated.
6) 1995: Total R&D personnel in the university sector overestimated.
7) Private sector without R&D personnel in social sciences and humanities.
Source: OECD (Main Science and Technology Indicators 2013/2) and calculations by the Federal Ministry of Education and Research.
Data portal of the BMBF: www.datenportal.bmbf.de/portal/1.7.11 1

Tab. 10 2/2 R&D personnel in EU Member States and selected OECD Member States by personnel groups and sectors[1]

Country	Year	Full-time equivalents						
		Research-ers	Techni-cians and other staff	Total R&D personnel		Of which, active in the		
						Private sector	University sector	Public and PNP[2] sector
		Number			per 1 000 labour force	Share in %		
United Kingdom[5]	**1995**	145 673	131 184	**276 857**	9.9	52.4	.	.
	2000	170 554	118 044	**288 599**	10.0	50.4	.	.
	2005	248 599	76 317	**324 917**	10.8	44.8	47.0	8.3
	2010	256 585	94 181	**350 766**	11.2	44.2	48.6	7.3
	2012	252 652	105 393	**358 045**	11.2	44.7	48.9	6.3
Japan[6]	**1995**	673 421	274 667	**948 088**	14.2	60.5	30.6	8.8
	2000	647 572	249 275	**896 847**	13.3	64.9	25.4	9.7
	2005	680 631	216 224	**896 855**	13.5	68.0	23.4	8.6
	2010	656 032	221 896	**877 928**	13.2	70.0	21.5	8.5
	2012	.	.	**.**	.	.	.	.
Canada[7]	**1995**	87 380	57 590	**144 970**	9.8	56.6	29.7	13.8
	2000	107 900	60 040	**167 940**	10.6	62.3	26.9	10.8
	2005	136 700	81 890	**218 590**	12.6	65.0	26.1	9.0
	2010	156 260	72 830	**229 090**	12.3	61.3	29.5	9.2
	2012		.	**.**	.	.	.	.
United States	**1995**	795 274	.	.	.	.	.	.
	2000	983 208	.	.	.	.	.	.
	2005	1 101 062	.	.	.	.	.	.
	2010	1 198 280	.	.	.	.	.	.
	2012	.	.	.	.	.	.	.

1) Some values are only preliminary or estimated or cannot be fully compared to previous years (see original publication "Main Science and Technology Indicators 2013/2").
2) PNP: Private non-profit sector.
3) 1995 and 2000 graduates instead of researchers.
4) 2010 and 2012 Total R&D personnel and researchers underestimated, personnel in economic sector overestimated.
5) 2005 and 2010 R&D personnel and personnel in the university sector underestimated, personnel in economic sector overestimated.
6) 1995: Total R&D personnel in the university sector overestimated.
7) Private sector without R&D personnel in social sciences and humanities.
Source: OECD (Main Science and Technology Indicators 2013/2) and calculations by the Federal Ministry of Education and Research.
Data portal of the BMBF: www.datenportal.bmbf.de/portal/1.7.11 1

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5 Facts and figures relative to the German research and innovation system

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