Federal Ministry
of Education
and Research

Federal Report on Research and Innovation 2016

Short Version

Foreword

Germany is one of the leading countries in Europe and around the world as far as innovation is concerned. As a centre of scientific and technological development, it is both attractive and competitive, boasting an extremely efficient innovation system. Numerous indicators confirm this. Investments in research and development in Germany have never been higher than in the last few years. Today, more people are engaged in research and development than ever before.

Despite our position in the vanguard of innovation, we are facing mounting pressure from global competition. Yesterday's success is no guarantee of tomorrow's prosperity. With its *High-Tech Strategy,* the Federal Government is therefore not merely relying on existing strengths, but also consciously focusing on new priorities in research and innovation. By setting these priorities, we aim to gain new momentum and secure Germany's strong position in the international arena in the long term.

Promoting research, science and innovative dynamism is an investment in the future of our society. The world is changing: Our lives are becoming increasingly networked and fast-paced; and we are becoming more and more dependent on complex systems. Innovative ideas and scientific findings are more important than ever before. Digitalisation, demographic developments, migration flows, the scarcity of many natural resources and climate change are all spurring this global transformation. Our world is experiencing an explosion of knowledge and an astonishing technological evolution. New innovative ideas and the resulting marketable products and services are key to overcoming these challenges and maintaining our competitive edge.

The Federal Report on Research and Innovation presents the activities undertaken by the Federal Government and the *Länder* in these two fields. It provides a comprehensive overview of the status of innovation policy in Germany and takes account of the findings of the latest report of the Commission of Experts for Research and Innovation (EFI). The report shows that the increased commitment of the Federal Government and industry has enabled our country to further enhance its competitive position over the last two years.

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

Leading an innovative Germany

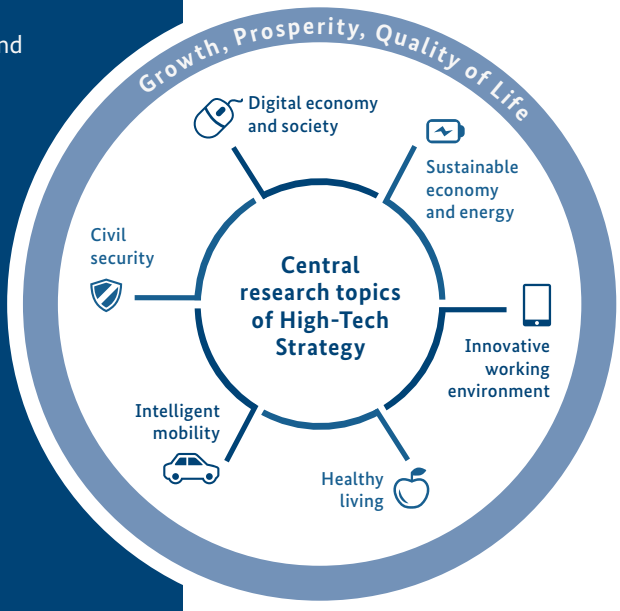
THE NEW HIGH-TECH STRATEGY
Innovations for Germany

New products and services are developed from good ideas, made in Germany. They are in demand worldwide and safeguard our prosperity and our quality of life. Innovative solutions have already been found for many pressing issues and challenges for the future. In other fields, further research and experimentation will be necessary. That is where a new High-Tech Strategy begins: by systematically examining the entire innovation process – from the creative kernel to implementation in new products and services. The new High-Tech Strategy focuses on research topics that are of particular relevance for society, and for growth and prosperity:

- Information and communication technologies characterise almost all our life and business. But how do we want to live, learn and work in a digital world?
- How do we shape manufacture and consumption that respect resources, are more environmentally friendly, more socially acceptable and thus more sustainable?
- What is the future of work?
- How can we work towards achieving advances in health and wellbeing?
- How do we prevent disruptions or bottlenecks in energy supply, IT communication, mobility or logistics?

The new High-Tech Strategy brings together all the actors involved in innovation to combine forces and smooth the path from idea to application. They also ensure that conditions remain buoyant for innovation in Germany. For this, skilled professionals are just as necessary as better financing for innovation or research-friendly copyright law.

Further information is available online
www.hightech-strategie.de/en



Introduction

This short version of the Federal Report on Research and Innovation 2016 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 introduces the *Federal Government's objectives and priorities in the area of research and innovation policy.* It illustrates how, with its High-Tech Strategy, the Federal Government is making a firm commitment to research and innovation; promoting a high-performance science system; opening up greater prospects through education and integration and upholding its internationality to boost progress and competitiveness.

Part II presents the structures of the *German research and innovation system*. Thereby it answers the following questions: "Where does research and development take place?", "Who finances research and development?", "How does government research and innovation funding work?" and "How efficient is the German research and innovation system by national and international standards?".

Part III, the *Federal Government's research and innovation policy,* outlines the emphases of federal research funding in Germany.

Part IV describes how *the Federal Government and the Länder act in concert* in funding science and research.

Part V, covering *International cooperation in research and innovation,* highlights the international orientation of German research and innovation policy. Significantly, it includes an overview of the objectives and priorities of Germany's international cooperation in research and innovation.

Lastly, **Part VI** summarises the *research and innovation policy of the Länder*, by taking a closer look at all 16 *Länder*.

Comprehensive, detailed information about the activities of the Federal Government and the *Länder* in these areas, about the organisations and institutions that conduct research and development, about research and development in the private sector and relevant international cooperation can be found at www.bundesbericht-forschung-und-innovation.de, in the long, German version of the report and in the supplementary volumes, which are also available online for download and ordering.

References to further information like internet addresses are marked with a blue arrow.

Info boxes explain important terms, present projects and programmes or provide additional information.

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I The Federal Government's objectives and priorities in the area of research and innovation policy

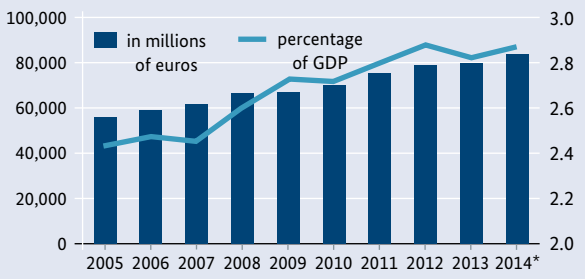
At a glance

The Federal Government's research and innovation policy serves society, the economy and the individual citizens in our country. It aims to find solutions to global challenges, boost Germany's competitive edge and safeguard future-proof employment. In doing so, the policy is oriented towards a sustainable economic framework and reduced resource use.

Investments in research and development (R&D) in Germany have never been higher than in the last few years. Over the period 2005 to 2016, Federal Government expenditure on research and development increased from 9 billion euros to the target figure of 15.8 billion euros in 2016, a growth of over 75%. According to provisional estimates, in 2014, the state and industry together invested almost 84 billion euros in R&D, in other words, approximately 2.9% of the gross domestic product (GDP). Thus, the goal of the Europe 2020 strategy – for 3% of GDP to be invested annually in R&D – has almost been achieved. It was these investments that made Germany's recent increase in innovative capacity possible in the first place. Further advancements in the digitalisation process will strengthen Germany's position as an innovation hub. At the same time, the transition must be managed to ensure that employment and social participation are maintained, competition is not restricted and consumers' interests are protected. Among small and medium-sized businesses in particular, the potential for creating new jobs in industry, as well as in industry-related and more knowledge-based services, can – and indeed must – be maximised. The Federal Government is playing a major role in this endeavour (cf. the info box *Germany's innovation model in the age of digitalisation*). Innovations are the drivers of our economy; they accelerate product and service cycles and have a direct impact on value chains and competitiveness. They are developed in a complex process that evolves from basic to applied research. The priority for the future will be to activate previously unexploited innovative potential, especially in the small and medium-sized enterprises (SMEs) sector and by encouraging more start-ups, and to increase society's involvement in the process. In accordance with a broad understanding of innovation, in its *High-Tech Strategy,* the Federal Government supports both technological and societal innovations that aim to play an active role in transformation processes. Innovative strength depends on a number of factors: on excellent, creative research, a society that is receptive to innovation, entrepreneurs who are willing to invest, a well-trained, committed workforce, pro-innovation policies and a dynamic, attractive science and education system that offers equal opportunities. The Federal Government is pursuing this integrated approach in its research and innovation policy.

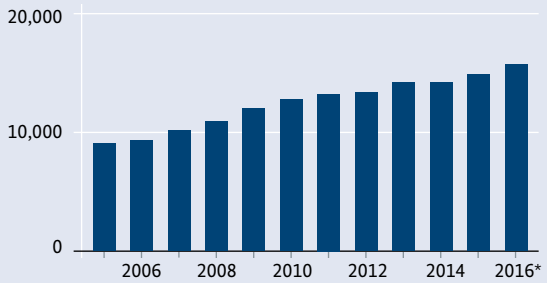
The measures described are in the responsibility of the respective ministries. They are financed, subject to available budgetary resources, within the framework of the budgetary and financial planning approaches (including posts/permanent posts).

Fig. I-1: Gross domestic expenditure on research and development (2005–2014)



* Left: provisional figure for 2014; right: target figures for 2015 and 2016

Fig. I-2: Federal Government expenditure on research and development in millions of euros (2005–2016)



Source: BMBF's Data Portal

Germany's innovation model in the age of digitalisation

Competitive advantages in the key skills required for digitalisation will be decisive in ensuring that we continue to enhance our innovative capability in the international arena and safeguard employment and value creation in this country. In its ninth report, the Commission of Experts for Research and Innovation (EFI) calls for an overall strategy that addresses the structural scope of digitalisation and fosters the digital transformation of the economy. In future, the Federal Government is focusing on four fields of action to increase the dynamism of the German economy.

With regard to its capacity for innovation, Germany is among the worldwide leaders. In R&D terms, five of Europe's ten top performers are German companies. At 9.2%, no other EU country's share of medium and high-tech exports in the balance of trade is as high as in Germany. The traditional strength of the German economy has always been and remains the manufacturing sector. With just over one sixth of its workforce directly employed in manufacturing, Germany is a world leader. In particular, the numerous hidden champions among the small and medium-sized enterprises are some of the best in the world.

The present strength of Germany's innovation model can only be maintained in the long term if we succeed in keeping pace with the technological advances resulting from digitalisation and with the opportunities for new business models. Due to its transformational power in society, industry and politics, digitalisation will not merely have an evolutionary impact but also be highly disruptive. Markets on which German companies are successfully positioned today may undergo fundamental changes. Although this poses significant risks for our future competitiveness, it also opens up new opportunities. For example, according to the World Intellectual Property Organization, for the three emerging technologies, Germany comes in third place for 3-D printing and ranks fifth in nanotechnology and robotics among the global drivers of innovation.

For this reason, the Federal Government places emphasis on four fields of action:

1. The traditional strengths of Germany's economy – particularly in industrial value creation with its considerable share of high technologies – are to be further expanded in order to establish a basis for new intelligent, knowledge-based production environments. To this end, the Federal Government is funding concepts like Industry 4.0 and investing in the development of autonomous systems, smart services and the digitalisation of the medical sector.

2. Digitalisation gives rise to new value creation potential and frees up room to manoeuvre, especially in the field of data-based services. In order to allow more innovative business models to emerge from the developments of the so-called platform economies, Big Data applications and the Internet of Things, the framework conditions need to be more conducive to innovations and start-ups, as well as more consumer-friendly. This calls for a modern regulatory framework to safeguard self-determination, freedom, transparency, data protection and security. Secure information infrastructures and full compliance with both consumer and data protection form the basis of this framework.

3. Specially trained, skilled personnel, who are creative and open-minded to boot, are crucial in shaping the digital transformation in industry, both in academia and in vocational training. In future, more young people should acquire extensive IT skills and bring their knowledge into play in the companies.

4. Finally, it is essential that we broaden the basis for local innovation activities. The innovative strength of small and medium-sized enterprises must be maximised and start-ups encouraged to ensure that the SME sector remains powerful in the digital era.

The Federal Government will continue to accelerate the modernisation of Germany's economy in these fields of action. The overarching goal is to shape the research and innovation policy framework to enable creativity to develop its full potential with regard to the digital revolution and come up with new, intelligent and knowledge-based solutions.

1 The High-Tech Strategy – a strong commitment to research and innovation

Since 2006, the *High-Tech Strategy* has been pooling research and innovation funding across governmental departments. By bringing together the key players from science, industry and society, it aims to transform knowledge into innovations as quickly and effectively as possible.

With its *High-Tech Strategy,* the Federal Government has set new research and innovation priorities (cf. the info box *Ten years of the High-Tech Strategy*). From 2014 to 2016 (planned), under the umbrella of the *High-Tech Strategy,* the Federal Government has meanwhile invested approximately 34 billion euros in developing forward-thinking solutions for a sustainable economic framework and clean energy sources, maintaining an efficient health care system, intelligent mobility, secure communication and innovative companies – in other words, in reinforcing Germany's position as an innovation hub.

This focus on the major challenges facing society marks a departure from past research and innovation policy. Funding key technologies plays a part. The *High-Tech Strategy* has established specific research policy models and objectives in a total of ten forward-looking projects (cf. the info box *The forward-looking projects of the High-Tech Strategy*). Each forward-looking project plays a part in finding systemic solutions for a better quality of life, protects our natural environment and gives the economy competitive advantages in key lead markets. Industry, science and politics act in concert in implementing these projects.

1.1 Joining forces for prosperity and competitiveness

Since 2014, the Federal Government has been systematically advancing the development of new expertise and forward-thinking solutions in six areas. The central questions concern the sources of our future prosperity and our quality of life. The Federal Government is investing in innovative solutions that are characterised by a strong scientific and technical dynamic or high innovation potential and which will give Germany a competitive edge in the international arena.

The transdisciplinary strategic approach of the *High-Tech Strategy* is recognised both nationally and internationally as a successful example of good governance: framework programmes like *Horizon 2020* adopt a similar approach. Moreover, the Commission of Experts for Research and Innovation has consistently acknowledged that the *High-Tech Strategy* represents an excellent governance model of an R&I system.

Promoting the digital economy and society

The digital economy and the internet are affecting industry, science, society and politics on an unprecedented scale. Information and communication technologies are major drivers of innovative value chains, networks and new business models in numerous application fields. Although the exponential growth of vast quantities of data facilitates an explosion of knowledge, it also entails new risks and challenges, for example, in terms of consumer rights and data security. The successful integration of digital technologies in industrial sectors and areas of societal need is a decisive factor in upholding Germany's competitiveness, as we have solid expertise in this regard. The Federal Government is proactive in shaping the digital revolution integratively and with foresight. It is currently pursuing this objective in its *Digital Agenda 2014–2017*. The progress and implementation reports published to date on the *Digital Agenda 2014–2017* indicate that many of the measures addressed by the Agenda have been realised.

A strong alliance made up of players from politics, industry, trade unions and research is working with the *Industry 4.0 platform* to harness the economic potential of the ongoing digitalisation of the value chains and to develop new intelligent, knowledge-based production environments on the basis of Germany's successful industry structure. Moreover, for small and medium-sized enterprises (SMEs) and craftsman's establishments, the digital transformation offers enormous potential in terms of improved processes or manufacturing techniques and by making innovative e-business solutions accessible. Therefore, the Federal Government is prioritising its support with regard to the digitalisation of SME work und production processes. In application-oriented research projects, the *Industry 4.0 – Shopfloor Research* initiative demonstrates how Industry 4.0 solutions can be put into practice. In future, before introducing and implementing innovative process and system solutions, SMEs will be able to try them out in realistic 'test environments'.

In implementing specialised programmes for key technologies, such as materials research and photonics, the Federal Government will gear new funding initiatives even more closely towards SMEs than before. In order to facilitate their adjustment to digital business processes and develop their digital expertise, SMEs receive support under the *Mittelstand-Digital* programme and, since 2015, under the new pilot schemes of the *go-digital* initiative, with a focus on internet marketing, digitalised business processes and IT security.

A further undertaking are the new *Mittelstand 4.0 competence centres,* which raise SME awareness for the technological and economic possibilities of digitalisation and support the digital transformation by providing specific demonstration facilities and test environments. A total of ten such competence centres will be

Ten years of the High-Tech Strategy

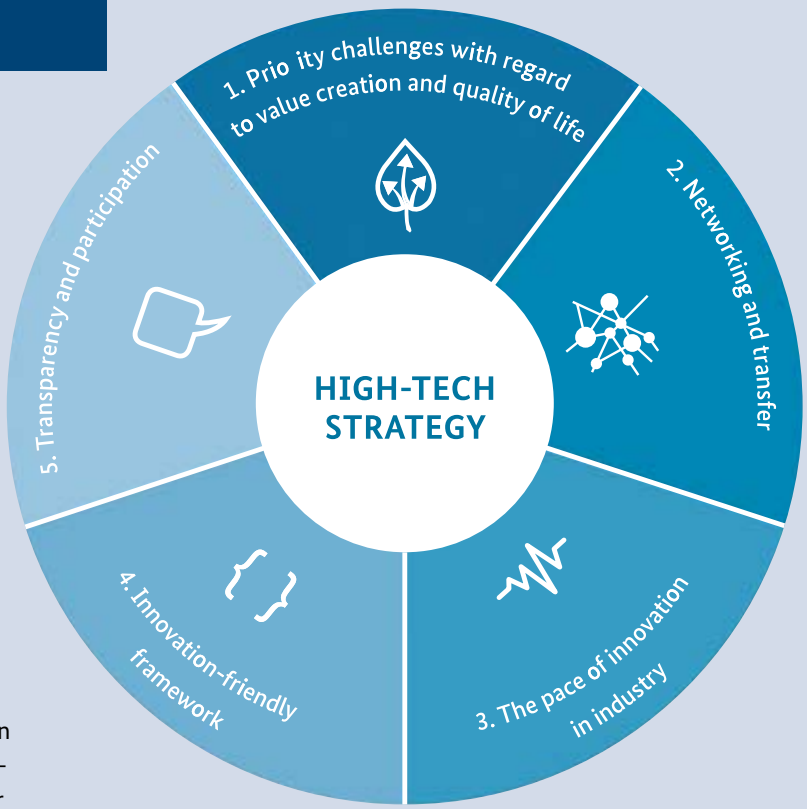
Over the past decade, the *High-Tech Strategy* has strengthened Germany's position in the global competition by successfully stepping up and pooling investments in research and innovation.

While the *High-Tech Strategy* was originally directed first and foremost at the market potential of specific technology fields, from 2010 onwards, it took greater account of society's demand for forward-thinking solutions and of putting them into practice. Since 2014, the central aspects of an all-embracing research and innovation policy have been considered in a holistic context. This approach unlocks innovation potential that enables the formidable social challenges of our times to be overcome, transferring these novel answers systematically into applications.

The *High-Tech Strategy* thus spans the entire innovation process from the creative idea through to its implementation in the shape of new products and services. Under this umbrella, all Federal Government departments work together on common objectives and implementation steps. In the process, the *High-Tech Strategy* channels the numerous resources into a common direction. The main priority here are research topics that are particularly relevant for growth, prosperity and quality of life.

The new *High-Tech Strategy* is implemented according to its five pillars of innovative strength:

1. **Priority tasks:** the *High-Tech Strategy* is establishing thematic priorities in research and innovation in order to gain new expertise.
2. **Networking and transfer:** the *High-Tech Strategy* uses new instruments for innovation funding to pool the regional, national and international expertise of companies, universities, research institutes and other stakeholders.



3. **Dynamism of innovation in industry:** the *High-Tech Strategy* provides targeted support to innovation processes in German industry, first and foremost in small and medium-sized enterprises.
4. **Favourable conditions for innovation:** from the outset, the *High-Tech Strategy* links research topics with cross-cutting issues and creates the optimal framework conditions for research and innovation.
5. **Participation and transparency:** as a central stakeholder, the *High-Tech Strategy* involves society in the research and innovation process.

For ten years, the *High-Tech Strategy* has been improving the environment in which ideas arise and are implemented as marketable products and services. In so doing, it fosters greater value creation and new employment potential in Germany for the long term.

in operation by the end of 2016. Lastly, there is a centre that caters specifically to the needs of skilled craftsmen.

Information and communications technology, electronics, robotics and bionics play a key role in the interaction of man and machine. The *Bringing technology to the people* research programme promotes the development of innovative solutions that provide support in more and more aspects of our lives.

The increasingly widespread use of digital technologies, both in the workplace and the home, raises questions regarding the opportunities and risks of digitalisation, for example, in view of the fundamental right to informational self-determination. Here again, the Federal Government is establishing the necessary research capacities. The *German Internet Institute* will adopt an interdisciplinary approach to researching the ethical, legal, economic and participatory aspects of the internet and digitalisation, thereby compiling important reference information and practical expertise for the future. Work began to establish the institute when a funding guideline was published in September 2015.

Open access can contribute to an enhanced information flow in the scientific community and the increased visibility of research findings. Therefore, publications and data resulting from publicly funded research should be made openly accessible. Thus, the Federal Government is working to develop an *open access strategy*.

By introducing the *National Action Plan on Open Data*, the Federal Government pledged to ensure the widespread publication of administration data. Using this data for digital innovations, thereby fostering digital entrepreneurship, is one of the key objectives of the *modernity fund,* from which innovative data-based projects have been receiving funding since 2016.

Laying the foundations for a sustainable economic framework and a sustainable energy supply

It is imperative that we improve the environmental performance, resource efficiency and social compatibility of our production methods and consumption patterns, thereby increasing their sustainability. Mindful of its responsibility towards current and future generations, the Federal Government is focusing on the vision of a sustainable development that generates innovations.

The transformation of our production and consumption habits constitutes a challenge for society as a whole, whereas the competitive position of German companies must also be given due consideration. The goal is for Germany to maintain its position as a technological leader while acting in a sustainable and climate-friendly manner. Therefore, the Federal Government is empowering *platforms* where representatives from science, industry, civil society and politics join forces to stimulate sustainable development: the *City of the Future innovation platform,* the *Green Economy Platform*, the *National Platform of Education for Sustainable Development*, the *Construction of the Future research initiative,* the *Energiewende Research Forum*, the *Energiewende Research and Innovation Platform* and the *Energy Research Networks*.

The Federal Government is pooling its research endeavours for an environmentally friendly, reliable and affordable energy supply and the transition to sustainability in the Federal Government's *Raw Material Strategy*, the *FONA³ framework programme* and the *National Research Strategy BioEconomy 2030 – our route towards a bio-based economy*. The Federal Government continues to rigorously implement its *6th Energy Research Programme*, which serves as a framework for the implementation of interdepartmental funding initiatives in fields of particular relevance for the *Energiewende*: grids, storage infrastructures and, since 2016, solar construction/the energy-efficient city.

Launched in 2015, the *Research for Sustainable Development framework programme (FONA³)* promotes sustainability research even more effectively and has a stronger interdisciplinary, demand-oriented and application-oriented focus. Under *FONA³*, the Federal Government encourages sustainability research with the aim of highlighting options for a sustainable lifestyle and economic framework. *FONA³* will serve to incorporate sustainability research more closely in the public forum, thereby increasing its relevance to sustainable development. Three flagship initiatives address key social tasks and political priorities:

- *Green Economy:* the transition to an internationally competitive, environmentally friendly and socially compatible economic framework
- *City of the Future:* the sustainable development of cities and urban areas
- *Energiewende*: Germany's transformation of its energy supply

In the new *Copernicus projects,* the Federal Government is pooling the resources of the major players from industry, science and society with a long-term, ten-year perspective in order to develop sustainable solutions and facilitate the restructuring of the energy system.

Supporting the innovative working environment

The working environment and value creation processes are undergoing a fundamental transformation. Our globalised economy is being shaped by a strong service sector orientation and interactive value creation processes. Digitalisation is paving the way for new forms of working and will have a lasting impact on qualification profiles and job descriptions. At the same time, people are developing new preferences with regard to their careers.

With *Work 4.0*, the Federal Government is involved in a dialogue process with social partners, associations and companies to define the requirements for tomorrow's working society. The *Digital Working World platform* focuses on finding business solutions to the challenges of the digital transformation. The dialogues go hand in hand with diverse research endeavours into the future of work, for example, on the value systems of the workforce and the impact of digitalisation on labour market trends.

Today, more than ever before, being innovative necessitates complex processes that involve the combined effect of technological evolution as well as developments in human resources, organisation and skills. Therefore, for the first time, the *Innovation for Tomorrow's Production, Services and Work* framework programme takes a holistic approach to research in the fields of production, services and work. With its *Future of Work* programme, the Federal Government is furthering the development of strategies to help companies, particularly SMEs, to cope with the challenges arising from the structural change in the working environment.

Highly qualified personnel and excellent working conditions play a significant role in facilitating innovation. The Federal Government is committed to creating an inclusive, safe environment in which skilled, healthy and motivated employees can work on new products and services. Launched by the Federal Ministry of Labour and Social Affairs, the *New Quality of Work Initiative (INQA)* is a joint undertaking of social partners, chambers and politics that offers specific support and advisory services for good business practice. The Prevention Act of 17 July 2015 improved the framework conditions for occupational health promotion and prevention.

The forward-looking projects of the High-Tech Strategy

Germany's key innovation players are working together towards a specific goal in ten forward-looking projects. Each forward-looking project identifies systemic solutions in one innovation field. Thus, based on an innovative network of companies and public research, the projects provide answers to the major issues of our time. Thereby they enhance our quality of life and secure Germany's position at the forefront of global competition in key lead markets of the future.

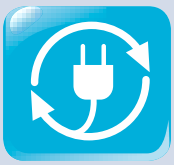
The CO_2-neutral, energy-efficient and climate-adapted city

Energy and resource consumption in Germany is mainly concentrated in the cities. Therefore, urban areas play a pivotal role in overcoming the major challenges of the 21st century. Owing to the considerable, steadily increasing necessity to adapt and the manifold impact of the climate change on our cities, it is imperative that all societal actors and all areas of policy-making be brought together to form an interdisciplinary alliance, both in conceptual frameworks and in practical terms. The Federal Government founded the National Platform for the *City of the Future* with this goal in mind. Experts on this platform have developed a *Strategic Research Agenda for the City of the Future*, which was presented to the public in 2015. The next step is to implement the agenda. In February 2016, the Federal Government launched the *Innovation Platform City of the Future,* which coordinates and links the research and innovation policy initiatives of various government departments, local authorities, science, industry and civil society, thereby accelerating the transfer of knowledge and technologies into municipal practice.

Renewable resources as an alternative to oil

As an energy source and the prime material of numerous chemical products, crude oil is currently the bedrock of the global economy. Nonetheless, supplies are dwindling and oil combustion exacerbates climate change. Renewable resources that can be used for energy or material recovery offer promising alternatives to crude oil and other fossil fuels like coal and natural gas. This forward-looking project aims to explore and unlock the potential of these resources. It is an integral part of the Federal Government's *National Research Strategy BioEconomy 2030.* The Federal Government established the German Bioeconomy Council in 2009 to support the implementation of the strategy. The *National Research Strategy BioEconomy 2030* is scheduled to be updated in 2017 based on an evaluation.

Intelligent restructuring of the energy supply



With the dawn of the renewable energy era, the nuclear power phase-out and Germany's energy transition are extremely ambitious tasks, whose successful conclusion calls for the close cooperation of politics, industry, science and civil society. Above all, it is now up to the scientific community to quickly lay the foundations and make the technological breakthroughs that are necessary to assure Germany's energy supply in the long term. In August 2011, the Federal Government outlined the roadmap for this forward-looking project in its *6th Energy Research Programme.* The result of an extensive consultation process, it was coordinated with the research activities conducted by industry and in the scientific institutes.

Treating diseases more effectively with the help of personalised medicine

Having spurred health research, modern molecular biology is now opening up new perspectives for evidence-based medicine in conjunction with medical informatics. One of its aims is to identify diagnostic markers that make it possible to estimate the potential risk of diseases, predict the success of therapies and monitor their progress. Biomedical treatment approaches are particularly promising in this context. The development of customised prevention approaches and therapy methods, minimising the side effects of drugs and making treatment more effective: such are the priorities of personalised medicine, which was first recognised as a research field in its own right by the Federal Government in the *Health Research Framework Programme* it adopted in December 2010. A number of new funding initiatives have been launched under the *Personalised Medicine action plan,* which was introduced in 2013.

Better health through targeted prevention and an optimised diet

A healthy lifestyle and a living environment that is conducive to health can help prevent or at least delay the onset of chronic diseases. For this reason, prevention and nutrition research funding is aimed at providing the scientific foundation for effective, convenient prevention and health promotion that are tailored to the needs of specific target groups. In addition, it calls for the development of strategies to improve the population's eating habits and the availability of healthy foods on a long-term basis. In 2013, the Federal Government adopted an *Action Plan for Research into Prevention and Nutrition*.

Retaining independence well into old age

The percentage of senior citizens in the population is steadily increasing. By the year 2030, more than 22 million people in Germany will be 65 or older, in other words, 29% of the total population. The demographic shift to an ageing society inevitably poses certain challenges – while offering valuable opportunities at the same time. To exploit these opportunities, the Federal Government developed the *New Future of Old Age* research agenda, approving it at the end of 2011. The agenda comprises six research fields, which govern the approach of this forward-looking project.

Sustainable mobility

Mobility is the indispensable prerequisite for personal freedom, social cohesion and economic prosperity. Nevertheless, more and more land and resources are being steadily swallowed up by the increasing volume of traffic around the world, causing noise, traffic jams and air pollution. In the face of climate change, the rising world population and the finite reserves of fossil fuels, tomorrow's mobility must be established on a new, sustainable basis. In this forward-looking project, the Federal Government is therefore pursuing its goal of developing sustainable mobility models with high safety standards, which reduce emissions and protect the environment, while reinforcing Germany's competitive edge. Both the *National Platform for Electric Mobility* and the *Joint Agency for Electric Mobility* are participating in the project.

Web-based services for businesses

The internet has long since outgrown its application as an infrastructure that provides access to information worldwide. Within a few short years, it has evolved into a ubiquitous platform offering services around the clock, as evidenced by the success of hundreds of thousands of available applications for all aspects of our lives. To date, most of these applications have catered for the needs of private users. However, commercial applications are increasingly being integrated in the business processes of many companies and administrations. Web-based services offer enormous growth potential for both providers and users of information technology; the Federal Government is taking this potential into account in its forward-looking project.

Industry 4.0

The economy is on the brink of the fourth industrial revolution. Driven by the internet, the real world and the virtual world continue to converge into an Internet of Things. The key characteristics of tomorrow's industrial production are the extremely individualised products that are manufactured in highly flexible (large-scale) production environments, the integration of customers and business partners to a large extent in the business and value-creation processes, and the interconnection between products and high-quality services, leading to 'hybrid products'. German industry now has the opportunity to play an active role in shaping the fourth industrial revolution. Approximately 250 stakeholders from more than 100 organisations are involved in the *Industry 4.0 platform.* In cooperation with representatives from politics, industry, science, associations and civil society, the project outlines potential approaches to ensure the successful implementation of Industry 4.0 in enterprises, recommends specific courses of action and presents Industry 4.0 to industrial SMEs.

Secure identities

Not only is trust a valuable asset, it forms the basis of every stable and enduring relationship. Trust can indeed be cultivated and protected in the internet: if people can be as certain in the virtual world as they are in real life that their own identity is secure and that other users are who they claim to be. At the same time, there must be room for anonymity and pseudonymity, not least because the internet allows for personal references to individuals, the scale, intensity and transparency of which differ considerably from the real (analogue) world. In this forward-looking project, the Federal Government seeks to show ways of reaching this goal. With secure identities, users will be able to exercise their right to informational self-determination in the world wide web, while building a solid foundation for business and commerce in cyberspace. These functionalities therefore open up long-term growth perspectives for network-based business models. They also provide an effective means of countering cybercrime issues, like identity theft or phishing. This forward-looking project works closely with its sister projects Web-based services for businesses and Industry 4.0. The 2015 programme, *Safe, secure and empowered in the digital world*, established a new research framework. The *National Reference Project for Cybersecurity in Industry 4.0* und three *competence centres* research and develop solutions that protect individual privacy in the internet.

Maintaining a healthy lifestyle

Health is a vital element of our individual and social well-being. Our increased life expectancy and high level of prosperity do not automatically mean a better standard of living. The Federal Government is therefore prioritising its commitment to health research. At all times, the primary objective is ensuring that people benefit from research findings promptly, thereby directly helping to improve their quality of life. The Federal Government's *Health Research Framework Programme* defines the strategic orientation of research in this field.

One central aspect is the fight against widespread diseases. With six *German Centres for Health Research* and two large research networks, the Federal Government is investing in efficient structures for basic research and patient-oriented research. The goal of this concerted effort involving universities, non-university research facilities and governmental research institutes is to develop new prevention and treatment options, see them successfully translated into clinical application and to prepare for socially relevant challenges of the future in the healthcare sector. To complement these activities, the new *Berlin Institute of Health (BIH)* takes an overarching systems medicine research approach by researching complex disease mechanisms in their entirety and developing new approaches to therapy. These infrastructures bring together the best scientists in their field to research key health topics. In addition to the framework programme, new forms of care provision and health services research are to gain further ground thanks to the *innovation fund* that has been set up at the Federal Joint Committee.

Personalised medicine offers enormous potential for effective therapies and in terms of keeping side effects to a minimum. The *Personalised Medicine action plan* is being implemented for more efficient disease control. In the context of personalised medicine, it is becoming increasingly important to be able to integrate different data formats and interpret vast quantities of data. As digitalisation entails tremendous opportunities – but also formidable risks and challenges – in the health care sector, the Federal Government is stepping up its efforts in this respect. Therefore, the Federal Government has laid the appropriate groundwork by introducing a new *medical informatics* strategy, which will fund the establishment of data integration centres and the development of innovative IT solutions.

Departmental research initiatives will study the *ethical aspects* of both the digital revolution and the demographic shift. In this way, the accumulation of medical data can be used to increase the accuracy of diagnostic methods and improve therapeutic options, in other words for the benefit of patients.

Special emphasis is being placed on research into rare diseases. The *National Action Plan for People with Rare Diseases* aims to significantly improve the health situation of sufferers.

The Federal Government is fostering research into public health, irrespective of the individual's age, gender and social status. Prevention and early detection are vital components for a long and healthy life; they can prevent, or at least mitigate, the progression of chronic lifestyle diseases, including the underlying risk factors. The *Prevention Act* of 17 July 2015 seeks to provide a framework that facilitates cooperation between the stakeholders and ensures that the quality and effectiveness of health promotion and prevention programmes are encouraged. In this context, the social insurance agencies may carry out pilot schemes autonomously or with third parties. The Federal Government

launched *IN FORM – Germany's national initiative to promote healthy diets and physical activity,* aimed at bringing about lasting improvements in dietary and exercise habits. The *Lifelong Health and Well-being Initiative* was established to document people's specific concerns at various stages of their lives and to develop tailored – and thus even more effective – concepts that promote a healthy lifestyle and prevention. The key element of research in the field of prevention is the long-term collection of data in large population groups (cohorts). Therefore, Germany's largest population endeavour to date, the *National Cohort*, is currently being set up.

Not only do innovative solutions bring about decisive advances for our individual well-being, they also have the potential to open up sales markets around the world and generate value creation. The Federal Government is strengthening the innovativeness and competitiveness of Germany's health care industry in a new specialised programme on *medical technology*. In order to boost Germany's reputation as a hotspot for research and production, while safeguarding the supply of effective, innovative medicines, the Federal Government has been engaging in an interdepartmental *pharmaceutical dialogue* with partners from industry, science and the industrial trade union *IG Bergbau, Chemie, Energie*. The Federal Government is addressing the special challenges facing small and medium-sized enterprises in this area by introducing additional measures, like the new *Medizintechnologie.de* information platform. The information platform is one outcome of the *National Strategy Process on Innovations in Medical Technology*. In the National Strategy Process, the Federal Government intends to establish a basis for a coherent innovation policy in the field of medical technology – at the interfaces of research, health and economic policy.

Promoting intelligent mobility

Germany is an innovation leader for safe, sustainable mobility solutions. The primary tasks for tomorrow's mobility consist in connecting modes of transport and vehicles, developing new vehicles and drive systems, along with sustainable fuels for the various modes of transport.

The Federal Government is therefore pursuing its goal of developing sustainable mobility models with high safety standards, which reduce emissions and protect the environment, while reinforcing Germany's competitive edge. Electromobility in particular plays a crucial technological role in the climate-friendly transformation of our mobility. Accordingly, with its *National Platform for Electric Mobility,* the Federal Government is encouraging strategic dialogue between industry, science, politics, trade unions and associations. Vehicle automation and networking play a pivotal role in developing intelligent mobility systems. The Federal Government has dedicated its *Strategy for Automated and Connected Driving*, its *New Vehicle and System Technologies* programme and other specialist programmes to pursuing this goal. In order to maximise the energy efficiency and cruising range of electric vehicles, the Federal Government has set funding priorities in battery research, the charging infrastructure, grid integration and the development of holistic, energy-efficient vehicle concepts.

Moreover, the Federal Government is committed to improving efficiency by optimising the interfaces between the individual modes of transport, for example, by promoting a virtually seamless travel chain, with door-to-door passenger information and ticketing services, and by funding groundbreaking projects at the interface where the public transport network, car-sharing schemes and the bicycle converge.

Ensuring civil security

Safeguarding security and freedom is of the utmost importance for our society. New threats like international terrorism or cybercrime are placing different demands on our internal security. The Federal Government's primary objective is to help protect our free society.

Everyday life increasingly depends on the trouble-free functioning of technical security mechanisms and the smooth interaction of the complex systems and infrastructures that govern our energy supply, communication, mobility or logistics. Even minor disruptions may lead to supply shortfalls and cause considerable economic damage. Civil security research makes a valuable contribution to protecting citizens against possible threats, thereby enhancing their safety – and thus their quality of life.

With the advance of the digital revolution, the demands placed on the security, integrity and reliability of digital infrastructures and services increase accordingly. Although the exponential growth of vast quantities of data facilitates an explosion of knowledge, it also entails hitherto unknown risks, especially in terms of the right to informational self-determination. The Federal Government regards IT security as a crucial element for innovation and growth in Germany. This is borne out by the research framework programme *Safe, secure and empowered in the digital world 2015–2020*, an interdepartmental package of measures aimed at developing secure, innovative IT solutions, and the *Cyber Security Strategy for Germany*, for safeguarding civil security. Effective instruments are a prerequisite for accessing the internet and the digital world in a safe, self-determined way. Located in Darmstadt, Karlsruhe and Saarbrücken, three high-powered *IT security competence centres* operate with a thematic and organisational focus on the greatest challenges in the field of IT security.

1.2 Improving cooperation and promoting implementation

The Federal Government promotes multi-focus, interdisciplinary networking and the transfer of ideas, knowledge and technology along the entire innovation chain. The close collaboration between science and industry in research and development is one of the traditional strengths of Germany's innovation system.

The close interconnection of science, industry and society is the key to successfully transferring ideas into commercially promising innovations of enormous social benefit on the one hand and to greater scientific insight on the other.

Over the past few years, by introducing measures like the *Leading-Edge Cluster Competition*, the Federal Government has set a clear course towards the development and transfer of regional innovation potential. These collaborations, partnerships and innovation alliances have led to a fusion of expertise. Approximately 100 innovation clusters throughout Germany have been admitted under the *go-cluster – cluster excellence* programme. The Federal Government intends to pool the efforts of science, industry, society and politics even more effectively, using the resulting synergies to give Germany a greater competitive edge and sustainable prosperity.

Activating networking potential and opening up new markets

The Federal Government is making it easier for small and medium-sized enterprises (SMEs) to access scientific expertise in future. Apart from the technical universities, universities of applied science are often valuable partners for SMEs. The *Strong universities of applied science – impetus for the region* measure reinforces universities' status as regional poles of innovation, thereby creating new scope for SME cooperation. Cooperation with institutions of higher education and

non-university research facilities also figures prominently in measures that are specifically geared to SME requirements, like the *Central Innovation Programme for SMEs* or the *SME innovative* funding scheme. The opportunities for temporary exchanges of personnel between industry and the research sector – facilitating networking and competence development – are to be improved in order to expand the SME knowledge base. Furthermore, from 2016, *innovation forums* are to be established throughout Germany to enable SMEs and research institutes to collaborate on new ideas that transcend technologies and disciplines, and to develop modes of implementation.

The Federal Government empowers SMEs in regional networks and supports them in their role as initiators of value creation and guaranteed apprenticeships. The *Research Campuses* are already offering SMEs an opportunity to work on future trends, for longer periods and in one location, on an equal footing with partners from science, industry and society. The goal is to increase the number of SMEs in *strategic innovation consortia* in order to strengthen Germany's regional innovation base still further. To this end, the excellent coordination and management skills of German clusters and networks can be relied on to serve as catalysts for joint SME research projects.

In light of the increasingly transnational dimension of the processes involved in knowledge generation and value creation, cooperation between universities, research institutes and companies is to be intensified with international partners. National funding programmes that foster networking with international partners, thereby helping German SMEs to step up their activities overseas, are already available: the *Internationalisation of Leading-Edge Clusters, Forward-Looking Projects and Comparable Networks* measure is aimed particularly at SMEs, enabling them to play an active role in international partner consortia. The further development of the *Central Innovation Programme for SMEs* provided additional incentives for German SMEs to engage in international cooperation. In future, under the umbrella of *SME international,* the Federal Government is extending its information and advisory services on European and international innovation cooperation for German SMEs.

Accelerating diffusion

The Federal Government has underlined its commitment to ensuring that good research ideas are transferred more rapidly into innovations. This includes assessing at the earliest possible stage whether an idea is actually suitable for translation into an innovative product or a new service. The objective of the Federal Government's VIP+ funding programme, *Validation of the technological and social innovation potential of scientific research*, is to close the gap that frequently exists between basic research findings and potential applications. The Federal Government's new measure, *WIPANO – Knowledge and technology transfer via patents and standards*, helps public-sector research bodies and companies to patent and exploit their ideas and promotes innovative projects on standardisation. Without a doubt, bright ideas need protection, while standardisation facilitates their rapid diffusion throughout the markets.

1.3 Boosting SMEs' innovative dynamism and increasing value creation

Germany's *Mittelstand* is a key driver of its innovation system. As the very core of Germany's economic model, its regeneration power is crucial to securing Germany's foothold in the global competition. Small and medium-sized enterprises face major new challenges today and in the future, due to the digital revolution, changing roles in value chains and globalisation.

Although German corporate expenditure on innovations, in other words, on research and development, marketing, prototypes or setting up production facilities, remains at a consistently high level – 145 billion euros in 2014 – the percentage invested by small and medium-sized enterprises (SMEs) is decreasing. At the same time, the percentage of companies that have successfully launched new products and services on the market, known as the innovator rate, has also dropped, although, at 37% in 2014, this remains stable compared to the previous year.

For many years, state R&D funding has benefited SMEs at a disproportionate rate. From 2007 to 2015, federal R&D funding in support of SMEs rose from 783 million to 1,445 million euros. The *Mittelstand* innovation programmes have been restructured, streamlined and simplified, and new, customised measures introduced. In its ninth report, the Commission of Experts for Research and Innovation expressly welcomed the Federal Government's intensified commitment.

In future, four programme families will guide companies through each stage of the innovation cycle from the idea right through to the successful market launch. Funding is aimed at:

- Innovative start-ups (grants and venture capital for start-ups and newly founded companies, like *EXIST*, *INVEST* and the *High-Tech Start-Up Fund*)
- Innovation competence (grants for consulting services like *go-inno* and *go-digital*)
- Technology transfer (grants for patent applications and pre-competitive research projects, like the *Industrial Collective Research* mechanism)
- Market-oriented technology endeavours (grants for market-driven technology projects, like the *Central Innovation Programme for SMEs*)

A ten-point programme for SMEs (*"Vorfahrt für den Mittelstand"*) was developed in parallel. The four fields of actions are designed to:

- Increase SME participation in the specialised programmes (e.g. with *SME innovative* in the key areas of digital economy, healthy lifestyle and sustainable economic activity)
- Foster networking with large companies and research institutes (e.g. with *Strong universities of applied science – impulse for the region*, in *innovation forums* across Germany and in *strategic innovation consortia*)
- Provide skilled personnel and meet qualification requirements (e.g. via *STEM recruiting* programmes for small and medium-sized enterprises, a special *digitalisation programme in industry-wide training centres* and temporary *exchanges* between industry and the research sector)
- Improve the framework conditions and streamline funding processes (e.g. by means of *two-stage application procedures* and the advance financing of *exploratory or feasibility studies)*

The *Federal Funding Advisory Service on Research and Innovation* is the central point of contact for information on individual measures, not just those of the Federal Government, but also of the *Länder* and the European Commission.

The funding processes are updated on an ongoing basis. Bureaucratic hurdles have been abolished; for example, simplified application procedures have been introduced for small companies, all processes are to be gradually changed to a purely electronic, paperless transfer of information. This fulfils the requirements on easing the bureaucratic burden of small and medium-sized businesses that were laid out in the Cabinet Resolution of 11 December 2014.

Technology-neutral, intersectoral R&D funding

For many small and medium-sized enterprises, technology-neutral funding provides vital support on their path to innovation. The companies make their own decisions with regard to investments in technologies and products they want to invest in. The state does not stipulate the thematic areas: SMEs are able to direct their research and development endeavours according to their own specific, entrepreneurial priorities.

The *Central Innovation Programme for SMEs* is a funding programme for the market-oriented research and development projects of small and medium-sized enterprises. Both individual and cooperation projects or networks with other companies or research institutes are eligible for funding. Moreover, the management and organisation of innovative cooperation networks is encouraged. In 2015, the programme was redefined: the eligible costs were increased, the entitlement was relaxed to include larger SMEs and the funding rate was increased by up to 10% for international projects.

The *Industrial Collective Research* mechanism addresses the pre-competitive requirements of small and medium-sized enterprises; the funded research institutes are R&D service providers for SMEs. The companies are actively involved in designing and supporting the projects.

Exploiting the potential of key technologies for the economy

The aim is for SMEs' innovative capacity to take optimal effect in all essential innovation processes that uphold Germany's future viability. This includes the targeted funding of future-oriented key technologies in the technology-specific programmes. Owing to their economic leverage effect, key technologies play a vital role. Innovative developments in the fields of information and communications technology, micro-electronics, photonics, biotechnology, production technologies, materials science and the nanosciences form the basis for new products, processes and services in numerous industrial and social applications.

The Federal Government has introduced several specialised programmes to promote key technologies and boost companies' innovative capacity. SMEs and medium-sized 'hidden champions' are the focus here, receiving support in their extensive use of key technologies for new products and services, which enables them to access specific specialised funding. Having proven particularly effective, *SME innovative* was extended in 2015 to include further lines of funding in materials research and photonics; the number of SMEs active in the field of 'Electromobility and electronic systems' will continue to rise from now on. Elite SMEs that are both highly innovative and high-performing are to receive greater support in future for their networking activities and internationalisation endeavours.

The *SME innovative* funding initiative is expected to be enlarged in some cases to include the larger SME target group with up to 1,000 employees.

In order to excel in future in the international arena, it is vital to increase the total number of small and medium-sized companies that conduct active research into future-oriented solutions. To this end, the Federal Government is not content with increasing funding for cutting-edge research but is also turning the spotlight onto non-innovation active SMEs with needs-based funding schemes. Thus, during the run-up to an R&D project, an entry-level module will be added to *SME innovative* to finance short feasibility studies, for example. In addition, measures that are open to SMEs will have two-stage application procedures that allow for reliable funding prospects, based on a preliminary draft proposal. This will help reduce the complexity of application procedures.

Spurring entrepreneurial focus

By earmarking grants, consulting services and venture capital, the Federal Government is taking steps to further improve the start-up climate and ensure that Germany consolidates its position as a major international investment location and start-up hub, in the segment of innovative fledgling companies. The Federal Government supports emerging companies from the original ideas, which are developed in the universities and research institutes, from the start-up right through to the initial growth phase.

The support available for scientific high-tech start-ups has been appreciably extended. Specific examples include a significant increase in funding for start-ups under the *EXIST programme* and start-up competitions like *IKT Innovativ* or the *Founding Push Biotechnology (GO-Bio*). The *German Accelerator* helps German high-tech start-ups to optimise their business models during a three to six-month stay abroad and scale them internationally in order to prepare a go-to-market strategy. The *German Accelerator* has since been enlarged to include the life sciences, in addition to the original technology segments of ICT and cleantech.

Furthermore, the Federal Government promotes the development of new target groups for innovative start-ups. In future therefore, the *EXIST programme* will also focus more strongly on foreign start-up teams, who intend to establish companies in Germany under *EXIST.* In its newly launched nationwide network, *WOMEN Entrepreneurs,* comprising almost 180 female entrepreneurs, the Federal Government is campaigning for a greater entrepreneurial focus in girls and young women. The thriving company succession exchange platform *nexxt-change.org* aims to approach students and university employees.

Unlocking regional innovation potential

The Federal Government invests in the potential for innovation found in structurally weak regions. The *INNO-KOM-Ost* programme fosters the innovative achievement capacity of non-profit, external industrial research institutes by making funds available for ambitious research and development projects. With the measures that make up *Entrepreneurial Regions - The BMBF Innovation Initiative for the New German Länder*, the Federal Government is promoting the creation and expansion of exceptional technological, scientific and economic competence in East German regions. Over the past 15 years, the funding of cooperation and the exchange of knowledge between the public research infrastructure and companies has contributed to the development of an internationally competitive economic structure in East Germany that is characterised by small and medium-sized enterprises. From 2016 on, *Entrepreneurial Regions* is to be transformed into a national innovation funding concept to support regions that are particularly affected by the challenges arising from structural change.

1.4 Laying the foundation for creativity and innovative strength

The Federal Government continues to advocate framework conditions that facilitate a sound productive environment for innovation and value creation. It is poised to take on international competition for the best talents by providing modern working conditions that are compatible with different life phases. Highly qualified women and men are the key to Germany's growth and competitive edge.

Securing the skilled labour base is one of Germany's priority tasks. Moreover, fair competitive conditions, open markets, adequate financing options and the effective protection of intellectual property rights are prerequisites for the emergence of creative ideas and their translation into innovations.

Activating the potential of skilled workers

In a progressively ageing society, securing the skilled labour base is essential in order to preserve our capacity for innovation in the long term. Germany's dual system of vocational training is a cornerstone for maintaining its future demand for skilled labour, particularly in small and medium-sized enterprises. In light of the increasing differentiation and diversity of the educational landscape, young people need support, for example, in the form of targeted careers guidance and vocational preparation schemes, to encourage them to engage in further training. Sealed in December 2014, the *Alliance for Initial and Further Training 2015–2018* brought together the Federal Government and the Federal Employment Agency (BA) with representatives from industry, trade unions and the *Länder* to boost Germany's dual vocational education system and campaign for equality in terms of on-the-job and academic training. This goal is accompanied by specific programmes and support measures. In February 2016, the Federal Government proposed legislation to enforce vocational training and unemployment insurance cover (AWStG), with the particular aim of persuading more low-skilled workers, long-term unemployed and older workers to participate in advanced vocational training, thereby securing the availability of skilled personnel and maximising their qualification potential.

Besides further training, recognising international qualifications is an effective instrument in strengthening the skills base. The Federal Government's *Assessment and Recognition of Foreign Professional Qualifications Act* (Recognition Act) improves career opportunities for individuals with foreign qualifications and facilitates their integration into the labour market: during the first three years, from 2012 to 2014, more than 44,000 applications for recognition were submitted and the vast majority of foreign professional qualifications were recognised as being equivalent. Customised information and advisory services contribute significantly to the success of the recognition process. The Federal Government is working with partners in industry and the *Länder* to build on this success.

Even if the entire domestic manpower available were utilised, there would still be a need for international experts. With information measures like the *www.make-it-in-germany.com* portal or the new *Working and Living in Germany hotline*, the Federal Government provides information on working conditions in Germany and the recruiting process for qualified professionals from abroad. Moreover, the Federal Government has also taken swift action for the persons currently arriving in Germany as refugees, with targeted measures to support their desire to integrate and prepare them for entering employment.

Comprising the Federal Ministry of Labour and Social Affairs (BMAS), Federal Ministry for Economic Affairs and Energy (BMWi), BMBF, Federal Ministry of Family Affairs, Senior Citizens, Women and Youth (BMFSFJ), Confederation of German Employers' Associations

(BDA), German Trade Union Confederation (DGB), IG Metall (industrial union of metalworkers), IG BCE (industrial union for mining, chemicals and energy), ver.di United Services Union, Association of German Chambers of Commerce and Industry (DIHK), German Confederation of Skilled Crafts (ZDH) and BA, the *partnership for skilled workers in Germany* bundles existing services and improves the dissemination of best practices from day-to-day business. The focus is on the potential groups of women, older workers and migrants. Together, the partners campaign for the availability of qualified professionals and attractive working conditions.

The *Fachkräfte für die Region* (Skilled Personnel for the Region) innovation office identifies, categorises and underpins regional networks to retain skilled labour by providing extensive information and advisory services, and organising events. Having successfully linked players with a labour market focus like employment agencies, job centres, local authorities, chambers of commerce and industry, associations and companies, the 580 currently active networks have joined forces to launch regional projects and initiatives aimed at retaining skilled workers in the region.

Granting access to venture capital

Obtaining adequate financing is a prerequisite for innovative activity, especially for young, dynamic start-ups. By introducing the range of measures from the *key issues paper on venture capital,* the Federal Government has taken the right steps to ensure that fledgling start-ups gain continued access to the venture capital market.

INVEST offers targeted incentives for business angels, who provide capital for an enterprise at an early stage following the start-up. The pool of applicants is set to be extended and the upper funding limit increased in 2016. The *High-Tech Gründerfonds*, the *ERP-Startfonds* and its successor *coparion* all invest in research-intensive technology companies during the start-up and expansion phase. With a volume of 500 million euros, the new *ERP/EIF growth facility* means that the capital requirement of fast growing, capital-intensive businesses of up to 20 million euros will be better served in future. Furthermore, the *ERP/EIF fund of funds* participates in venture capital funds that invest in fledgling technology companies, most of which are active in Germany. Moreover, the *European Angels Fund* facilitates the co-financing of investments in innovative companies made by experienced business angels.

Refining the legal framework

Fierce competition is the most important driver of innovations. Restraints of competition and obstacles to market access make it difficult for fledgling companies in particular to achieve market success with their new products and services. Therefore, the Federal Cartel Office and the Federal Network Agency protect competition between market players.

This is particularly true of the exceptionally dynamic telecommunications sector, in which regulations have to be adapted to technical developments on an ongoing basis in order to stimulate innovations. For example, the Federal Cabinet passed an *amendment to the Telemedia Act (TMG)* in September 2015 to bring about greater legal certainty for WLAN operators in questions of liability, to pave the way for greater WLAN coverage in Germany and achieve the rapid dissemination of innovative business models. The corresponding parliamentary procedure is still ongoing. A new legal ruling that will empower consumers and encourage competition gives users a free choice of router. The Act enters into force on 1 August 2016.

Standardisation and effective legal metrology are integral elements of economic and innovation policy. The elimination of non-tariff trade barriers and the international harmonisation of standards and norms are the subject of ongoing multi- and bilateral negotiations. The metrology system was restructured under the 2015 German *Weights and Measures Act* and systematically adapted to comply with European guidelines. Owing to its high volume of over 300 billion euros per year, *public procurement* can provide powerful incentives for more innovation in industry. A *competence centre* advises public procurers to demand more innovation on the market, thereby setting innovation incentives for the economy.

1.5 Arousing curiosity with a more future-oriented approach

In addition to the activities of science and industry as key drivers of innovation, a current trend are innovations that develop via active citizen involvement at the heart of society. As acknowledged by EFI in its ninth report, the Federal Government recognised the relevance of social innovations at an early stage, taking them into account in its *High-Tech Strategy*. In the interests of a learning approach, the funding instruments and the wealth of experience in this field should be further refined and extended in future.

The Federal Government fosters a society that is open to new ideas and full of enthusiasm for future technologies and innovations. With a whole range of new initiatives, it offers interested citizens the opportunity to actively engage in shaping innovation and research policy. From April to October 2015, German citizens participated in discussions on the many different facets of the *quality of life* at over 180 dialogue forums held up and down the country. The new national dialogue series, *Forum for the Future*, focuses on the future orientation of research and science. Currently under construction, the *House of the Future* will present possible scenarios of life in the future, highlighting the manifold opportunities of research and innovation in exhibitions and events.

Agenda processes and platforms like the *National Platform of Education for Sustainable Development* or the *Digital Society Forum* exemplify the participation of multiple stakeholders in identifying research priorities.

In open innovation processes, citizens can progress from being merely spectators to become active players. The *Open Photonik* funding measure aims to facilitate new forms of collaboration between science, industry and citizens, thereby opening up additional innovation paths and potential.

1.6 Working towards implementation

Accompanying evaluations and impact research are at the core of the *High-Tech Strategy*. The Federal Government is also systematically enhancing the evaluation practice as a whole.

The *High-Tech Strategy* continues to be implemented in an effective, coordinated and proactive manner. To this end, the Federal Government also calls on the expertise of external advisory bodies (cf. also the info box *Effectively mobilising and designing innovation processes together*). For the most part, the major funding measures of the *High-Tech Strategy* are evaluated prior to, during and on conclusion of the initiative.

The *High-Tech Strategy* is closely intermeshed with other government policy areas like the *Skilled Workers Concept*, the *Demographic Strategy*, the *Digital Agenda* and the *Sustainability Strategy*. Thus, it combines all the aspects and stakeholders involved in the innovation process and serves as a central instrument for the coordination of national innovation policy. Ultimately, a broad discourse on positive visions for the future that is highly visible in the public arena is indispensable for a forward-looking innovation policy. Therefore, at the end of the legislative period, the *High-Tech Forum* will present recommendations for transdisciplinary strategic guidelines and priority areas for strengthening Germany's position as a hotspot for research and an innovation hub.

Further information is available online

Commission of Experts for Research and Innovation: www.e-fi.de/index.php?id=1&L=1

High-Tech Forum: www.hightech-forum.de/en

Innovation Dialogue between Federal Government, industry and science: www.acatech.de/uk/home-uk/mission-statement.html

Effectively mobilising and designing innovation processes together

Given the dynamic nature of scientific and technological progress, the demand for orientation, discussion and active participation continues to grow. For this to happen, technological innovation potential and society's demand for innovation must be identified and analysed, and a study made of the correlation between them. To this end, the Federal Government consults with panels of leading experts.

Established by the Federal Government in 2006, the *Commission of Experts for Research and Innovation (EFI)* pools interdisciplinary discourse relating to innovation research from the fields of economics and social sciences, education economics, engineering, natural sciences and technology foresight. The EFI Commission advises the Federal Government by comparing and analysing the German research and innovation system over time and by international standards, by reviewing priority issues and recommending courses of action for the continued development of the German research and innovation system. The Commission publishes its key results in its *annual reports on research, innovation and Germany's technological performance.*

Since early 2015, the eight Expert Forums of the High-Tech Forum have provided guidance on and made recommendations for implementing and enhancing the new *High-Tech Strategy – Innovation for Germany*. On the one hand, this involves advising the Federal Government on the strategic development of the *High-Tech Strategy*; on the other, it includes guidance on implementing new thematic priorities by means of suitable support mechanisms and types of programme. It formulates new research tasks, recommends specific courses of action and develops future scenarios. To this end, the experts have identified eight key topics. An expert forum has been established for each topic – for example on Autonomous Systems, which addresses in particular the development and use of autonomous programmes and robots in everyday life by debating ongoing concerns and drafting solutions. The final report on the work of the *High-Tech Forum*, including a presentation of its findings, is expected to be published in spring 2017.

The *Innovation Dialogue* brings together high-ranking representatives from science and industry to discuss the strategic direction of innovation policy with the Chancellor, the Federal Minister of Research and Education and the Federal Minister for Economic Affairs and Energy. Since autumn 2010, nine *innovation dialogues* have taken place, focusing on subjects such as the innovation potential for value creation and employment as a result of digitalisation, STEM education or the innovation potential of human-machine interaction.

2 For a high-performing science system

In cooperation with the *Länder*, the *Federal Government's Higher Education Pact, Initiative for Excellence, Pact for Research and Innovation, Quality Pact for Teaching* and *Teacher Training Quality Campaign* have all reinforced the science, research and innovation landscape in Germany. The goal now is to maintain this strength and consolidate Germany's position in the global competition. To this end, the Federal Government is raising the visibility of the country's science and research system, while increasing the focus on excellence. The extension of the opportunities for cooperation between the Federal Government and the *Länder*, pursuant to the amendment of Grundgesetz Article 91b (German Basic Law, GG), represents an important element in this respect.

As a leading centre of science, research and innovation, Germany has a powerful attraction for national and international students and researchers:

- With 1,318 scientific publications per million inhabitants in 2014, Germany has a higher publication intensity than either the United States or France.
- The excellence rate of these publications has increased steadily over the last few years, finally peaking at 16%. Therefore, approximately one sixth of the scientific papers published in Germany are among the most cited works around the world.
- In 2013, over 230,000 individuals were employed in the higher education sector and the non-university research facilities (including governmental research institutes). Compared with 2005, this represents an increase of some 34%. Women currently account for approximately 40% of this group.
- More and more students of a given age cohort are completing their education with a university degree. The so-called graduation rate rose from 19.9% in 2005 to 31.6% in 2014. Over time, a sharp growth was recorded in the number of graduates in engineering as well as in mathematics and natural sciences.
- Both students and established scientists regard Germany as an attractive host country, with its popularity continuing to soar over the past few years. Between 2008 and 2014, the number of foreign students in Germany rose by 30% from approximately 233,600 to 301,400.

A decade of pacts: an impressive track record

Since 2005, the Federal Government and the *Länder* have jointly administered a 'package of pacts' – the *Initiative for Excellence*, the *Higher Education Pact* and the *Pact for Research and Innovation* – that has achieved significant advances in the research system. The Federal Government is now carrying on this legacy.

By continuing the *Pact for Research and Innovation* for the years 2016 to 2020, the Federal Government and the *Länder* are making provision for the financial security of science organisations. They are aiming to grant individual science organisations an annual funding increase of three percent, provided the legislative bodies allocate sufficient resources. Regardless of the permanent Federal Government/*Länder* financing basis defined in the implementation agreements, the funding increase will be financed exclusively by the Federal Government during this period. The non-university research and science organisations included in the pact have opened up forward-looking fields, strengthened their national and international networks and enshrined the transfer of knowledge and technology in their strategic mission. The combination of research policy goals and financial security has reaped tangible rewards.

The *Initiative for Excellence* has brought new energy and dynamism to the German science landscape. Research endeavours are outstanding in numerous fields, while many universities have realigned their strategic focus. The Federal Government firmly believes that fostering cutting-edge research at universities is the right way forward in international competition.

The international, independent expert committee commissioned by the Federal Government and the *Länder* to evaluate the Initiative for Excellence and its impact on Germany's science system reached a similar conclusion. Chaired by Prof. Dr. Dieter Imboden, the committee evaluated the *Initiative for Excellence* in its final report, which was published on 29 January 2016, as a successful instrument for improving the quality and international competitiveness of the German science system.

On 22 April 2016, the Joint Science Conference of the Federal Government and the *Länder* (GWK, incl. the financial side) unanimously approved the draft of the administrative arrangement in accordance with Article 91b (1) GG to promote cutting-edge research at universities and resolved to submit it for approval and signature to the leaders of the Federal Government and the *Länder* for their meeting on 16 June 2016. The core elements of the arrangement are as follows:

- The Federal-*Länder* agreement is concluded for an indefinite period. The overall programme is endowed with the sum of 533 million euros per year. The funds will be provided by the Federal Government and the respective *Land* in which the individual universities are located at a ratio of 75 to 25.

- The clusters of excellence promote internationally competitive research fields at universities or consortia of universities on a project-by-project basis. Annual funding of approximately 385 million euros is earmarked for clusters of excellence. Every year, funding of between 3 and 10 million euros per cluster of excellence is appropriated for 45 to 50 eligible projects. As a rule, funding is granted for two periods of seven years; it is also possible to reapply. Universities with clusters of excellence may apply for a university lump sum as a strategy award to strengthen their governance and strategic focus. This amounts to one million euros annually per cluster of excellence. If a university has several clusters of excellence, the university lump sum for the second cluster of excellence is 750,000 euros and 500,000 euros for the third.

- The University of Excellence funding scheme is directed towards permanently strengthening the universities as institutions (or a consortium of universities) and consolidating their leading position in the international research system based on their successful clusters of excellence. Every year, monies in the amount of approximately 148 million euros are earmarked to fund universities of excellence. The funding scheme sponsors between eight and eleven eligible projects, which undergo an independent, external evaluation every seven years.

- Provided they support the ultimate goal of top-level research, both funding schemes also underpin measures in the field of research-oriented teaching,

research infrastructures or the transfer of ideas and knowledge. The decision-making process regarding the allocation of funding to clusters and universities of excellence is based on scientific criteria.

The Federal Government and the *Länder* have extended the opportunities for cooperation in the research sector, pursuant to the amendment of German Basic Law. The Federal Government initiated the amendment to Art. 91b GG, meaning that, in future, it can engage in joint funding measures with the *Länder* to support not just non-university research institutes, but also universities.

Ensuring the effective promotion of early career researchers and scientists

Germany's science system must attract brilliant minds and creative thinkers. Therefore, the Federal Government is committed to establishing working conditions and career prospects in the scientific community that are internationally competitive. The Federal Government and the *Länder* are currently negotiating a joint initiative that aims to make it easier for young scientists to plan their careers, while enhancing the transparency of the various steps.

The reform of the Academic Fixed-Term Contract Act (*Wissenschaftszeitvertragsgesetz*) initiated by the Federal Government entered into force on 18 March 2016. The reform is designed to improve the management of fixed-term regulations in an academic context and is directed at improper short-term contracts in particular. In future, the duration of fixed-term contracts for scientific personnel must be commensurate with the intended qualification; where the limitation is due to third-party funding, it should be based on the approved project duration. This amendment counteracts the undesirable developments in the practice of issuing fixed-term contracts, without prejudicing the essential flexibility and dynamism of the research sector; moreover, it underpins the activities of universities and research institutes, thereby improving the conditions of employment for young scientists.

Fostering departmental research

The departmental research conducted by the Federal Government at the interface of science, society, politics and industry is an indispensable component of the country's science system. Departmental research is carried out by 38 federal institutions with R&D responsibilities, together with seven non-university R&D organisations, working within a framework of continuous collaboration. By functioning as an interface, they contribute substantially to the success of relevant social, political and economic innovation processes. The various institutes and organisations meet the departments' R&D requirements by conducting research of their own, by acting in concert with other research institutes or by assigning research contracts to external researchers.

Departmental research covers a broad spectrum of tasks. Its remit includes such areas as scientific research on statutory tasks; scientific and technical services such as permits and approvals; maintaining databases, operating expert systems and monitoring networks, collaboration in developing and updating legislation and standards at national, European and international level; knowledge and technology transfer; research, studies and social reporting on current socio-political issues.

The departmental research institutes maintain a wealth of scientific expertise that is available at short notice to support the government's actions and provide advisory services to aid the political decision-making process. To this end, they address current, ongoing problems affecting society, science and industry, and develop various options for government measures. They conduct research into relevant issues within their individual areas of responsibility and undertake initial research with a long-term perspective in preparation for future social challenges.

For this reason, as stipulated in the coalition agreement, the Federal Government is working to strengthen its departmental research. This ensures that all departmental research institutes are able to profit from the Freedom of Science Act.

3 Opening up greater prospects through education and integration

Excellent qualifications are a precondition for excellent opportunities, participation and the innovative capacity of our country. They are the key to integration and advancement through education. This calls for an education system that is permeable and compatible, that encourages individuals to develop their talents, regardless of their background or level of resources. Educational equity must be further enhanced. This is the joint responsibility of the Federal Government, the *Länder,* local authorities and society.

Over the last few years, Germany has made good progress towards achieving its goal of becoming the Republic of Education:

- The results of PISA 2012 (Programme for International Student Assessment) show that the performance of Germany's schoolchildren has improved steadily since the first PISA surveys in 2000; it is now significantly above the OECD average in the competence areas of mathematics, natural sciences and reading skills. Moreover, pupils with a migration background and low socio-economic status were able to improve their academic performance substantially. Almost no other OECD country was successful in improving pupils' educational skills, while at the same time mitigating the effects of social origin.

- At the same time, there was a further reduction in the number of early school leavers. Whereas, in 2006, 75,900 young people left school without a *Hauptschulabschluss* (certificate of secondary education), this figure fell to 47,000 by 2014.

- There was also a decrease in the number of young people in the transition system designed to foster the maturity required for successful vocational training; new admissions to the transition system dropped from 417,649 in 2005 to 257,626 in 2013.

- At a mere 7.7 % (2014), youth unemployment in Germany remains the lowest in the European Union, where the average is 22.2%.

Overall, the planned spending on education for 2015 by the Federal Government, *Länder* and local authorities comes to approximately 123.7 billion euros, an increase of around 37 billion euros compared to 2005. Accordingly, if public sector education expenditure is viewed in relation to the total government budget, almost one in five euros was invested in education. The Federal Government has steadily increased its commitment to education: in the period from 2014 to 2015 alone, investments in education rose by 11%, or almost 116% compared to 2005.

Establishing the concept of lifelong learning

Good education opens up individual opportunities, ensures that people are fully integrated, participating members of society and is the best recipe for countering shortages of skilled manpower. Thus, a good education system must focus on people's entire education biographies – from early childhood education to lifelong learning. Numerous Federal Government initiatives are helping to ensure that Germany meets this requirement:

- The *Little Scientists' House* programme is introducing children to science, mathematics and technology – and, starting in 2016, to education for sustainable development – in Germany's largest early childhood education initiative.

- While conducting independent experiments in the *student labs* set up in non-university research facilities, children find it easier to understand scientific theories and are encouraged to explore them. The programme complements the formal education system and creates an interface between school and professional training. Educators and teachers can also take part in the wide range of training courses.

- In the *Culture Empowers You. Alliances for Education* programme, the Federal Government is supporting extracurricular activities aimed at the cultural education of disenfranchised children and adolescents, while promoting active citizenship.

- The *Educational Chains* initiative and the *career orientation programme* are helping to make pupils at secondary schools aware of their options in vocational training; as required, these endeavours also provide individual support for pupils as they pursue their training goals.

- Sponsored jointly by the Federal Government and the *Länder*, the *Advancement through Education: Open Universities* competition aims to give professionals and people with vocational qualifications better access to higher education.

- *Upgrading scholarships and training fellowships* are available for talented, motivated professionals who wish to take advantage of specific training opportunities or enrol on a degree course.

- Under the *Decade for Literacy*, the project funding is promoting new learning options for functionally illiterate adults.

- Since 2008, the federal *Learning subsidy* programme has been encouraging people on a low income to take part in individual professional development. The 13 *organisations for the promotion of young talent* that receive federal funding and the *Scholarship Germany* programme support gifted, committed undergraduates and doctoral students. The recent evaluation and the accompanying research have powerfully reaffirmed the effectiveness of the programme. Scholarship Germany, which is funded on a 50:50 basis by the Federal Government and private sponsors, plays a major role in establishing a new donation culture, attracting highly qualified experts and linking the universities with local enterprises. Over 22,000 students currently receive a scholarship.

- The enhancement of the *Higher Education Pact* is preparing universities for a further increase in the number of young people aspiring to higher education.

- Teacher training has a key function in the education system. Therefore, the Federal Government and the

Länder have launched a *Quality Pact for Teaching* to support the development and use of innovative concepts in teacher training programmes.

- Within the framework of the European Social Fund (ESF), the *Promotioning vocational education for sustainable development. Enabling green skills for climate-friendly, resource-efficient action at work* (BBNE) programme funds projects that raise awareness for new production processes, working procedures and competence on the way to achieving green core competencies and climate-friendly and resource-efficient business management.

- The *National Platform of Education for Sustainable Development* is committed to making key sustainable development issues an integral part of teaching and learning in general.

Education and digitalisation

Digital media have made enormous inroads into our everyday lives. It is now a question of developing their potential still further for teaching and learning processes. By virtue of their individualised solutions, digital media offer enormous opportunities for overcoming the major challenges facing the education system as they are able to accommodate the growing heterogeneity of students. Both higher and lower achievers can thus be supported in a more targeted way. Digital media make it possible to respond more promptly to complex and rapidly evolving qualification requirements. For both teaching staff and students, an adequate level of media literacy is a prerequisite for ensuring that this is put into practice and for preventing a digital divide in society. Therefore, promoting such skills will be a top priority over the next few years. The Federal Government launched the *Growing up with Media* initiative to boost media education in families and strengthen the conditions for developing media literacy from an early age. At the same time, particular emphasis must be placed on the quality assurance of digital education media and on data protection.

Reinforcing vocational training

In recent years, the education system has become more efficient and more equitable. Nevertheless, social background continues to have an enormous impact on educational success. Therefore, further improvements in the area of equal opportunities in education continue to be a primary objective for the Federal Government. Germany's dual system of apprenticeships plays an important role in this context. The *Alliance for Initial and Further Training* has undertaken to reinforce the dual system of apprenticeships and to motivate even more young people to enrol. Its close orientation to real-world employment is one major advantage of the dual system of training. To ensure that as many young people as possible benefit from the system, the Federal Government has systematically expanded its promotion of individual counselling and orientation programmes and its support of lower achievers prior to and during training. It continues to enhance vocational and educational guidance programmes and counselling for pupils and trainees and to remove barriers between vocational and university-based education. The *Educational Chains* initiative helps young people cope with the transition from school to vocational training. The Federal Government's careers-advice initiative *Chance Beruf* bundles the measures relating to qualifications, opportunities and advancement. The education and training structure programme *JOBSTARTER* introduces initiatives to reinforce apprenticeships and on-the-job training, thereby combating the shortage of qualified personnel. The *Coordinating Office for Vocational Training and Migration* promotes training in companies owned by migrants and encourages young people with migrant backgrounds to participate in apprenticeships. The joint Federal Government/*Länder* competition, *Advancement through Education: Open Universities* aims to offer attractive education prospects to those with vocational qualifications.

The *Upgrading Training Assistance Act* (AFBG, also known in Germany as the *Meister-BAföG* or *Aufstiegs-BAföG*) provides financial support to participants who have enrolled in professional development training courses. They receive a non-means tested contribution towards the cost of the training; in addition, those attending full-time courses are eligible for a means-

tested grant to help cover their living expenses. As of 1 August 2016, the third amendment to the Upgrading Training Assistance Act will increase numerous AFBG benefits, make funding available for new target groups, optimise structures, simplify the process and react to trends in regulating professional vocational training. Under the AFBG, the maximum living allowance for single persons is to be raised from 697 euros to 768 euros, while the maximum contribution towards course and examination fees will increase from 10,226 euros to 15,000 euros.

Introducing needs-based *BAföG* support

With the *25th BAföG amending law*, the Federal Government has assumed the full cost of financing benefits granted as of 2015 under *BAföG* (the German Federal Training Assistance Act); it is thereby relieving the *Länder* of the burden of approximately 1.17 billion euros per year in the long term and to grant them additional scope for education financing, for universities in particular. Furthermore, the benefits are being substantially improved, with both the entitlements and income deductions being increased by 7% with effect from the beginning of the 2016/2017 school year and the 2016/2017 winter semester. Therefore, the annual average number of *BAföG* recipients is set to rise by approximately 110,000 during 2017, the first full year that the changes take effect.

Reducing the red tape and streamlining the process, as well as introducing the option of online applications nationwide, will make the *BAföG* even more user-friendly. Thus, pupils and students who are dependent on *BAföG* allowances will be able to rely on solid education funding. The *BAföG* amendments are a decisive step towards greater training participation and more equal opportunities.

Integration through education

Germany has 16.4 million inhabitants with a migrant background. This figure represents approximately one fifth of the population. To a large extent, socio-economic status is still the main reason why children, adolescents and young adults with a migrant background perform below their peers on average, in terms of participating in education, or achieve lower levels of academic success. Nevertheless, increasing investments and the further development of the education system are helping young people with a migrant background to catch up. Supporting measures that specifically target the potential of migrants also play a part in increasing access to education and apprenticeships. One example is the Coordinating Office for Vocational Training and Migration (KAUSA), which was set up to promote dual training in companies owned by migrants.

Education will continue to play a vital role in integrating people with migrant backgrounds. It is imperative to pursue these successful approaches and use them to integrate the refugees. With the support of the European Social Fund (ESF), the Federal Government has introduced extensive measures to facilitate the integration of those who are newly arrived in Germany, for example, German language courses, processes to recognise skills and potential, and integration in apprenticeships and employment (cf. also the info box *Integrating refugees through education*).

Integrating refugees through education

Having accepted a large number of refugees in 2015 alone, Germany is now facing a challenge of historic proportions. The long-term goal will be to integrate a vast number of mainly young people, provided they have reasonable prospects of remaining in Germany for a significant period. The ability to speak German is key to achieving this goal: whether in day care centres, at school and in further training, integration into the labour market or social inclusion, all promotional programmes call for adequate language skills. The Alliance for Initial and Further Training agreed on specific measures to facilitate the integration of displaced persons in education and work (e.g. developing German language courses, coaching refugees to cope with the daily routine of training and work, and ensuring long-term residency for apprenticeships and initial employment).

Supporting language development

The Federal Government has extended its integration courses and made them available to refugees and asylum seekers with good prospects of permanent residence. The courses do not merely teach German, but also pass on the fundamental values of our democratic society. Various other programmes are also being further developed that cater specifically for career-related language skills, for example. The Federal Government supports refugees who are willing to take up or return to a course of studies, in particular with language preparation courses and helps in documenting that they meet the linguistic and academic requirements.

Integration in education and work

School-age children and adolescents from refugee families must be integrated in day-care centres and schools as smoothly and quickly as possible. This is the enormous task facing the *Länder*. Depending on their individual capacities, older teenagers and young adults should be encouraged to undertake apprenticeships, a degree course or further training. It is imperative that existing skills and potential be recognised, along with any professional qualifications that refugees have already obtained. The Recognition Act has proven to be an effective instrument in assuring the availability of skilled personnel by easing the integration of people with foreign qualifications in the labour market.

Instruments that facilitate training preparation or provide support during training are open to recognised refugees and those entitled to asylum. The Federal Government advises companies on all issues pertaining to refugee integration, for example, with the Centre of Excellence on securing skilled labour. Furthermore, companies receive support in integrating suitable refugees for internships, apprenticeships and employment in the form of welcoming guides at the chambers of commerce.

In addition, the Federal Government has facilitated access to educational funding for tolerated persons, for example by offering assistance during training and reducing required waiting periods from four years to 15 months for vocational training grants and the assisted training scheme. Access to introductory qualifications has also been made easier for asylum seekers and tolerated persons by exempting internships that are excluded from minimum wage requirements from approval by the Federal Employment Agency.

The different training routes will prove particularly successful if the individual integration instruments, for example, general and work-based language tuition, the funding measures of the Federal Employment Agency and in-depth, practical careers guidance, build on each other in a meaningful manner, thereby systematically paving the way for dual training.

Social integration

The integration course is the key component of all inclusion endeavours into economic, cultural and social life in Germany. The course is augmented with support measures that are specifically aimed at refugees, which provide access to existing programmes or develop and underpin initiatives organised by employees and volunteers in order to facilitate social inclusion and integration. However, these support measures and projects are not just aimed at refugees and asylum applicants: they are also directed at the host society in Germany itself. For example, without the tens of thousands of dedicated German volunteers, it would not be possible to cope with the increasing influx of refugees.

Only by offering measures in all three areas – language development, integration in education and at work, and social inclusion – will it be possible to achieve the ultimate goal of rapid, successful integration. The Federal Government is coordinating the three pillars of language development, integration in education and work, and social inclusion in a targeted manner: emulating the interaction of these aspects in real life, for which these measures are designed as preparation.

Internationalisation in education

With regard to vocational training, the Federal Government cooperates with many partner countries in the European Union and the OECD, together with a number of other industrialised, emerging and developing countries. In recent years, numerous countries have shown an even keener interest in Germany's dual system of vocational training because it has proven to be highly effective in the needs-based qualification of skilled personnel and a key factor in assuring employability and social participation. In addition, by ensuring that German companies abroad have an adequate supply of suitably trained, skilled workers, the dual system of vocational training is of vital importance. Therefore, the Federal Government has significantly increased the international exchange of information and stepped up the corresponding advisory services at the Federal Institute for Vocational Education and Training.

Thanks to its excellent transition into apprenticeships and employment – combined with the pledge made by the social partners in the *Alliance for Initial and Further Training* to improve the situation – the dual system of vocational training serves as a role model for countries in Europe with high levels of youth unemployment. In 2013, the European Commission initiated the *European Alliance for Apprenticeships* (EAfA) with the goal of ensuring a greater degree of employability in young adults in the Member States by means of company-based training and work-based learning. The *EAfA* promotes youth employment and supports the aims of the Youth Guarantee, while reducing the disparity between skills supply and demand on the labour market. Managed by the Commission, the success of *EAfA* lies with the joint commitment of politics, industry and partners to modernise the training systems. The self-imposed obligation of companies to provide apprenticeships plays a vital role in this respect.

The Federal Government plays an active part in shaping the OECD's education programme to aid the evaluation and development of the vocational training systems, even at international level.

4 Upholding internationality to boost progress and competitiveness

Global challenges can only be overcome through partnership. As one of the world's leading innovation hubs, Germany plays an active pioneering role in both the national and international arena. In this spirit, at the G7 Summit in Schloss Elmau, the Federal Government campaigned for greater cooperation in research and development activities and in finding solutions to current urgent issues. The international networking of all German stakeholders from science and research – and thus their integration in transnational knowledge flows – is a crucial factor in preparing for and overcoming such challenges. As this network guarantees the competitiveness and achievement potential of German science and industry, the Federal Government makes every effort to facilitate these relations. Europe continues to be the unshakeable central pillar of Germany's international commitment.

In the course of globalisation and the growing interdependence of international interests, education, research and innovation are in a constant state of flux. In view of the progressively transnational processes of knowledge generation and utilisation, it is more important than ever before to reaffirm Germany's position as a high-performance innovation hub. Numerous indicators are evidence that Germany is at the top of the international league and benefits from globalisation:

- With an overall market share of approximately 12% in research and development-intensive goods, Germany has maintained its outstanding competitive position in the global marketplace behind China and ahead of the United States. Medium and high-tech exports account for approximately 9% of Germany's trade balance.

- From 2003 to 2013, the increase in patents with world market potential per million inhabitants amounted to approximately 9%. Thus, the number of triadic patents in Germany per million inhabitants is more than 240% above the EU-27 average.

- In 2013, 59% of papers published were the result of cooperation between researchers at several research institutes. The share of international co-publications was particularly high, namely 54% in 2013. Therefore, the degree of networking in Germany's science sector is well above average.

- According to the EU Industrial R&D Investment Scoreboard, five of Europe's top ten corporate R&D investors are located in Germany.

- The European Commission's Innovation Union Scoreboard 2015 ranks Germany in fourth place as one of the European Innovation Leaders.

- As a hotspot for research, Germany is regarded as an attractive academic location and takes third place behind the United States and the United Kingdom among the destinations for international students from OECD countries.

The potential of international cooperation

The Federal Government intends to persist in fully utilising the potential and the opportunities that international cooperation offers Germany. At the same time, Germany has to accept its global responsibility: to help find groundbreaking solutions to the major challenges facing our societies and economies and put them into practice. It must do this, for example, by making its economy more sustainable, implementing the *Energiewende* and addressing the shortage of skilled manpower, along with issues related to migration and occupational mobility. Furthermore, international cooperation gives Germany's role greater definition and enhances the effectiveness of its science and research presence in the converging arenas of industry, research and urban centres. The instruments launched by the Federal Government range from the exploration and initiation of opportunities for cooperation, the implementation of specific research, innovation and education projects, right through to developing joint support programmes and establishing joint research infrastructures.

The creation of the *European Research Area* (ERA) has elevated Europe, making it a decisive factor in the alignment of international research policy; therefore, the Federal Government is actively pursuing the integration of its endeavours in the European framework. Concerted action on the part of important EU Member States enhances Europe's visibility, giving it added weight vis-à-vis the world's other major innovation regions. *Horizon 2020*, which runs from 2014 to 2020, was designed to complement national research programmes; with a total funding volume of 77 billion euros, it is the world's largest self-contained programme.

Moreover, Germany has been underpinning its bilateral cooperation with important partner countries around the world. This applies first and foremost to countries with dynamic growth and significant emerging markets; besides, it is of strategic importance in terms of access to excellent science and technology resources.

By virtue of their international contacts and specific tasks at the interface of science and practical application, the Federal Government's departmental research institutes play a crucial role in the development and international harmonisation of methods, standards, norms and regulations. Thus, they create conditions that are conducive to the success of innovation processes and international collaboration in tackling global social challenges, like the Ebola epidemic or the fight against antimicrobial resistances.

Germany's active involvement in multilateral initiatives and institutions like the *Organization for Economic Cooperation and Development* (OECD) and the *United Nations Educational, Scientific and Cultural Organization* (UNESCO) is conceived as a long-term investment in the future. On the one hand, these international organisations offer a framework for developing joint research standards and general conditions at the global level; on the other, by providing specific data processing and analyses, they ameliorate the basis for national and international policy decision-making – one example being the *Intergovernmental Panel on Climate Change* (IPCC).

A top priority: accelerating internationalisation

International collaboration in the fields of education, research and innovation enhances Germany's standing. There is often only a thin line between cooperation and competition. Therefore, having defined strategic priorities and developed instruments to maintain Germany's international competitiveness, the Federal Government is accepting global responsibility for the sustainable development of the economy. The Federal Government's 2008 *Strategy for the Internationalisation of Science and Research* created a framework for its diverse activities in this field. The BMBF's *International Cooperation action plan* is bringing Germany's profile as a recognised centre for science, education and innovation into sharper focus.

The Federal Government defines three overarching objectives in international collaboration within the knowledge triangle of research, innovation and education. Two other thematic priorities address Germany's responsibility in the world:

- Scientific excellence via international cooperation
- Developing innovation potential internationally
- Strengthening cooperation with developing and newly industrialised countries
- Assuming international responsibility and contributing to the solution of global challenges
- Creating perspectives through education – for people and the economy

The action plan was an important step in the ongoing development process of the internationalisation strategy. In light of the profound impact that internationalisation is now having on the entire science system – including the research institutes, universities, intermediary organisations and research-based companies – and since Germany needs to find answers to the resulting challenges, the plan will place particular emphasis on enhancing networking among science institutes.

The Federal Government deploys a broad range of instruments in working towards these objectives. These include stepping up the networking of international activities carried out by German science and research organisations, making excellent research infrastructures available for research cooperation at the international level and supporting foreign students and scientists. By expanding international research cooperation, driving the internationalisation of leading-edge clusters and comparable networks, and actively involving foreign partners, the *High-Tech Strategy* also intensifies international dialogue and exchange, and harnesses innovation potential, even across borders.

Another key area is improving Germany's international standing as an attractive location for science, research and innovation. Research marketing, the German Houses of Research and Innovation and strengthening the culture of welcome for foreign researchers all play a crucial role in this respect.

The Federal Government's internationalisation strategy is being refined in the current legislative period by implementing the provisions stipulated in the coalition agreement.

II The German research and innovation system

At a glance

A high-performance research and innovation system is crucial to maintaining Germany's prosperity and international competitiveness. Today's social and global challenges call for a multifaceted research and corporate landscape that is underpinned by a variety of institutions and stakeholders. To this end, the close intermeshing of basic research, applied research and industrial development – combined with the concerted efforts of different disciplines – are prerequisites for finding solutions to global challenges.

By international standards, the German research and innovation system (R&I system) excels by virtue of its high degree of continuity and division of labour. By interacting on all levels, the various stakeholders create framework conditions that are conducive to translating high-grade innovations from research and development (R&D) in enterprises into marketable products and services. The Federal Government regards research, innovation and education policymaking as primary fields of action. Over the long term, its targeted measures add to Germany's performance capacity and competitiveness as a hotspot for research and innovation.

Relevant indices show Germany's excellent position among international research and innovation centres: Germany consistently ranks among the leaders in the Global Competitiveness Index published by the World Economic Forum. The European Commission's Innovation Union Scoreboard 2015 ranks Germany in the group of European Innovation Leaders, together with the Scandinavian Member States.

Further information is available online

BMBF's Data Portal:
www.datenportal.bmbf.de/portal/en/index.html

Federal Statistical Office:
www.destatis.de/EN/FactsFigures/SocietyState/EducationResearchCulture/ResearchDevelopment/ResearchDevelopment.html

Wissenschaftsstatistik GmbH in the Stifterverband für die Deutsche Wissenschaft:
www.stifterverband.org/english

DFG – Funding Atlas 2015:
www.dfg.de/sites/fundingatlas2015

1 Overview of the German research and innovation system

In future, a high-performance research and innovation system will continue to be crucial in maintaining Germany's competitive edge.

Germany's R&I system boasts close interrelationships between its stakeholders, centres of competence and funding structures. The main structural features include the high proportion of research conducted and funded by the private sector compared to other countries, the broad spectrum of research fields, the high degree of specialisation in core areas of university research and the marked distribution of tasks in non-university research.

Since the formulation of the Lisbon Strategy in 2000, the Member States of the European Union have been striving to reach an R&D investment level of 3% of gross domestic product (GDP). In December 2015, the Federal Government and the *Länder* confirmed the increase in R&D expenditure as a share of GDP as an intermediate objective of the *Europe 2020* strategy. According to provisional estimates, this amounted to 2.88% in 2014. An international comparison confirms Germany's excellent performance, ranking fifth in Europe behind Finland, Sweden, Denmark and Austria.

1.1 Structure and stakeholders

Germany has a highly diverse R&I system, partly as a result of the country's federal structure and long tradition of science. It has a broad range of research fields and facilitates a high degree of specialisation in core areas. Moreover, the German R&I system owes its efficiency and success to the fact that its many and diverse players are willing to act in concert, by forming research alliances between non-university research institutes, universities and companies, for instance. There is a fundamental distinction between R&D funding and performing sectors.

R&D is often carried out in various public and private institutions. Figure II-1 shows the stakeholders in the R&I system and their interrelationships.

The Federal Government and *Länder* as funding stakeholders

As a function of their joint responsibility for research and in accordance with Germany's constitutional regulations, the Federal Government and the *Länder* cooperate in supporting research, technology and innovation and are major players in terms of funding research and development. National framework conditions are primarily set forth in the Federal Budget Code (*Bundeshaushaltsordnung*) and the Federal Budget Act (*Bundeshaushaltsgesetz*), in conjunction with the relevant law provisions of the *Länder*. These form the legal basis for the funding instruments that facilitate specific research funding: acting jointly, the Federal Government and the *Länder* provide institutional funding in a medium to long-term framework, the purpose of which is to safeguard basic research, the research infrastructure and the strategic orientation of the German research system. Provided from federal resources, project funding consists of specialised and support programmes, and provides funding for research, technology and innovation projects with a limited lifespan. Project funding is principally directed at application-oriented research. The Federal Government and the *Länder* fund approximately one third of all gross domestic expenditure on research and development.

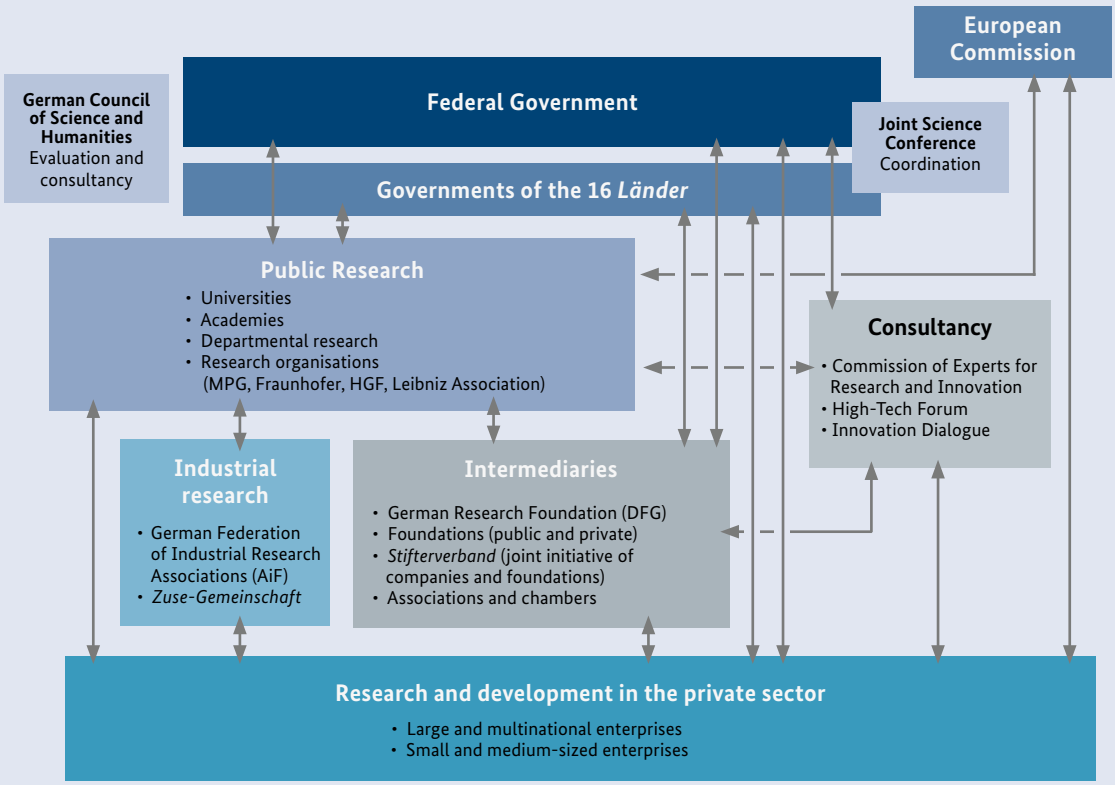
A number of coordinating and advisory bodies are on hand, namely the German Council of Science and Humanities (WR), the Joint Science Conference (GWK) and the joint committee of representatives from the Federal Government and the *Länder* on Research and Technology. Advisory services are also provided by the Commission of Experts for Research and Innovation (EFI), the High-Tech Forum and the Innovation Dialogue between the Federal Government, industry and science.

The private sector

The private sector provides about two thirds of the funding invested annually in research and development in Germany. These funds include both expenditure for companies' own R&D activities and expenditure for joint projects with partners from industry and science.

The research and development performed in the business enterprise sector is oriented strongly to applications: its overarching objective is to obtain results that can be directly commercialised. By contrast, basic research plays a subordinate role in the private sector. The huge variation in the regional distribution of R&D activities is determined for the most part by large companies. Nevertheless, despite their smaller share, small and medium-sized enterprises (SMEs) and start-ups also contribute significantly to the innovation performance of Germany's business enterprise sector, with this dynamic group blazing a trail in groundbreaking innovations. Another structural feature of private industry is the high concentration of R&D capacities on advanced technology sectors, compared to other countries.

Fig. II-1: Stakeholders of the German research and innovation system



Source: BMBF

Public research

A key player in the public research infrastructure is the higher education sector, in other words, the universities and universities of applied science. Besides the research conducted at universities, a vast array of non-university research projects are carried out for the most part by institutes that are jointly supported by the Federal Government and the *Länder*. These include the research facilities of the four large research organisations: the Max Planck Society (MPG), the Fraunhofer Gesellschaft (Fraunhofer), the Helmholtz Association (HGF) and the Leibniz Association. Moreover, non-university research organisations include the eight academies of science of the *Länder*, the National Academy of Science and Engineering (acatech), and the Leopoldina – the German National Academy of Sciences, as well as departmental research institutes.

The departmental research conducted by the Federal Government serves to prepare, support and implement political and administrative decision-making. It is linked to the fulfilment of the department's legal assignments and special tasks. This broad spectrum of challenging assignments is performed by federal institutions with research and development tasks, either independently, in cooperation with other research facilities or by awarding research contracts to external researchers (non-university research institutes). In addition, there are *Länder* and municipal research facilities, which are financed by the *Länder* and, to some extent, by third-party funding.

Intermediaries

The intermediary organisations in the German R&I system are essentially those stakeholders who support R&D activities with their own funding programmes and/or represent the interests of the stakeholders. They also include the German Research Foundation (DFG) and the *Stifterverband für die deutsche Wissenschaft* (Donors' Association for the Promotion of Sciences and Humanities in Germany).

Industrial research

The non-profit external industrial research institutes also act as an important interface between academia and an economy that is dominated by small and medium-sized enterprises in pre-competitive research. They are mainly organised via the German Federation of Industrial Research Associations (AIF) and the Zuse Association (*Deutsche Industrieforschungsgemeinschaft Konrad Zuse e. V.*).

European Commission

Launched on 1 January 2014, *Horizon 2020* (2014–2020), the EU framework programme for research and innovation is playing a key role in developing the European Research Area (ERA) and placing the European research landscape firmly on the global map. Adopted by the Council of the European Union and the European Parliament, and administered by the European Commission, the world's largest research and innovation programme has a total funding volume of approximately 77 billion euros. It bundles the research funding programmes at European level and places an even greater emphasis on cooperation between science, research and industry, and on innovation, than previous programmes.

1.2 State funding instruments

A functioning state research and innovation funding system calls for several pillars, for which the legal foundation is enshrined in the German Basic Law. The Federal Government and the *Länder* act in concert within the scope of their respective constitutional jurisdictions with regard to state research funding. They have several instruments at their disposal, which facilitate targeted research funding and financing: project funding, institutional funding and departmental research.

Funding research and development is the shared responsibility of the state and society. In order for research to be internationally competitive, and for the scientific and research communities 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. Thus, the Federal Government has funding authority for major scientific projects, such as research in the fields of aeronautics, space, oceanography and nuclear technology, and for international research institutes.

With regard to state research funding, the Federal Government and the *Länder* act in concert within the scope of their respective constitutional jurisdictions. The Joint Science Conference (GWK) and the joint committee of representatives from the Federal Government and the *Länder* on Research and Technology serve as forums for the exchange of ideas and for coordinating research, technology and innovation policy. Furthermore, they foster cooperation in funding research organisations. The GWK rules in cases of supra-regional importance (e.g. in connection with the Initiative for Excellence and the Higher Education Pact). The German Council of Science and Humanities (WR) advises the Federal Government and the *Länder* governments regarding the development – in terms of both structure and focus – of the higher education, science and research sectors.

The Union's framework for state subsidies to support research, development and innovation, and Section 4 of the General Block Exemption Regulation play a crucial role in this process. The national framework conditions are primarily set forth in the Federal Budget Code and the Federal Budget Act.

Institutional funding

Institutional funding refers to the overall operations and investments of research and science institutes, which are funded in the long term by the Federal Government or by the Federal Government and the *Länder,* acting in concert. The purpose of this funding is to safeguard the research infrastructure, expertise and strategic orientation of the German research landscape. Basic funding provided to institutions is subject to stringent requirements and strict accountability. Important examples of institutional funding include the allocations that the Federal Government and the *Länder* provide in the context of joint research funding pursuant to Art. 91b Basic Law, for example, basic funding for the research organisations MPG, Fraunhofer, HGF and the Leibniz Association.

Institutional funding accounts for more than one third of all government subsidies. Apart from the four research organisations listed above, funds are also allocated to the DFG, whose core task is to identify and finance the best research projects submitted by scientists. Institutional funding that is administered by the Federal Government alone primarily relates to the departmental research institutes, but also the Max Weber Foundation – International Humanities.

Project funding

Federal project funding is normally provided in the framework of general or specialised funding programmes, based on applications for fixed-term projects. Both individual projects and collaborative research projects involving several partners are eligible for such funding. Federal project funding is provided within the scope of the legal and political framework, which is set up at European and national levels.

It is necessary to distinguish between direct and indirect project funding: direct project funding refers to a specific field of research in each case. The purpose of such funding is to achieve high international standards of performance in selected areas of research and development. The aim of indirect project support is to encourage research institutes and companies, particularly SMEs, to engage in R&D activities. For example, it aims to support the development and enhancement of research infrastructure, research cooperation, technology and innovation projects, innovative networks and the exchange of personnel between research institutes and industry.

The department's project funding activities receive extensive support from so-called project management agencies or service providers, who have qualified in the course of a competitive process. For the most part, project management agencies are organisational units at suitably qualified research institutes or private companies, who perform scientific, technical and administrative management tasks in a variety of functions on behalf of federal ministries. These include, most importantly, expert and administrative advisory services for applicants, preparation for funding decisions, project support and monitoring of projects' success. In addition, the project management agencies provide consultancy and support services. Collaboration may be on a contractual basis or be delegated by way of appointment.

Contract research

In the framework of departmental research, federal institutes with R&D tasks conduct their own research and research contracts are awarded to third parties. In principle, R&D projects are assigned on the basis of a competition, either independently by the relevant departments or by federal institutes with R&D tasks; contracts are awarded or grants authorised in accordance with the regulations for public procurement and the allocation of public funds.

Contractors and grantees may be any persons and institutions working in the knowledge-based sector, including non-profit and industrial research institutes. R&D projects are awarded based on plans that have the flexibility to meet the current requirements for departmental research while facilitating the lines of research over several years. The research and development findings are generally published.

2 Financing and implementing science, research and development

Both industry and the state support, finance and conduct research and development in Germany. The vast majority – more than two thirds – of R&D activities take place in Germany's private sector, mostly in large companies. Universities, non-university and public research and science institutes account for approximately one third. The individual sectors report similar ratios for the distribution of R&D personnel in Germany. Furthermore, the important role of industry becomes clear when considering the funding of research and development. In 2013, the private sector financed 52.2 billion euros or just on two thirds of all gross domestic expenditure on research and development.

Research and development is carried out in a wide range of public and private institutions. This diversity of the German research and innovation system is reflected in the different sources of funding: R&D projects at public sector institutions also receive third-party funding, while some private research in companies is also publicly funded (cf. also the info box *R&D expenditure*).

Research and development expenditure has increased significantly in recent years. According to provisional estimates, in 2014, the state and industry together invested 83.9 billion euros in R&D. This is equivalent to 2.88% of the gross domestic product (GDP) and thus almost achieves the three-percent target identified by the *Europe 2020* strategy. Therefore, Germany is in the top league of countries with a very high level of R&D intensity.

In 2013, by far the largest share of the public R&D budget was allocated to universities (49.7%) and non-university/federal/*Länder* and municipal research institutes (42.5%). Public funding and support of R&D in industry is mainly directed at small and medium-sized enterprises. They finance more than one seventh (16%) of their internal R&D expenditure from public funds.

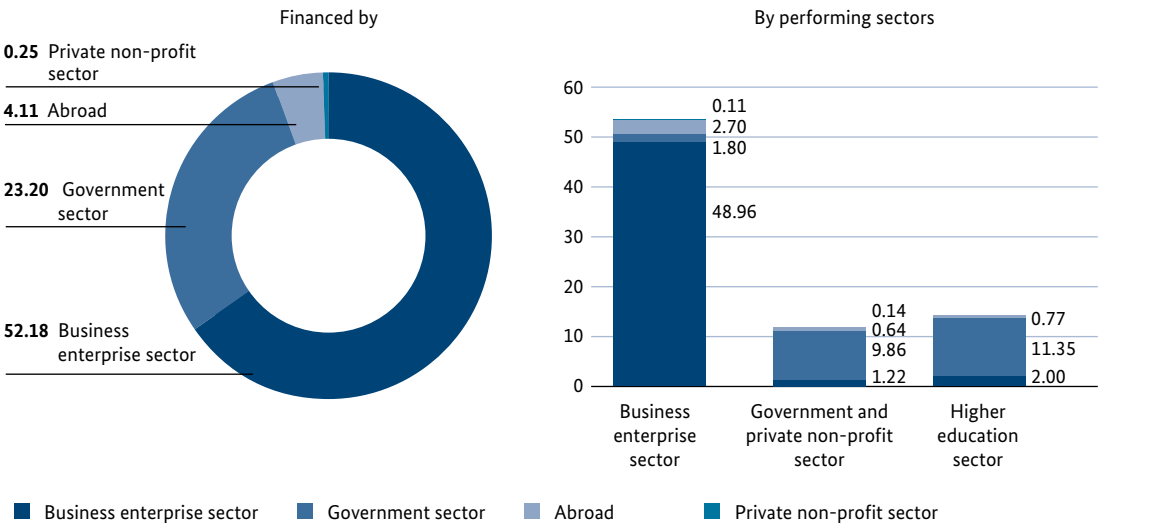
R&D expenditure

The architecture of the German R&I system is determined by the country's federal structure, the size and focus of its economy, and by the diversity of its many players. Gross domestic expenditure on research and development (GERD) is a key indicator of the R&D efforts of different countries and is used in international comparisons.

Overall, R&D expenditure was 79.73 billion euros in 2013. Contributions to GERD in the individual sectors in which R&D is carried out may differ widely: 53.57 billion euros, or approximately two thirds of GERD, were used in the private sector in 2013. The higher education sector appropriated approximately 14.30 billion euros. The federal, *Länder* and municipal research institutes and the private non-profit institutions show R&D expenditure of 11.86 billion euros.

The expenditure of the R&D performing stakeholders is financed by domestic industry, the government, private non-profit institutions and funding sources abroad. In 2013, the private sector financed 52.18 billion euros or approximately two thirds of GERD. Compared to other countries, this figure is extremely high and is regarded as a characteristic feature of the German R&I system. Approximately 30% of GERD is financed by the Federal Government, the *Länder* and private non-profit institutions. The remaining 5% is furnished by sources abroad (cf. also Fig. II-2).

Fig. II-2: Gross domestic expenditure on research and development (GERD) in the Federal Republic of Germany in 2013 (in billions of euros)



Source: BMBF's Data Portal, table 1.1.1

2.1 Federal Government and *Länder* funding of science, research and development

The Federal Government and the *Länder* are major players in terms of funding science, research and development. The German federal system enables both the Federal Government and the *Länder* governments to fund and promote research and innovation within their respective spheres of responsibility. Furthermore, the Federal Government and the *Länder* join forces in supporting scientific research institutes and projects of national importance.

Publicly funded research is a high priority in Germany. In 2013, the joint R&D expenditure of the Federal Government and the *Länder* came to 24.4 billion euros. The bulk of Federal Government spending on research and development is allocated by the BMBF and the Federal Ministry for Economic Affairs and Energy (BMWi).

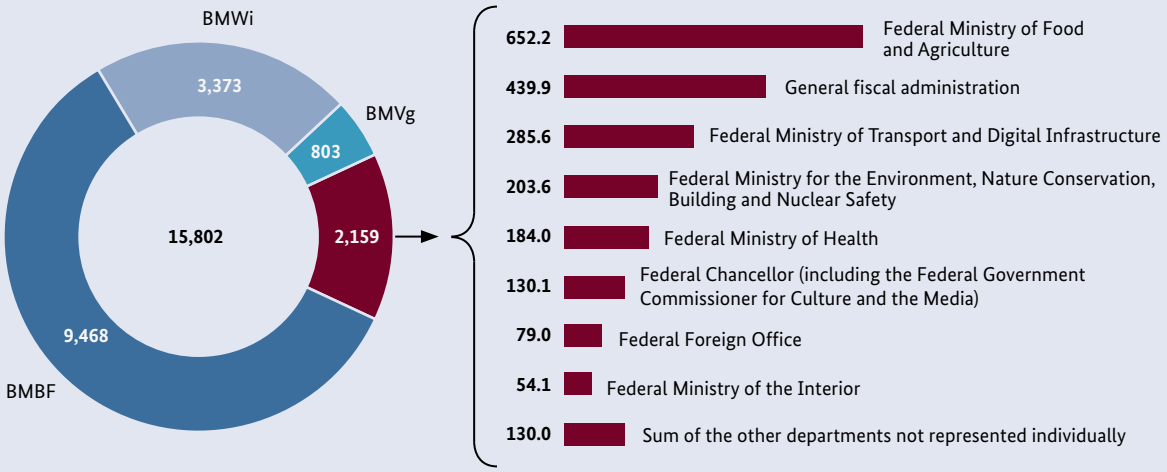
Public research funding is directed at basic research, which plays a subordinate role by virtue of the high external effects in the business enterprise sector, along with applied research.

The Federal Government's R&D expenditure

In recent years, Federal Government R&D expenditure has seen significantly more dynamic growth than in the 1990s and 2000s, increasing to just under 14.3 billion euros in 2013. Federal Government R&D expenditure is expected to rise to 15.8 billion euros by 2016. The BMBF accounts for approximately 60% of Federal Government R&D expenditure, the BMWi for about 21% and the Federal Ministry of Defence (BMVg) for about 5% (cf. also Fig. II-3).

Furthermore, Federal Government R&D expenditure as part of direct project funding and non-university departmental research has continued to increase in

Fig. II-3: Federal Government expenditure on research and development in 2016 in Germany by department (target in millions of euros)



Source: BMBF's Data Portal, table 1.1.4

recent years, totalling 5.5 billion euros in 2014. Approximately 6.5 billion euros of relevant Federal Government R&D expenditure have been earmarked for 2016. The BMBF, the BMWi and the BMVg together account for 81.3%, with the BMBF alone accounting for approximately 56% (cf. also Fig. II-4). Federal Government R&D expenditure as part of indirect project funding totalled 0.8 billion euros in 2013; expenditure of 0.9 billion euros is planned for 2016.

In 2014, the Federal Government's departmental research institutes were allocated some 993 million euros for R&D activities. Moreover, in order to meet departmental research needs, the Federal Government also awards research contracts and projects to universities, non-university research facilities and companies.

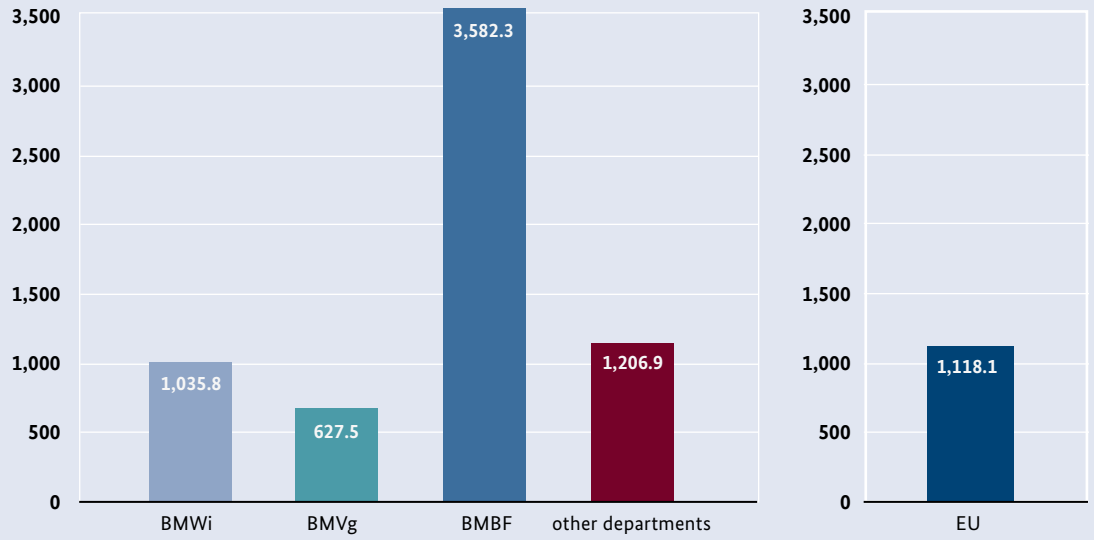
Added to this is the effective R&D expenditure by the EU in Germany from the *Horizon 2020* framework programme for research and innovation. The annual average total of the lifespan to date, from 2014 to 2015, amounted to approximately 1.1 billion euros.

Joint funding of research and science by the Federal Government and the *Länder*

The Federal Government and the *Länder* join forces in supporting scientific research institutes and projects of national importance. The Federal Government/*Länder* agreements determine the specific configuration of this joint research funding.

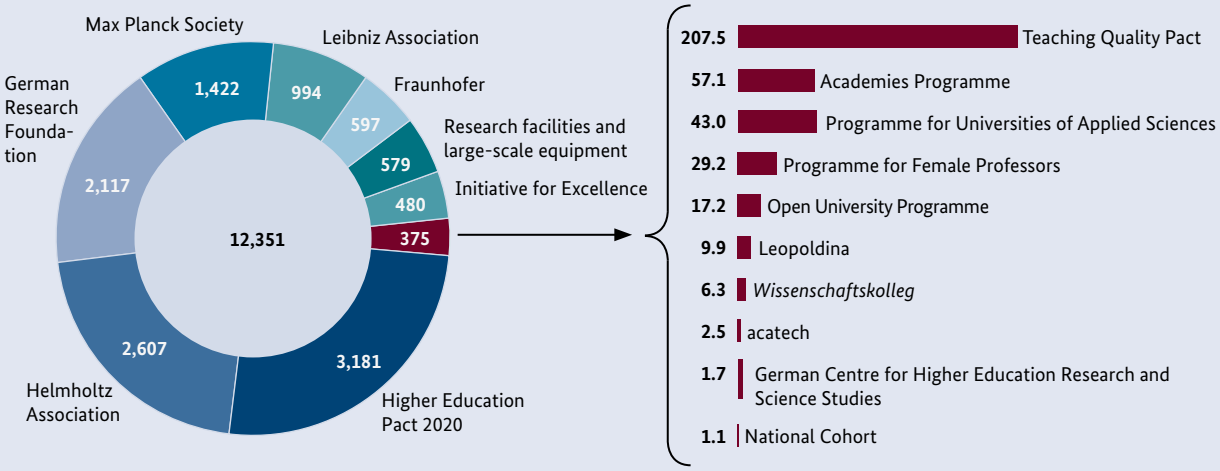
In 2013, the joint funding arrangement had a total budget of 12.35 billion euros. Two thirds were assumed by the Federal Government (66.7%) and one

Fig. II-4: Federal Government expenditure on research and development as part of direct project funding and departmental research (2016 target in millions of euros) plus effective R&D expenditure by the EU in Germany (in millions of euros)



Including expenditure, as of 2001, for contracts under departmental and defence research and development, for the development of the higher education and science sectors and for achieving equal opportunities for women in research and teaching.
Does not include basic funding of federal research institutions with departmental research tasks.
As the budget for Horizon 2020, the framework programme for research and innovation (lifespan 2014-2020) is set to rise sharply from year to year, a mean of the lifespan to date is indicated instead of a reference date.
Source: BMBF's Data Portal, table 1.1.7, EU data: H2020 ECORDA contract database; as of 26.02.2016

Fig. II-5: Joint funding of the Federal Government and the *Länder* by funding areas in 2013 (in millions of euros)



Source: Joint Science Conference (2015)

third by the *Länder* (33.3%). Compared with 2012, the Federal Government and the *Länder* increased the total monies allocated to the joint funding by approximately 1.64 billion euros, or 15.3%. With some 3.18 billion euros, the Higher Education Pact 2020 accounts for the largest portion of Federal Government/*Länder* funds in the breakdown of the total 2013 budget by funding areas. The funding allocated to the research and science organisations involved in the Pact for Research and Innovation (DFG, HGF, MPG, Leibniz Association and Fraunhofer) totalled approximately 7.75 billion euros (cf. also Fig. II-5). In 2015, the institutional research funding made available by the Federal Government and the *Länder* amounted to 9.4 billion euros. Of which, 6.6 billion euros were provided by the Federal Government and 2.8 billion by the *Länder*.

The larger, densely populated *Länder* dominate the regional distribution of overall funding for 2013, like North Rhine-Westphalia with around 2.30 billion euros (18.6%), Baden-Württemberg with around 1.94 billion euros (15.7%) and Bavaria with around 1.67 billion euros (13.6%). The remaining West German *Länder* account for 3.29 billion euros (26.6%) and the East German *Länder*, including Berlin, for approximately 2.89 billion euros (23.3%). The remaining sum of around 267 million euros (2.2%) cannot be attributed to a particular region.[1]

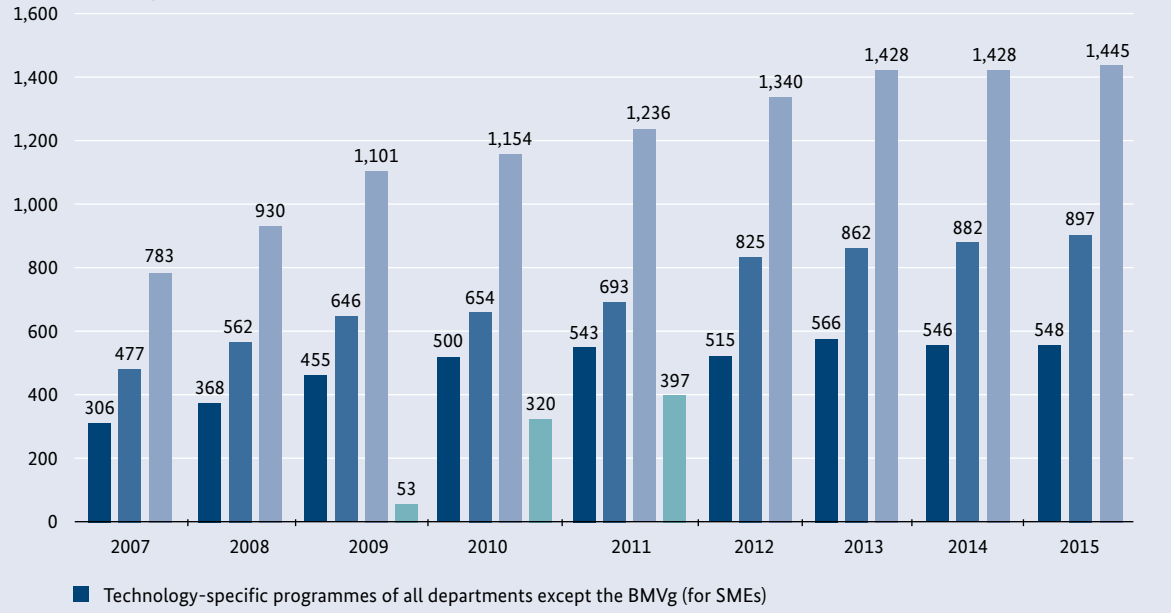
R&D expenditure of the *Länder*

Besides the activities of the Federal Government and the joint Federal Government/*Länder* activities, the *Länder* carry out *Land*-specific research, technology and innovations policy funding measures. These address the specific strengths of the individual regions, as well as any existing spatial structures and special features. These regional differences are a vital asset in strengthening the German R&I system as a whole.

In 2013, the R&D expenditure of the *Länder* (not including the municipalities) came to 10.14 billion euros, a slight decline compared to around 10.15 billion euros in the previous year. The *Länder* share of the total R&D expenditure of the Federal Government and the *Länder* amounted to just over 41%. This figure also shows a slight downward trend.

1 GWK (2015): Joint research funding of the Federal Government and the *Länder*, cash flows in 2013, issue 44.

Fig. II-6: Federal Government project funding that goes directly to, or for the benefit of SMEs, pursuant to the national definition (in millions of euros)



Source: BMBF, BMWi

Public funding of R&D in industry

In 2013, the public share of gross domestic expenditure on R&D projects in the business enterprise sector came to approximately 1.8 billion euros in Germany. At 3.4%, the public funding of R&D in industry is below the average for OECD countries at 6.6%, yet ahead of other innovation leaders like Switzerland and Finland, for example.[2]

In Germany, the public funding of R&D in industry employs the instrument of project funding and primarily addresses projects in pre-competitive, application-oriented research. Specialised funding programmes have been set up for basic technologies that accelerate developments in central fields of application, thereby acting as growth drivers in many sectors. The *High-Tech Strategy* focuses on issues related to communication, climate, energy, work, health, nutrition, mobility and security. Added to this are the special technology-neutral funding programmes that are aimed in particular at or benefit SMEs.

In Germany, large companies with a minimum of 500 employees account for considerably less than half of the total public R&D financing in the business enterprise sector, although these companies carry out the majority – 85% – of internal industry R&D activities. Overall, in these companies, public funding makes up less than 2% of their internal R&D expenditure. By contrast, SMEs with fewer than 250 employees finance 16% of their internal R&D expenditure from public funds. Therefore, according to the figures published by *Wissenschaftsstatistik*, state R&D funding in Germany benefits SMEs at a disproportionate rate. From 2007 to 2015, Federal Government R&D funding to and in support of SMEs rose from 783 million to 1,445 million euros. The BMWi's technology-neutral programmes accounted for some 897 million euros (cf. also Fig. II-6).

2 Schasse, U. et al. (2016): *Forschung und Entwicklung in Staat und Wirtschaft, Studien zum deutschen Innovationssystem*, No. 2-2016.

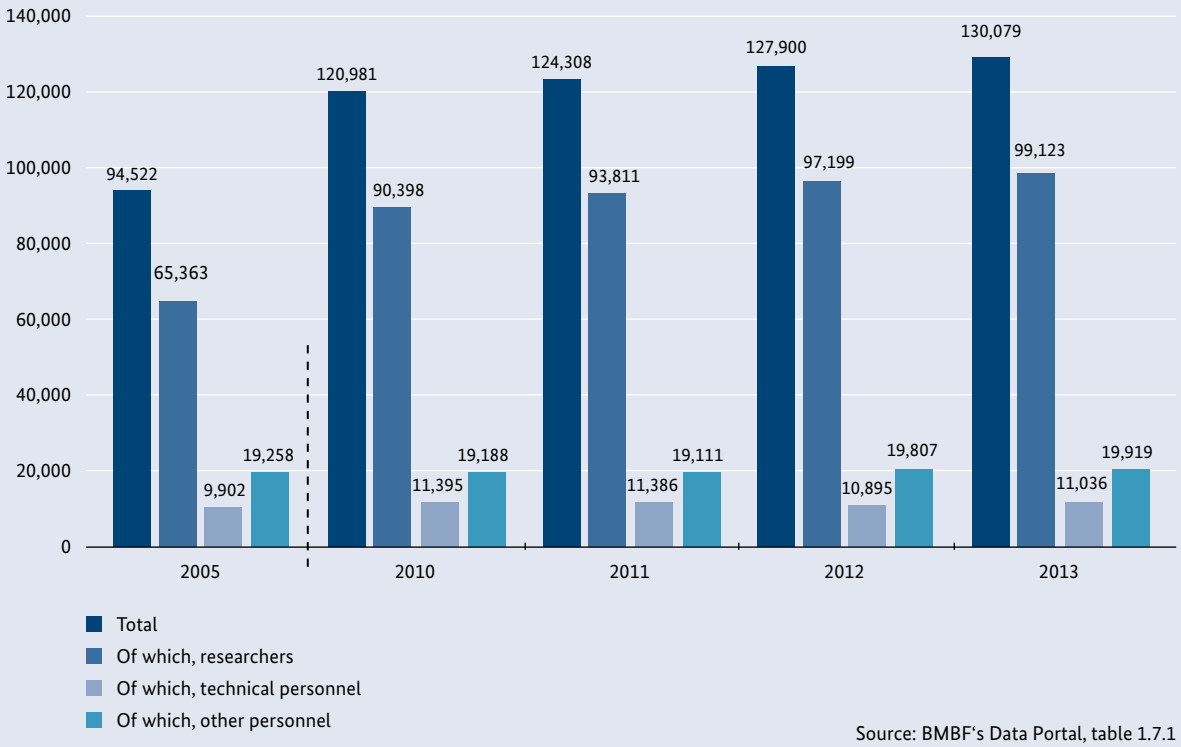
2.2 Institutions of higher education

The universities play a major role in carrying out research and development, and are a vital asset in ensuring progress and prosperity in Germany. As institutions of high-grade tertiary education and research, universities are key initiators of regional innovation. The spectrum of research at institutes of higher education ranges from basic research to application-oriented research, right through to development work.

Universities traditionally form one of the main pillars of the German R&I system. In 2013, they carried out R&D activities in the amount of approximately 14.3 billion euros, thereby accounting for 17.9% of the overall R&D. Their important standing is based on their highly diversified research activity in terms of content, disciplines and methodology, and the promotion of early career scientists, particularly at universities. This is also highlighted by the steady rise in R&D personnel (shown as full-time equivalents – FTEs) employed in the higher education sector and the increasing number of scientific personnel (researchers) as a percentage of the total R&D personnel at universities (cf. also Fig. II-7). Besides scientific personnel, technical and other personnel are also included in the total number of R&D personnel.

In Germany, the higher education sector comprises all state and state-accredited private and church-sponsored universities and universities of applied science. They act as the interface between research, the research-oriented qualification of students and the promotion of early career scientists. As a result, they contribute substantially to the success of Germany's R&I system. Furthermore, diverse forms of

Fig. II-7: Number of R&D personnel by personnel groups in the higher education sector in Germany (in full-time equivalents)



Source: BMBF's Data Portal, table 1.7.1

cooperation have sprung up within the universities and universities of applied science, between them and with non-university research institutes. These may be research consortia or collaborative research centres that are sponsored by the German Research Foundation. Some universities also house associated institutes (An-Institute). Although these exist as legally autonomous institutions with close organisational, staff and spatial links to the relevant universities, they are not an integral part. Their task is to research industry- and application-oriented fields between the poles of applied research and market-relevant product development.

Nowadays, even in application-oriented research and development, the universities of applied science play an ever more prominent role. Owing to their practical orientation and regional embeddedness, they are important links between academia and industry; moreover, they are optimally positioned as partners, particularly for the small and medium-sized enterprises in the region that do not have their own research and development departments.

According to the Federal Statistical Office, Germany currently has 427 institutions of higher education, including 107 universities, 6 teacher-training colleges, 16 theological colleges, 52 academies of art, 217 universities of applied science and 29 colleges of public administration.

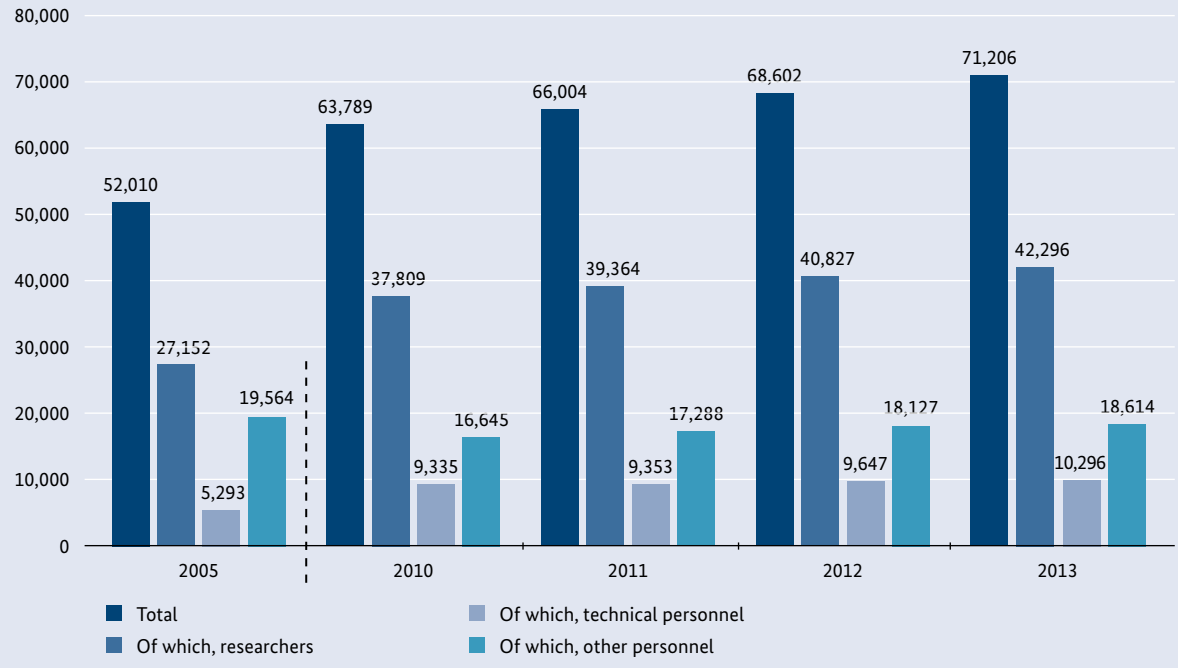
2.3 Non-university research institutions

In the non-university research landscape, the institutes of science, research and development that are jointly funded by the Federal Government and the *Länder* play a major role in conducting research and development. These include the four research organisations – the Max Planck Society, Fraunhofer, Helmholtz Association and Leibniz Association – together with the academies of science, most of which are organised in the Union of the German Academies of Sciences and Humanities.

Other facilities like foundations and associations are also financed by public funds. The most notable of these is the Max Weber Foundation, comprising ten humanities research institutes around the world. Although there are yet other facilities, like the Berlin Institute for Advanced Study, the German Centre for Higher Education Research and Science Studies and the caesar foundation, which is closely associated with the Max Planck Society, they are not examined in this report.

In recent years, the Federal Government and the *Länder* have made a significant contribution to achieving the target of increasing R&D expenditure, as outlined in the *Europe 2020* growth strategy. For example, the R&D expenditure of the research institutes that are jointly funded by the Federal Government and the *Länder* rose from 8.22 billion to 9.08 billion euros from 2011 to 2013, which may in part be attributed to the Pact for Research and Innovation. This represents an increase of 10.4%. This also led to a steady increase in R&D personnel. In 2013, a total of 71,206 FTEs were employed by the non-university research facilities presented here, of which 59.4% were researchers (cf. also Fig. II-8).

Fig. II-8: Number of R&D personnel by personnel groups in non-university research institutes in Germany (in full-time equivalents)



R&D personnel at institutes for science, research and development that are jointly funded by the Federal Government and the *Länder*, not including academies.

Source: Federal Statistical Office, Fachserie 14 Reihe 3.6 Table 6.1

Max Planck Society

The Max Planck Society (MPG) is the umbrella organisation of the currently 83 Max Planck Institutes, which mainly conduct basic research in the natural sciences, life sciences, social sciences and the humanities. The Institutes focus on research topics with a high degree of interdisciplinarity that are especially demanding in terms of funding or time requirements. Since its inception in 1948, no fewer than 18 Nobel laureates have emerged from the ranks of its scientists. The MPG currently employs 17,284 staff, including 5,654 scientists, and supervises 3,378 doctoral candidates. Women make up 44.6% of the total staff, 38.6% of the doctoral students and 29.4% of the scientific personnel (figures as of 1 January 2015).

The MPG Institutes offer outstanding research conditions and are thus one of Germany's greatest magnets for the world's scientific élite. In total, almost one third of the institute directors (33%), 39.6% of the researchers and more than half of the junior and non-tenured scientists (55.5%) do not hold a German passport. Among post-doctoral researchers, the figure is even higher, at approximately 72.4%.

Shining examples of the MPG's strong international focus include the intensive scientific exchange, the science-based cooperation of its institutes and the International Max Planck Research Schools that foster the development of junior scientists. Max Planck Institutes are involved in more than 4,500 cooperation projects with approximately 5,400 partners in 118 countries around the world.

Special mention must be made of their particularly close ties with German universities. Around 80% of Max Planck researchers who have obtained their post-doctoral lecturing qualification are actively involved in university teaching. MPG Institutes are represented in almost one third of the Collaborative Research Centres run by the DFG.

Further information is available online

Max Planck Society: www.mpg.de/en

Fraunhofer-Gesellschaft

The Fraunhofer Gesellschaft (Fraunhofer) is the largest research organisation for applied research in Europe. The fields of research fall into the following categories: Health and Environment, Security and Protection, Mobility and Transport, Energy and Resources, Production and Supply of Services and Communication and Knowledge.

Fraunhofer currently operates a total of 67 institutes and research units located throughout Germany, as well as subsidiaries in Europe, North and South America, the Fraunhofer Representative Offices and Fraunhofer Senior Advisors. The network facilitates worldwide access to the regions of greatest importance to present and future scientific progress and economic development.

Fraunhofer employs approximately 24,000 staff, who generated a research volume of over 2 billion euros in 2015. Roughly 1.77 billion euros may be attributed to contract research, its core business activity, 73% of which was produced by orders placed by industrial clients and publicly financed research projects. Applied research has a knock-on effect that extends beyond the direct benefits perceived by the customer: through their research and development work, the Fraunhofer Institutes help to reinforce the competitive strength of the economy in their local region. They promote innovation, strengthen technological capabilities, improve the acceptance of modern technology and ensure the much-needed practical training of the next generation of scientists and technicians.

Another important task for Fraunhofer is strategic research. The institutional funding provided by the Federal Government and the *Länder* enables research projects to be realised that help to bring about innovations in society and key technologies. These include research in fields like information and communications technology, life sciences, microelectronics,

light & surfaces, production, materials and components, as well as defence and security research.

Fraunhofer maintains close ties with universities, thereby supplementing its own basic research resources and recruiting the young scientists it requires. By the same token, the universities benefit from their cooperation with Fraunhofer in the form of practical training and the joint approach to practice-oriented research topics. Common features of this collaboration are joint appointments to chairs and the management boards of Fraunhofer Institutes.

Further information is available online

Fraunhofer-Gesellschaft:
www.fraunhofer.de/en.html

Helmholtz Association

The Helmholtz Association (HGF) is dedicated to pursuing the long-term research goals of state and society, and to maintaining and improving the livelihoods of the population. Strategic, programmatically oriented cutting-edge research is conducted in the following six research fields: Energy; Earth and Environment; Aeronautics, Space and Transport; Matter; Health and Key Technologies. In cooperation with national and international partners, the HGF contributes to unravelling complex systems by means of large-scale facilities and infrastructures. It combines research and technology development with perspectives for innovative applications and provisions for tomorrow's world.

The HGF brings together 18 scientific-technical and medical-biological research centres. With an annual budget of 4.24 billion euros (2015), the HGF is Germany's largest scientific organisation. A good two thirds of this funding comes from public sponsors. The individual Helmholtz Centres are responsible for attracting more than 30% in the form of contract funding provided by public and private sector sponsors. As of 2014, the Association's research centres employed 38,036 staff, of which 14,734 are scientists, 7,356 are PhD students and 1,657 are in vocational training. The HGF cooperates with diverse international partners to conduct competitive, cutting-edge research that produces results of worldwide significance. To this end, the Association creates strategic international alliances, consortia and networking with national and international partners from science and research, and especially from the universities and industry. Excellent promotion of early career researchers is very important to the Helmholtz Association, also at international level. Each year, several thousand visiting scientists and researchers come to the Helmholtz Centres, not least to work with their large-scale scientific facilities and instrumentation; in some cases, this equipment is the only one of its kind in the world. In 2014, 7,476 foreign

scientists made use of the infrastructures in the HGF centres. The HGF has international offices in Brussels, Peking and Moscow, in addition to the foreign representations of the research centres. For example, the German Aerospace Center (DLR) has its own offices in Brussels, Paris, Tokyo and Washington.

Further information is available online

Helmholtz Association: www.helmholtz.de/en

Leibniz Association

The Leibniz Association addresses issues of social, economic and ecological relevance. It conducts knowledge-driven and applied basic research, maintains scientific infrastructure and research museums, and provides research-based services. Moreover, the Leibniz Association identifies focus areas for knowledge transfer to policy-makers, academia, business and the public.

The Leibniz Association unites 89 independent research institutions, which are funded jointly by the Federal Government and the *Länder*; a further institute is connected, yet not jointly funded. The research spectrum of the institutions spans the natural sciences, engineering and environmental research to economics, spatial research and the social sciences, right through to the humanities. In 2014, the institutions of the Leibniz Association had a total budget of approximately 1.64 billion euros, almost two thirds of which is provided by institutional funding. Third-party funding from the public and private sectors represented a further substantial share, with a total of 363 million euros being raised in 2014.

In 2014, the research Infrastructures in the Leibniz Association employed a total staff of 18,144, including 9,217 researchers, 3,854 supervised doctoral candidates and 391 individuals in vocational training. Gender equality in science is one of the Leibniz Association's core objectives. Women currently account for 46.3% of doctoral students, 42.2% of academic staff and 27.3% of scientific leadership positions.

Since 2006, a total of 29 Leibniz Graduate Schools have been instituted. Furthermore, intensive cooperation with universities is of considerable strategic importance for the Leibniz Association: in 2014, there were 331 joint professorial appointments of leading scientists in conjunction with universities. The Leibniz ScienceCampi, of which 12 had been established as of 2015, is the Leibniz Association's effective model of cooperation between university and non-university research. A further seven ScienceCampi are expected to begin work in 2016. A ScienceCampus promotes cooperation on an equal footing between Leibniz institutions and universities in the form of thematically focused, complementary regional partnerships.

The Leibniz Association also administers the vast majority of supra-regional scientific information facilities and central specialised libraries in Germany. Their main tasks are to establish and maintain literature and specialised information databases, including online access to associated scientific computer centres, provide and operate specialised information services and enable online access to information databases via specialised computer centres.

Further information is available online

Leibniz Association:
www.leibniz-gemeinschaft.de/en/home

German Academies of Sciences and Humanities

The Academies are mandated with coordinating long-term basic research projects and cultivating interdisciplinary dialogue. They have also taken on the additional task of advising society. The Academies carry out symposia and public events, thereby contributing to intensive dialogue between science, society and industry. The basic budget of the Academies of Sciences and Humanities is funded directly by the *Land* in which the respective academy is located.

The Academies in Berlin, Düsseldorf, Göttingen, Hamburg, Heidelberg, Leipzig, Mainz and Munich have banded together in the Union of the German Academies of Sciences and Humanities, with the aim of coordinating their basic research and presenting themselves more effectively to other science organisations in Germany and abroad. The member academies comprise over 1,900 scholars of diverse subjects, all of whom are outstanding representatives of their research fields, both nationally and internationally. The Union coordinates the Academies' Programme, currently the most comprehensive humanities and cultural sciences research programme in Germany. Financed in equal parts by the Federal Government and the *Länder*, the programme currently has a total budget of approximately 63 million euros.

Moreover, the National Academy of Science and Engineering (acatech) in Munich and the German National Academy of Sciences Leopoldina in Halle (Saale) also operate under the umbrella of the Union of German Academies. A working academy, acatech currently numbers 443 members from science and business who are appointed in a personal capacity (as of 2015). Firstly, experts from science, business, politics and society develop sound concepts as input for the public and political debate; secondly, the Academy consults autonomously and independently on technology-related issues that are relevant to Germany's future as a business location. The Federal Government and the *Länder* each contribute half of the state funding, while acatech draws additional funding from project-specific third-party sources.

Also entrusted with this task as the German National Academy of Sciences, Leopoldina is financed by the Federal Government (BMBF) and the *Land* Saxony-Anhalt at a ratio of 80:20. With some 1,500 members, the Leopoldina brings together outstanding scientists, mostly from Germany, but also from Austria, Switzerland and other countries. As the National Academy, it is tasked with representing the German scientific community on international committees. In addition, it speaks out on social and political questions, providing a nonpartisan, factual framework for discussion.

Lastly, it founded the Young Academy in 2001, which was established on a permanent basis in 2011. It works specifically as the voice of early career scientists, opening up opportunities for active participation. In order to empower young researchers from around the world, the Federal Government also supports the *Global Young Academy*.

Further information is available online

Union of the German Academies of Sciences and Humanities: www.akademienunion.de/en

acatech: www.acatech.de/uk

Leopoldina:
www.leopoldina.org/en/leopoldina-home

Global Young Academy:
https://globalyoungacademy.net

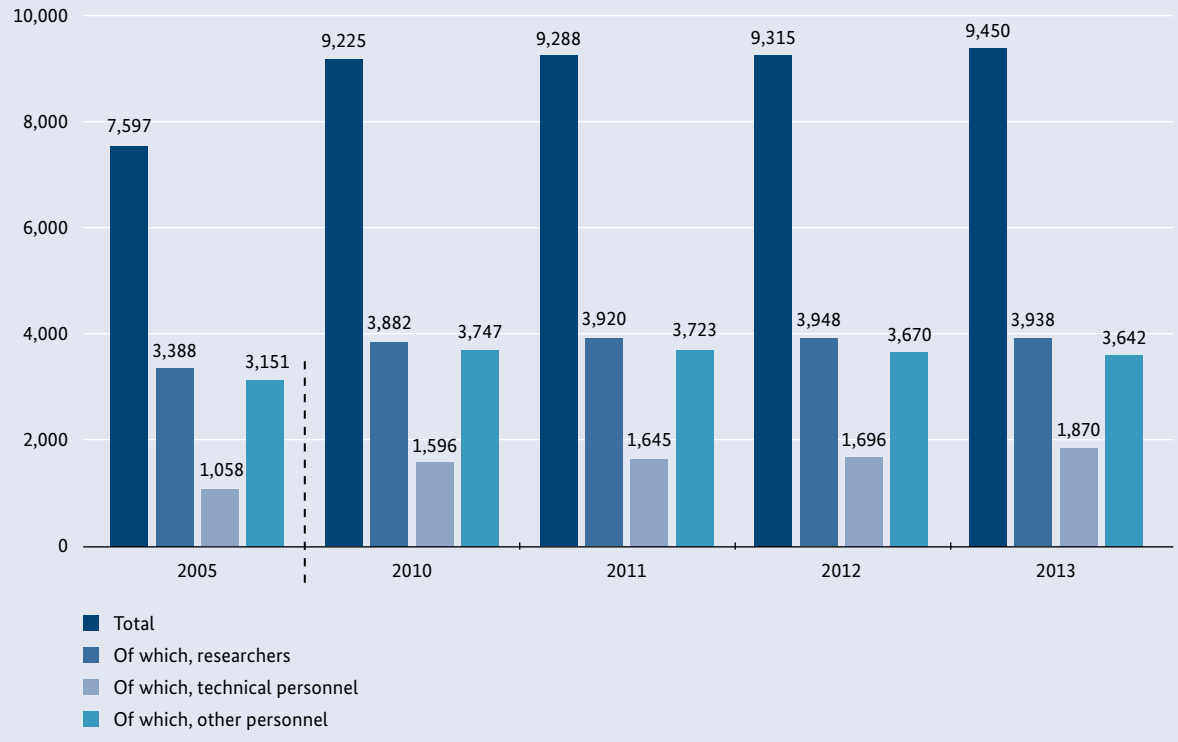
2.4 State research institutes

Apart from the universities and the institutes for science, research and development that are jointly funded by the Federal Government and the *Länder*, other public sector entities also carry out direct research and development assignments. They perform statutory tasks like authorisation, auditing and establishing regulations, as well as providing science-based advisory services for political decision-making processes. These include both Federal Government and *Länder* institutes with R&D tasks (departmental research institutes of the Federal Government and the *Länder*).

State research institutes are the backbone of the German R&I system; their function is to provide scientific advice to the Federal Government and take up research issues at short notice. To do so, among other factors, they require knowledge of the application and effect of modern technologies, about health and nutrition, mobility and urban development, the environment, energy and climate protection, about the changes in working and living conditions and the challenges of our globalised economy. Only then can the state take appropriate action and uphold security. The federal institutes perform their tasks under the remit of the responsible department. In addition, the federal institutes with R&D tasks promote early career scientists.

The funds earmarked for research and development activities, including R&D personnel in federal institutes, have increased in recent years. For example, from 2012 to 2014, R&D expenditure rose from 995 million euros to 1.06 billion euros. Thus, 88.1% of Federal Government R&D expenditure was incurred within the framework of institutional departmental research. Moreover,

Fig. II-9: Number of R&D personnel by personnel groups with R&D tasks at federal institutions (in full-time equivalents)



Source: Federal Statistical Office, Fachserie 14 Reihe 3.6 Table 6.1

in some cases, the institutes attract third-party funding. Over the same period, the number of R&D personnel increased from 9,288 to 9,450 FTEs. In 2013, researchers accounted for 41.7% of the total R&D personnel (cf. also Fig. II-9).

Each federal ministry is responsible for departmental research within its own portfolio (departmental principle). Departmental research is either conducted directly by the federal ministries or commissioned by the federal institutes with R&D tasks, of which there are currently 38. Moreover, with regard to departmental research, the departments liaise with other R&D institutes on an ongoing basis. The spectrum of this continuous collaboration ranges from regular exchanges of information right through to cooperation and institutional funding according to the provisions of funding legislation.

Some of the federal institutes with R&D tasks have outstanding research infrastructures, which are also made available to external research groups as a rule. In this way, they facilitate networking among the stakeholders of the German R&I system. In order to facilitate their external use, further the underlying science policy objectives and increase the transparency of the available options, work has now started on entering information on openly accessible research infrastructures into the inventory on the EU platform MERIL (Mapping of the European Research Infrastructure Landscape).

A number of federal institutes with R&D tasks maintain internal scientific information facilities and central specialised libraries, whose services are required to perform departmental tasks or are made available to interested experts.

The *Länder* and municipal institutes with R&D tasks are financed institutionally with funds provided by the *Länder* and, in some cases, by third parties. The R&D expenditure of the *Länder* for municipal and *Länder* institutes with R&D tasks (except for Leibniz Association) decreased from approximately 237 million euros in 2011 to around 203 million euros in 2013. A total of 2,401 FTEs were employed as R&D personnel in the institutes in 2013.

Further information is available online

Federal governmental research institutes (information only available in German):
www.bundesregierung.de/Webs/Breg/DE/Themen/Forschung/ressort/_node.html

Departmental research (only available in German):
www.bmbf.de/de/ressortforschung-540.html

MERIL: http://portal.meril.eu

2.5 Other R&D funding organisations

Apart from the abovementioned funding and financing mechanisms, a number of other R&D funding organisations also exist. As the central funding organisation for science-based research endeavours that give rise to further findings at universities and non-university research facilities, the German Research Foundation (DFG) plays a crucial role in enhancing Germany's international competitiveness and raising its visibility as a hotspot for research.

In addition, numerous foundations and other funding bodies that are organised as associations make a valuable contribution to assuring the quality of science and research.

German Research Foundation

The German Research Foundation (DFG) is the self-governing organisation of science and research in Germany. The main task of the DFG is to select and sponsor the best projects by researchers at universities and research institutions on a competitive basis; for the most part, funding is awarded to scientists at institutes of higher education. The statutory tasks of the DFG include facilitating national and international collaboration among researchers, fostering the advancement and training of early career researchers and advising parliaments and public interest institutions on scientific matters.

The DFG is a registered association. The member organisations include 69 higher education institutions, 16 non-university research institutes, 8 academies and 3 scientific associations. The Federal Government and the *Länder* have been funding the DFG since 2002 according to a standardised funding formula under which the Federal Government provides 58% of funding and the *Länder* 42% (Skeleton Agreement on Research Promotion in the version of 11 April 2001 and Agreement on the execution of joint funding of the DFG). The DFG had resources in the amount of approximately 2.86 billion euros in 2014 and almost 3 billion euros in 2015. A budget of some 3.1 billion euros has been earmarked for 2016.

Further information is available online

DFG – Research funding: www.dfg.de/en/research_funding/index.html

DFG – Annual report: www.dfg.de/en/dfg_profile/annual_report/index.html

DFG – Funding Atlas 2015: www.dfg.de/sites/fundingatlas2015

Foundations and funding bodies

A number of non-profit foundations make a valuable contribution to assuring the quality of science and research in Germany. The foundations complement public research funding and are outlets for private financial commitment. The benefactors thereby set an example of responsible action in a democratic state. Examples of important foundations that fund research in Germany include the Volkswagen Foundation, the Robert Bosch Stiftung, the Klaus Tschira Stiftung and the Stiftung Mercator, which fund projects and institutes in a variety of scientific fields. One joint initiative started by companies to promote science and research in Germany is the *Stifterverband für die deutsche Wissenschaft e. V.*, under whose umbrella over 615 foundations were managed in 2014, with total assets of 2.6 billion euros.

These should be differentiated from the foundations and associations, whose annual funding budget is provided mainly or exclusively by public sources or where the Federal Government subsidised their start-up financing. Apart from the DFG, these include the Alexander von Humboldt Foundation (AvH), the German Federal Environmental Foundation (DBU),

the German Foundation for Peace Research (DSF), the organisations for the promotion of young talent in the higher education sector – most of which are associations – and the German Academic Exchange Service (DAAD).

Further information is available online

Stifterverband für die deutsche Wissenschaft: www.stifterverband.org/english

Alexander von Humboldt Foundation: www.humboldt-foundation.de/web/home.html

German Federal Environmental Foundation: www.dbu.de/2535.html

German Foundation for Peace Research: www.bundesstiftung-friedensforschung.de/index.php/english

StipendiumPlus: www.stipendiumplus.de/en/dein-plus/stipendiumplus-who-we-are.html

German Academic Exchange Service: www.daad.de/en

European Union

The European Union is also an important financing and supporting stakeholder in the German R&I system, with *Horizon 2020* (2014–2020), the EU framework programme for research and innovation, as its central instrument. The total approved funding amounts to approximately 77 billion euros, making *Horizon 2020* the world's largest self-contained research and innovation funding programme. The European Union is thus pursuing its goal of creating sustainable growth and future-proof jobs in Europe, thereby increasing Europe's competitive edge. The target group of *Horizon 2020* includes universities, research institutes, companies (particularly SMEs) and other stakeholders involved in the development of innovations. All phases of the research and innovation process receive funding, from basic research projects right through to preparing marketable products and services.

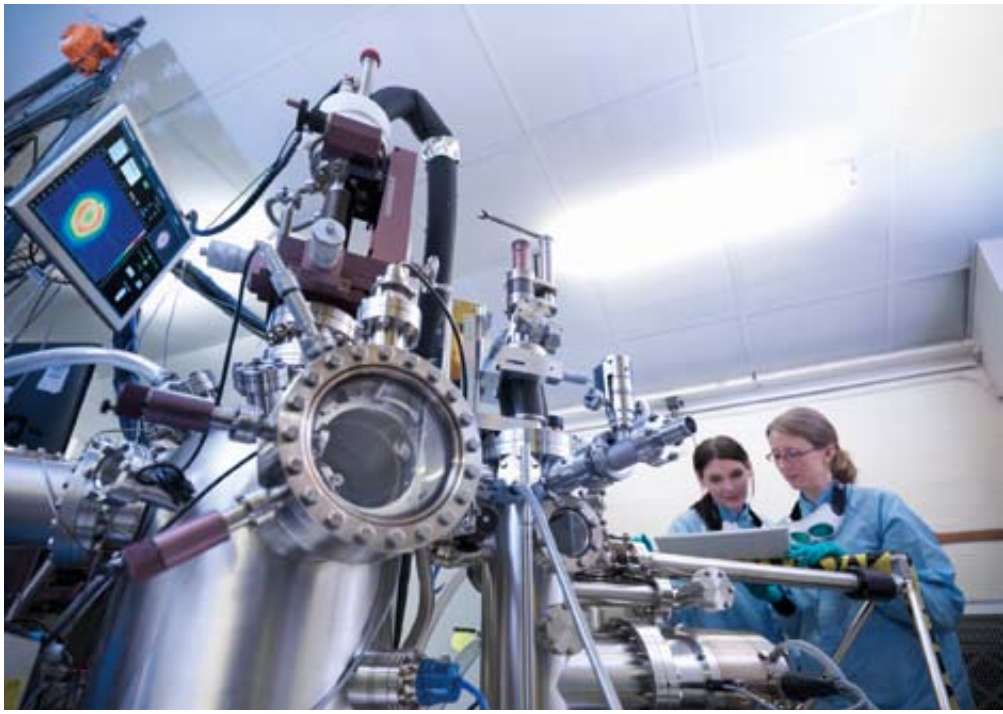
The programme is flanked by two mechanisms with which the EU and/or European countries endorse cooperation between research institutes and companies in Europe: *COST* (European Cooperation in Science and Technology) and *EUREKA* (Initiative for intensified technological cooperation in Europe). Driven largely by the interests of science and industry, these cooperation systems serve as an excellent complement to the European framework programmes. The European funding programmes play a major role in the external financing of R&D for Germany's business enterprise sector. In 2013, approximately 518 million euros came from EU funding programmes, in other words, around 16% of the industry R&D expenditure financed from abroad. Some 86% thereof was allocated to sectors of the manufacturing industry.[3]

3 *SV Gesellschaft für Wissenschaftsstatistik mbH* in the *Stifterverband für die Deutsche Wissenschaft* (2015): *a:r n'di: Zahlenwerk 2015 – Forschung und Entwicklung in der Wirtschaft 2013*.

2.6 Research and development in industry

Research and development (R&D) activities in companies are drivers of prosperity and employment. The largest portion of Germany's value creation is based on research-intensive products and services. By investing in research and development, companies are not merely creating added value for their own benefit, but also for that of the economy and society. New findings help other researchers in companies, universities and public research institutes to achieve new insights of their own. A good two-thirds of Germany's R&D is carried out in companies.

The internal R&D expenditure of German industry totalled 53.57 billion euros in 2013, which corresponds to about two thirds of all gross domestic expenditure on R&D or around 1.91% of GDP. Internal R&D expenditure was approximately 57 billion euros in 2014, with expenditure of 59 billion euros planned for 2015.



By far the largest share (48.96 billion euros in 2013) is borne by the business enterprise sector itself, thereby achieving a high self-funding percentage of some 91%. Moreover, German industry is characterised by its relatively high funding contribution to the R&D activities of the public sector. In 2013, the private sector's share of funding of R&D activities at universities and non-university institutes was 14% and 10% respectively, compared to the average of 5.9% and 3.4% for OECD countries.

In addition to industry's strong R&D commitment, the intensive cooperation with universities and research institutes is a crucial factor in the innovative success of German enterprises. These alliances accelerate the transfer of research findings into innovative products and services. One indicator that clearly shows this involvement in research consortia is the ratio of internal to external R&D: internal R&D expenditure totalled 53.57 billion euros in 2013, with approximately 14.96 billion euros being invested in external R&D in the same year. In 2014, companies significantly stepped up their expenditure to 57 billion and 16 billion euros respectively. External R&D expenditure is taken to mean spending on R&D assignments that companies do not conduct on their own premises.

While internal R&D expenditure dropped slightly by 0.4% in 2013 compared to 2012, external R&D expenditure reported an increase of 16.7%. The bulk – 62.5% – of external R&D expenditure went to other domestic companies, 39.7% of which to affiliated entities within the same group of companies. By implication, this means that third-party companies account for the largest share of external R&D expenditure to recipients in the domestic business enterprise sector. A further 26.3% was spent on R&D assignments abroad, while 8% was allocated to universities and non-university research institutes, and 3.3% to other German entities. In particular, the percentage of R&D contracts that are financed from abroad has more than doubled over the last ten years. By far the largest share of external R&D (approximately 87.9%) went to companies in

research-intensive sectors. The automotive industry enjoys an outstanding position in this respect. Just over half (around 55.4%) of all external industry-financed R&D expenditure was channelled into the automotive industry. Research-intensive services represent about 7% of external R&D expenditure.

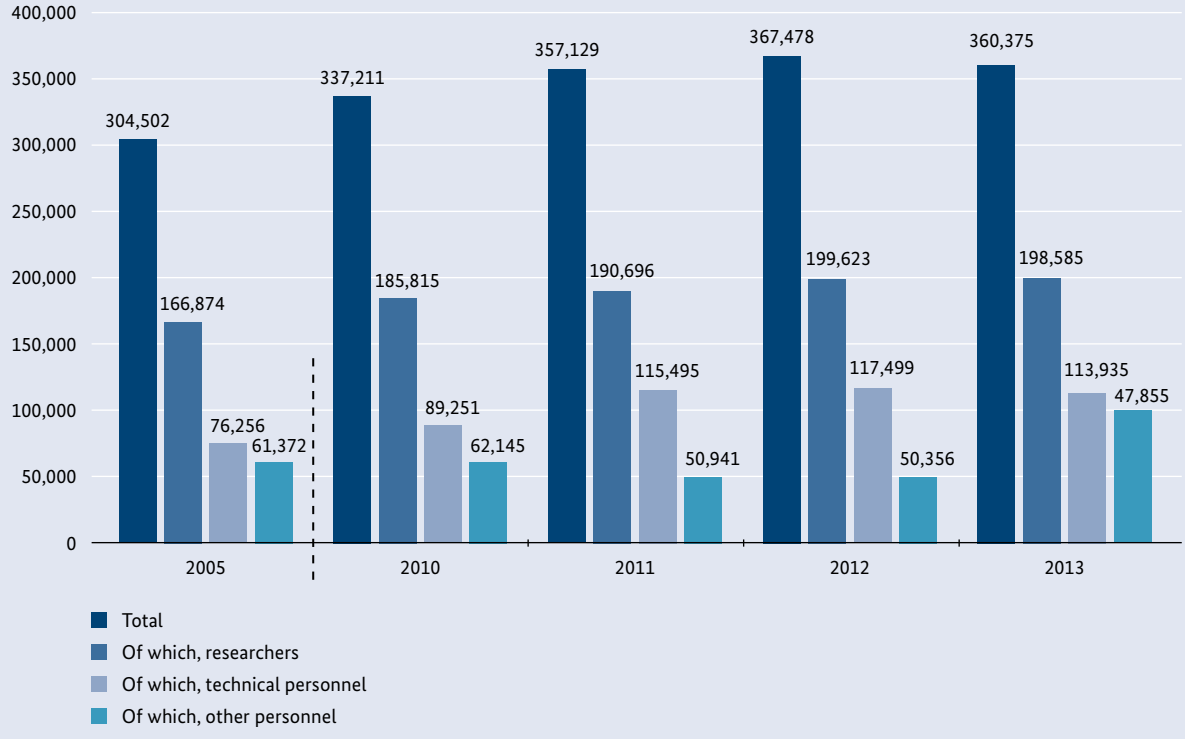
In essence, in German industry, R&D is carried out by large companies with at least 500 employees. In 2013, this group accounted for approximately 85.4% of internal R&D expenditure and employed almost three quarters (76.4%) of all R&D personnel. Small and medium-sized enterprises with fewer than 250 employees only make up 9.7% of internal R&D expenditure, although they employ almost one fifth of all R&D personnel (around 17%). In 2013, the internal R&D expenditure of small and medium-sized enterprises (up to 250 employees) amounted to 5,191 million euros. At the same time, they spent 849 million euros on external R&D contracts. The bulk of SMEs' external R&D expenditure remained in the business enterprise sector (around 43%). Compared to large companies, SMEs in Germany award more external R&D contracts to universities and non-university research institutes (27.3%). The corresponding figure for large companies was a mere 6.7%.

German industry's high level of R&D commitment is reflected in its international competitiveness: in 2014, Germany's export volume of research-intensive goods came to approximately 570 billion euros, accounting for over half (around 54%) of the country's total exports of industrial goods. Some 12% of the global trade volume of research-intensive products originated in Germany in 2014.[4] Five of Europe's ten top corporate R&D investors are German companies. The percentage of companies that launched new products or services in 2014, namely 36.8%, was extremely high by European standards.

A characteristic feature of the R&D structure of Germany's industry is its high concentration on research-intensive industry sectors, which were responsible

4 Gehrke, B.; Schiersch, A. (2016): *FuE-intensive Industrien und wissensintensive Dienstleistungen im internationalen Vergleich, Studien zum deutschen Innovationssystem*, No. 6-2016.

Fig. II-10: Number of R&D personnel by personnel groups in the business enterprise sector in Germany (in full-time equivalents)



Source: BMBF's Data Portal, table 1.7.1

for three quarters (around 76%) of corporate R&D expenditure in 2013. Research-intensive sectors include mechanical engineering and vehicle manufacturing, the chemical and pharmaceutical industries, and the electrical industry. Research-intensive industry sectors that are considered advanced technology play a particularly important role as they account for more than half (around 51%) of internal industry-financed R&D expenditure. The automotive industry enjoys an outstanding position in this respect. Almost one third (around 32%) of all internal industry-financed R&D expenditure benefits the automotive industry. By international standards, with just one quarter (around 25%) of internal R&D expenditure, cutting-edge technology sectors play a subordinate role in Germany. This figure can be broken down as follows: manufacturers of data processing equipment, electronic and optical products, approximately 14%, the pharmaceutical industry around 8% and aerospace around 3%. The same applies to research-intensive services, which together account for approximately 10% internal industry-financed R&D expenditure in Germany.

In 2013, the business enterprise sector employed 360,000 FTEs, the majority of the R&D workforce (around 61.2%) in Germany. As in university and non-university research, a significant increase in the number of R&D personnel has been apparent for some years now. A similar trend can be observed in the number of researchers compared to the total R&D workforce, which rose to 55.1% in 2013 (cf. also Fig. II-10). Most of these persons were employed in the automotive sector (104,422 FTEs), the electrical industry (76,205 FTEs) and mechanical engineering (41,941 FTEs).

There is huge variation in the regional R&D capacities of the German business enterprise sector for the following reasons: the pronounced sectoral specialisation of individual regions, the corresponding research priorities and traditional development paths. A regional analysis of central *Land*-related innovation indicators like R&D intensity (R&D expenditure as a percentage of the relevant GDP) illustrates the differences. In 2013, R&D intensity varied from 3.87% in Baden-Württemberg to 1.11% in Saxony, 0.75% in Schleswig-Holstein right down to 0.42% in Saxony-Anhalt. The situation is similar with regard to the regional distribution of R&D personnel intensity (as a percentage of research and development staff, in full-time equivalents per ten thousand employed persons). Baden-Württemberg's business enterprise sector reports 171 full-time R&D positions in industry per ten thousand employed persons, with 53 FTEs in Saxony, 39 FTEs in Schleswig-Holstein and 26 FTEs in Saxony-Anhalt. These examples demonstrate that the regional differences in the levels of R&D capacities in the business enterprise sector are not just limited to West and East Germany. Moreover, there is a significant north-south divide in Germany.

Further information is available online

Wissenschaftsstatistik GmbH in the Stifterverband für die Deutsche Wissenschaft:
www.stifterverband.org/english

3 Development of the resources for research and development in selected countries

By international standards, Germany has been in the top league of countries with a high level of R&D intensity for many years. In recent years, Germany has seen positive developments, both in terms of R&D expenditure and R&D personnel. R&D intensity in Germany has increased steadily since 2006. Today, Germany performs well above the OECD average of 2.37% for this indicator.

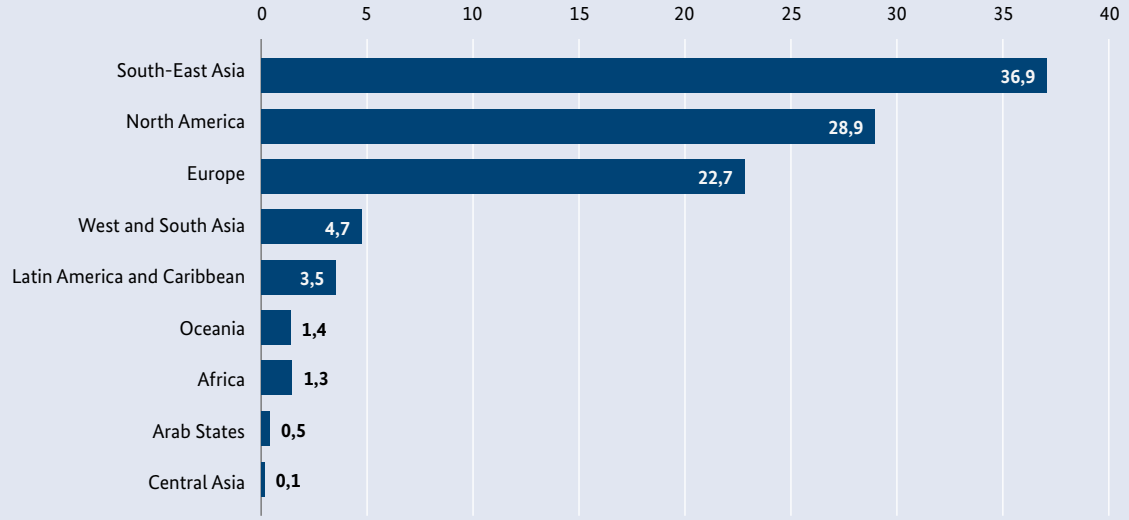
Around the world, R&D expenditure has seen strong growth in the last few years. Total worldwide R&D expenditure for 2001 is estimated at 753 billion US dollars in terms of purchasing-power parities. The corresponding figure for 2006 is considered to be 1,051 billion US dollars, with 1,478 billion US dollars being spent worldwide on R&D in 2013.[5]
Figure II-11 shows that R&D mainly takes place in three geographical regions: North America, Asia and Europe. In 2013, North America (USA, Canada, Mexico) accounted for 28.9% of the world's R&D expenditure, 22.7% was invested in Europe, with this figure rising to 41.6% in South-East, West and South Asia. The remaining 7% of worldwide R&D expenditure is divided between the regions of Central and South America, the Middle East, Australia and Oceania, and Africa.

The three largest R&D performing countries (USA, China and Japan) together account for over half of the total worldwide R&D expenditure in 2013.[6]
The United States is the clear leader in this category, with a share of 27% of all expenditure around the

5 In constant prices from 2005. Cf. UNESCO Institute for Statistics, July 2015.

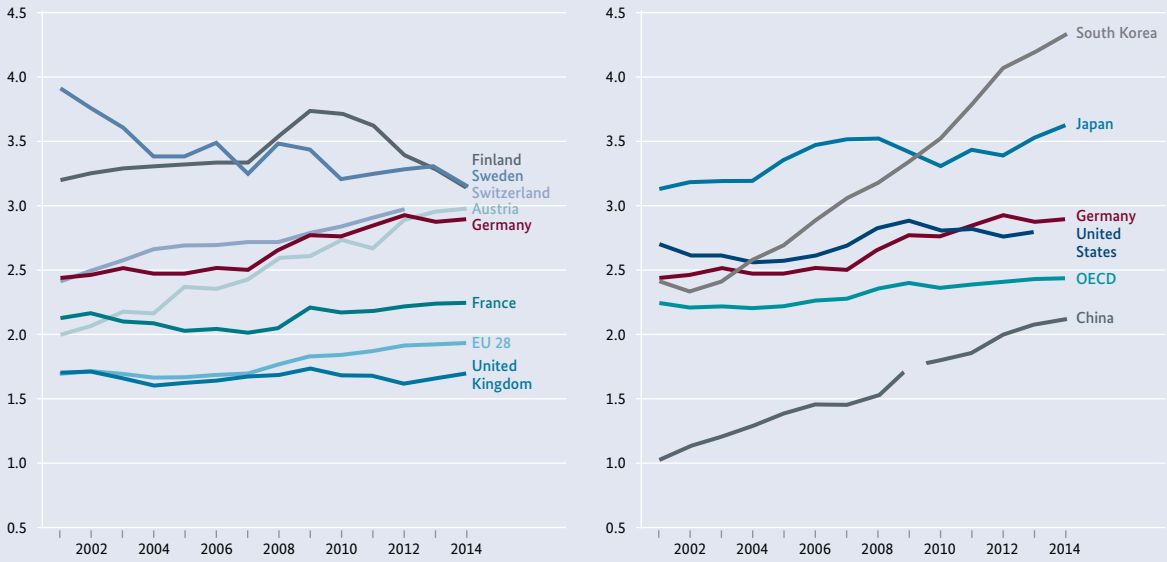
6 Cf. National Science Foundation, Science and Engineering Indicators 2016, Table 4-4, online at: http://www.nsf.gov/statistics/2016/nsb20161/#/report/chapter-4/cross-national-comparisons-of-r-d-performance

Fig. II-11: Worldwide R&D expenditure (by percentage shares per region, 2013)



Source: UNESCO Institute for Statistics (UIS) (July 2015), online at http://data.uis.unesco.org.
The countries have been grouped in keeping with the regions in the UNESCO Science Report (USR)

Fig. II-12: Gross domestic expenditure on R&D (GERD) in % of GDP by international comparison, over time



Source: OECD, Main Science and Technology Indicators (2015/2). Some figures are preliminary, data estimated in some cases.
The break in the time series for China is due to statistical and methodical adjustments.

world. In 2001, this figure was some 37%. China moved up to second place in 2013, with 20% of the world's total R&D expenditure, while Japan ranked third with 10%. These are followed by Germany in fourth place, with a share of 6% of global R&D expenditure, ahead of South Korea, France, Russia, Great Britain and India, which each account for 2 to 4% of worldwide R&D expenditure.

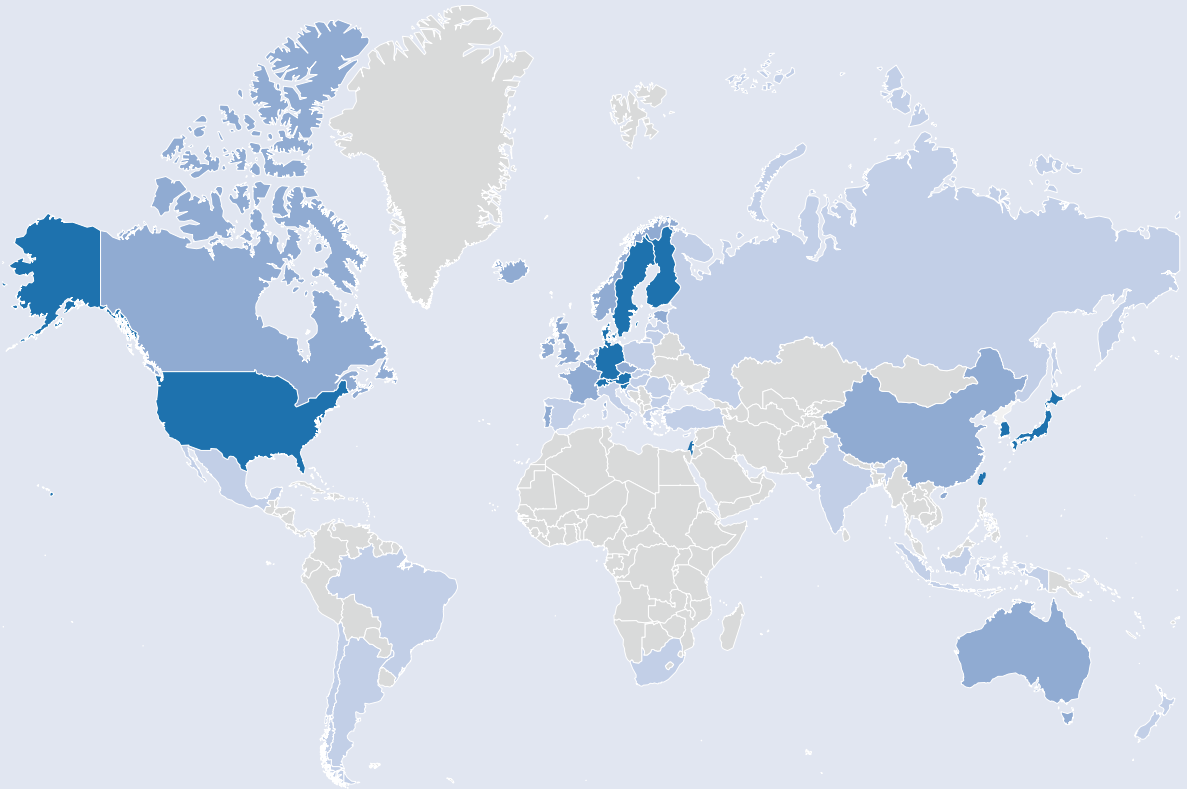
The development of R&D intensity is the central indicator when considering Germany's R&D expenditure compared to other countries (cf. also Fig. II-12). Since the formulation of the Lisbon Strategy in 2000, the Member States of the European Union have been striving to reach an R&D investment level of 3% of gross domestic product (GDP).

With GERD at 2.88% of GDP in 2014, Germany managed to achieve a very good result by international standards. R&D intensity in Germany has increased steadily since 2006. Today, Germany scores well above the OECD average of 2.37% and even ahead of the United States with 2.74%.

Average R&D expenditure of the EU-15 came to 2.07% in 2013. In terms of R&D intensity in Europe, Germany is in fifth place among the EU-28 countries, behind Finland, Sweden, Denmark and Austria.

By contrast, R&D intensity levels below 1.5% are often reported by countries that are undergoing economic catch-up processes; nevertheless, countries like Italy (1.31%) and Spain (1.26%) are also below the 1.5% mark (cf. also Fig. II-13).

Fig. II-13: GERD as a percentage of GDP worldwide, 2012



Source: OECD, Main Science and Technology Indicators (2015/1)

Figure II-14 shows the development of R&D expenditure in the business enterprise sector, compared to important OECD countries. This attests to Germany's strong position, particularly within Europe.

Development of R&D expenditure of higher education institutions and the state

Depending on the country, the emphasis placed on R&D in the public sector differs enormously. The corresponding shares vary greatly among the highly developed economies: while R&D expenditure in France's public sector, for example, amounts to around 34% of total R&D expenditure, the United States invests about 25% and Korea some 20% of the overall funding.

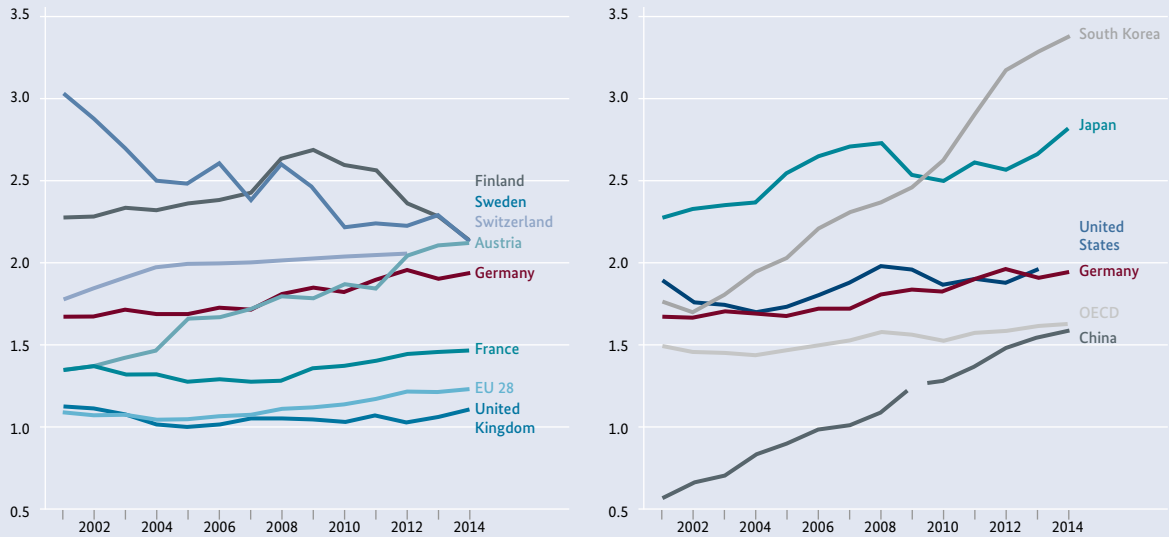
In Germany, the public sector accounted for around 33% of gross domestic expenditure on R&D in 2013, of which 18% was allocated to the universities and 15% to non-university research facilities.

In recent years, Germany's Higher Education Expenditure on R&D (HERD) has risen appreciably, both in absolute terms and as a percentage of GDP; this may in part be attributed to the momentum resulting from the *Initiative for Excellence* and the *Higher Education Pact* 2020 (cf. also Fig. II-15).

R&D expenditure in the public sector has undergone a similar development. The R&D expenditure of non-university and departmental research institutes in Germany has continued to rise in recent years (cf. also Fig. II-16). Germany is thus leading the way in Europe, setting itself apart from all other European countries.

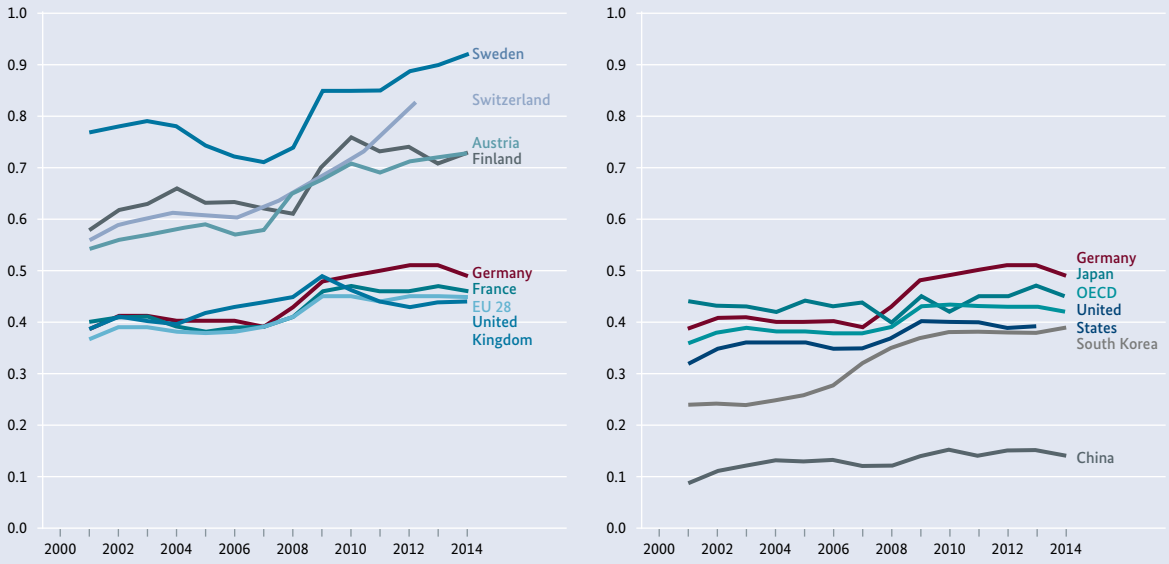
The increase in public R&D spending in Germany also reflects recent endeavours to boost non-university research. Particular mention should be made here of the annual 3% increases in the basic institutional funding of the science and research organisations, which are borne jointly by the Federal Government and the *Länder*, as agreed in the *Pact for Research and Innovation* (by 2020).

Fig II-14: Business Enterprise Expenditure on R&D (BERD) in % of GDP by international comparison, over time



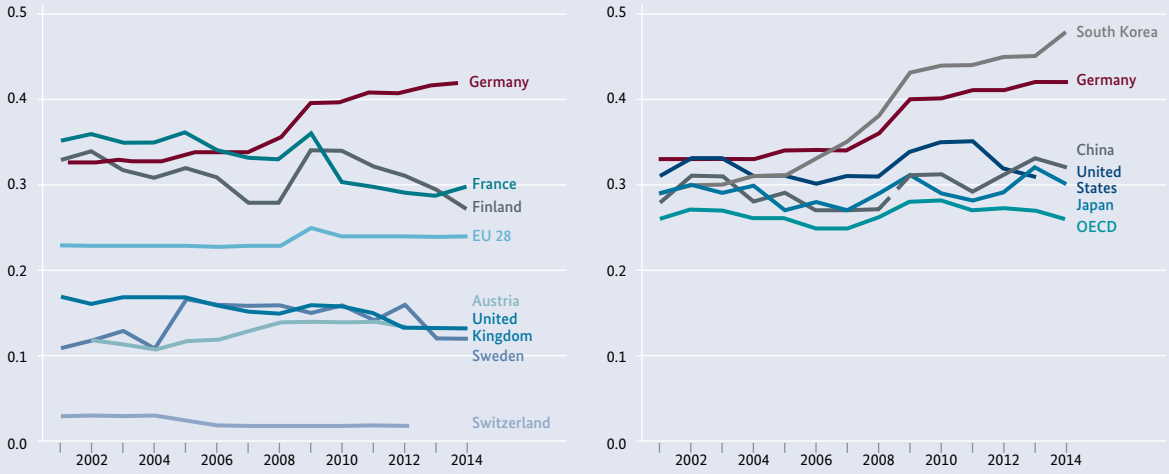
Source: OECD, Main Science and Technology Indicators (2015/2). Some figures are preliminary, data estimated in some cases. The break in the time series for China is due to statistical and methodical adjustments.

Fig. II-15: Higher Education Expenditure on R&D (HERD) in % of GDP by international comparison, over time



Source: OECD, Main Science and Technology Indicators (2015/2). Some figures are preliminary, data estimated in some cases.

Fig. II-16: Government intramural expenditure on R&D (GOVERD) in % of GDP by international comparison, over time



Source: OECD, Main Science and Technology Indicators (2015/2). Some figures are preliminary, data estimated in some cases.
The break in the time series for China is due to statistical and methodical adjustments.

Worldwide development of R&D personnel

A comparison of R&D personnel by country entails a certain degree of ambiguity. Particularly in non-OECD states, methodological problems tend to hamper attempts to survey R&D personnel consistently.

Figure II-17 shows the development of knowledge-intensive employment in selected countries, based on R&D personnel intensity (full-time equivalent R&D personnel per thousand employed persons). Since the beginning of the decade, there has a marked increase in personnel intensity in Germany.

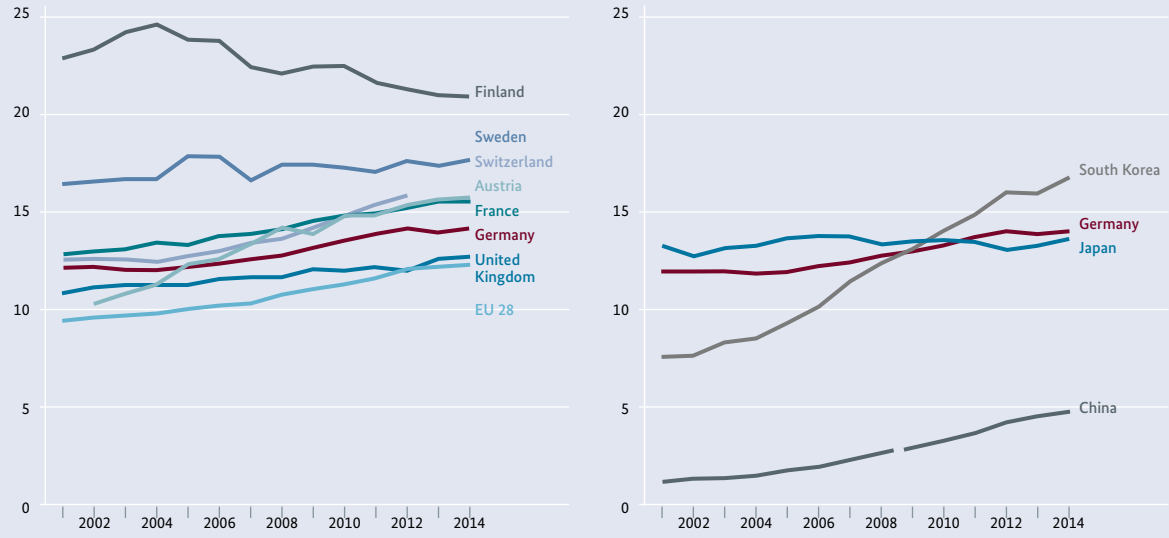
In a global context, the total number of R&D personnel (scientific personnel, technical personnel, other personnel) is more difficult to estimate because the relevant statistical data are incomplete. The number of scientists serves as a benchmark. According to OECD figures, the worldwide scientific personnel workforce grew by more than 40% between 2000 and 2012, reaching a level of approximately 6.5 million researchers in 2012, in all OECD countries and in China, Argentina, Romania, the Russian Federation, Singapore, South Africa and Taiwan.[7] There are an estimated 7.8 million researchers worldwide.[8]

Figure II-18 provides an overview of the global resource input in the areas of R&D, in terms of the three dimensions R&D intensity, percentage of researchers of the total workforce and R&D expenditure for the base year 2014. Despite the abovementioned limitations in the statistical comparability – especially regarding data for BRICS countries – the relevant international positions are once again clear. The figure illustrates the close relationship between R&D expenditure and research personnel with regard to the total workforce. This representation shows Germany's relative proximity to the United States and Japan, as well as other European countries. Significantly, the BRICS countries (still) show relatively low levels of R&D intensity and research personnel intensity. The variations in this

7 Calculation pursuant to OECD-MSTI 2015/1, Table 7: Researchers in all OECD countries and in China, Argentina, Romania, the Russian Federation, Singapore, South Africa, Taiwan.

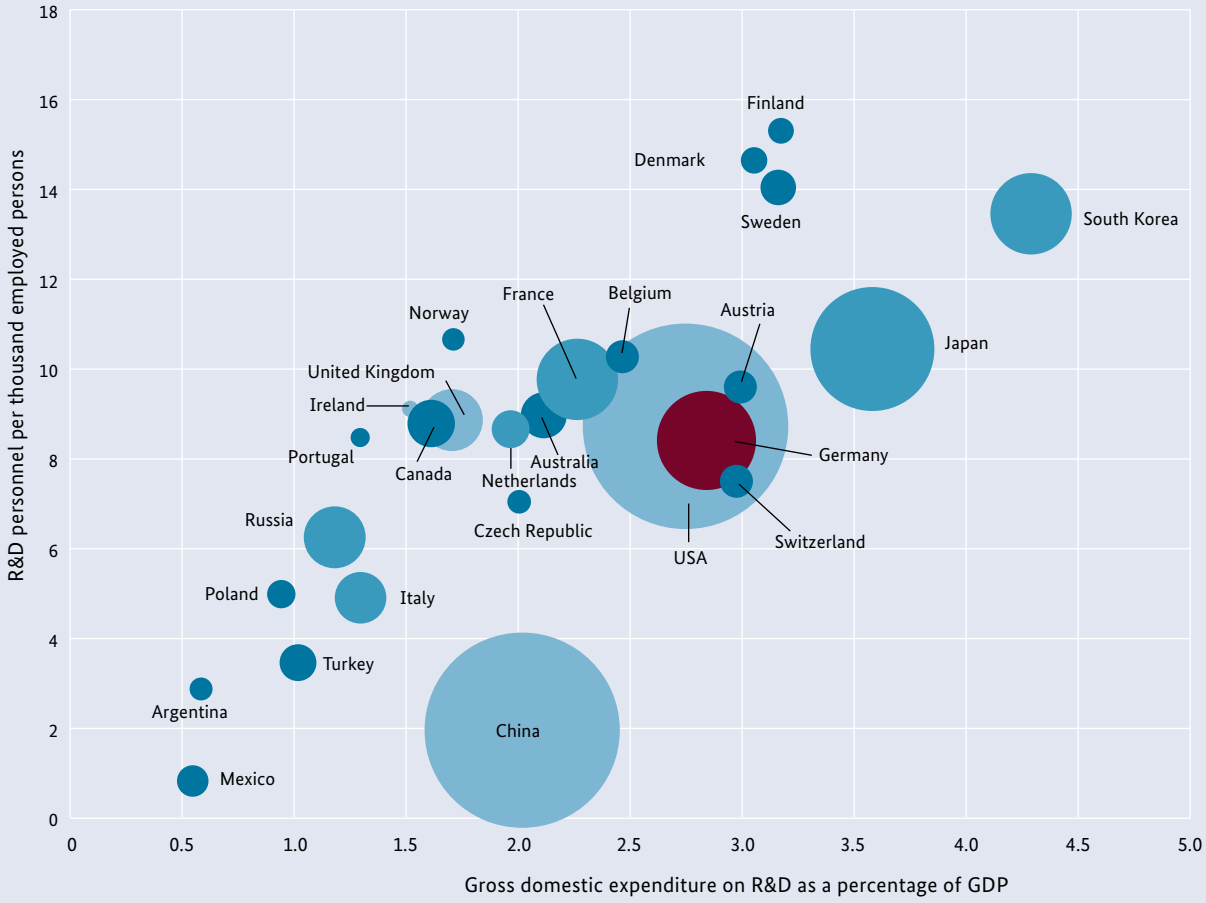
8 Based on the data in the UNESCO Science Report: towards 2030, Table 1.2, Bonn.

Fig. II-17: R&D personnel intensity in selected countries, over time (full-time equivalent R&D personnel per thousand employed persons)



Source: OECD, Main Science and Technology Indicators (2015/2). Some figures are preliminary, data estimated in some cases. The break in the time series for China is due to statistical and methodical adjustments.

Fig. II-18: Researchers and gross domestic expenditure on research and development in 2014 (in absolute figures and as a percentage of GDP)



No data was available for 2014 in some cases; percentages are based on the latest available figures.

Source: OECD Main Science and Technology Indicators

overall interrelationship may be due to the differing R&D costs (especially expenditure on R&D personnel) or to the patterns of R&D specialisation. The rate of economic growth in the BRICS countries over the past few years attests to their huge R&D potential, provided the necessary basis is established.

4 Performance of the German research and innovation system (output)

The performance of national research and innovation systems is regarded as the central factor in safeguarding entrepreneurial competitiveness and employment in knowledge-based economies over the long term. With regard to key indicators that describe the output of research and innovation, Germany has succeeded in holding its ground, even improving its position in the international arena in recent years. These indicators include scientific publications, transnational patents and the share of world trade in research-intensive goods. This development can also be seen in the results of pertinent composite indicators.

In recent years, the number of scientific publications originating in Germany has continued to climb. The frequency with which the published results were cited in other publications also rose accordingly, while an increasing proportion of publications from Germany are among the most cited works in the world. In addition, a further rise in patenting activities has been observed over the last few years. With regard to its share of world trade in research-intensive goods, Germany is a European leader.

By both European and international standards, the performance of the German R&I system is considered extremely high. Nevertheless, a selective examination of individual indicators fails to do justice to the complex, multi-dimensional nature of this topic as they merely reflect certain aspects of the R&I system. Therefore, the following section will also take a closer look at selected results of pertinent composite indicators[9] from benchmarking studies, like the Innovation Union Scoreboard (IUS), the acatech/BDI Innovation Indicator (II), the Global Innovation Index (GII) and the Global Competitiveness Index (GCI).

9 Composite indicators are obtained by compiling individual indicators into a single index.

4.1 An international comparison of selected individual indicators measuring the output of the German research and innovation system

The performance of R&I systems can be measured based on numerous so-called output indicators, which describe the performance of an R&I system from various perspectives. Noteworthy examples here are scientific publications and patents, which are prerequisites in turn as input, enabling findings and inventions to be turned into applications for industry and society. The indicators used in empirical innovation research to measure innovation success include the innovator rate and innovation intensity. Another important indicator is trade in research-intensive goods, which reflects the economic commercialisation of research and innovations.

Apart from indicators that record the number of publications and patents, other indicators that can be used to measure the performance of a research and innovation system include the shares of product and process innovations and trade volumes, as well as value creation and productivity development. These indicators consider the outcome of an R&D process from a variety of perspectives (from the technical invention itself, its ascent via a company's products and processes, right through to its market penetration) and are described as qualitative or quantitative indicators.

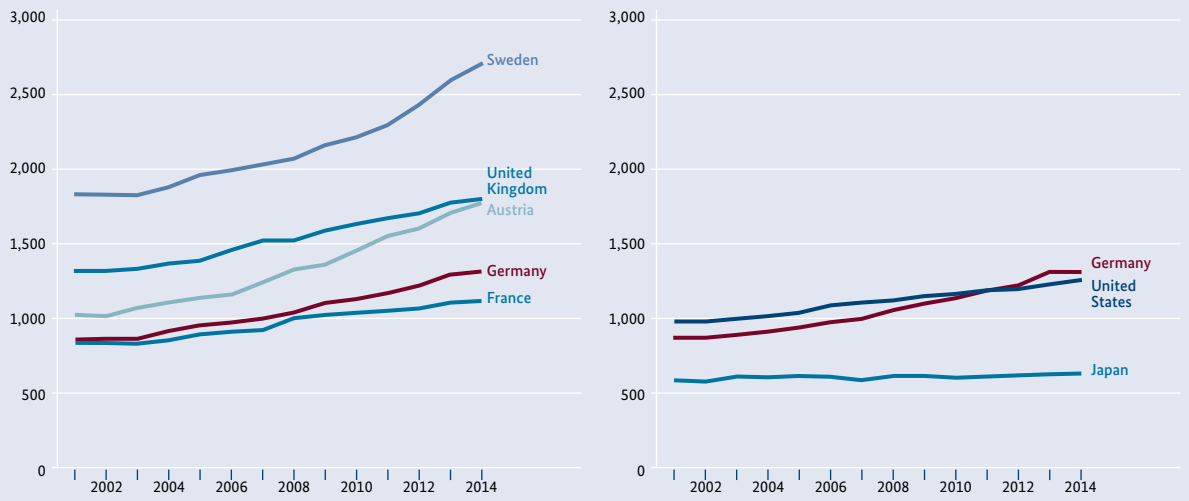
In order to be able to draw any conclusions regarding Germany's performance as a centre of research and innovation in the international arena, the following sections will only take those indicators into account, for which data are available from other countries over a longer period. This enables prognoses of long-term trends and short-term developments.

Publications

Successful R&D activities result in scientific findings and discoveries, which find expression in scientific publications, among other things. Along with patents, they represent the central output of the scientific community. Bibliometric methods can be used to analyse scientific performance. In innovation policy contexts, publications are viewed as indicators of science performance, due to the growing importance of knowledge as a production factor.

With 1,318 publications per million inhabitants in 2014, Germany has a higher publication intensity than the United States (cf. also Fig. II-19). It must be remembered that quantitative comparisons of publication indicators presuppose the prudent collection and interpretation of the data. For example, scientific disciplines may differ considerably in terms of their typical publication patterns. With regard to the number of publications per million inhabitants, the Scandinavian countries, among others, report exceptionally high

Fig. II-19: Number of scientific publications, over time (per million citizens)



Source: BMBF's Data Portal, table 1.8.3

publication intensities. During the period under review, Japan's research and science output remained at a relatively constant level, which was significantly below that of comparative countries.

One of the factors reflecting the significance of a publication within the scientific community is how frequently the published results are cited by other researchers. In recent years, Germany has continuously improved its strong position in the development of its excellence rate (the proportion of publications that feature in the 10% most cited papers worldwide, of the total number of publications). In 2012, the excellence rate of Germany's scientific publications was 16%, propelling it into sixth place (compared to ninth place in 2004), behind Switzerland, Denmark, the Netherlands, the United States and Belgium. This not only means that Germany produces more publications but that they are increasingly at the forefront of their respective disciplines (cf. also Fig. II-20).[10]

10 Mund, C.; Conchi, S.; Frietsch, R. (2014). 4. Indicator report: Bibliometric indicators for the Pact for Research and Innovation – 2015 Monitoring Report and GWK (2015). Pact for Research and Innovation – 2015 Monitoring Report, issue 42.

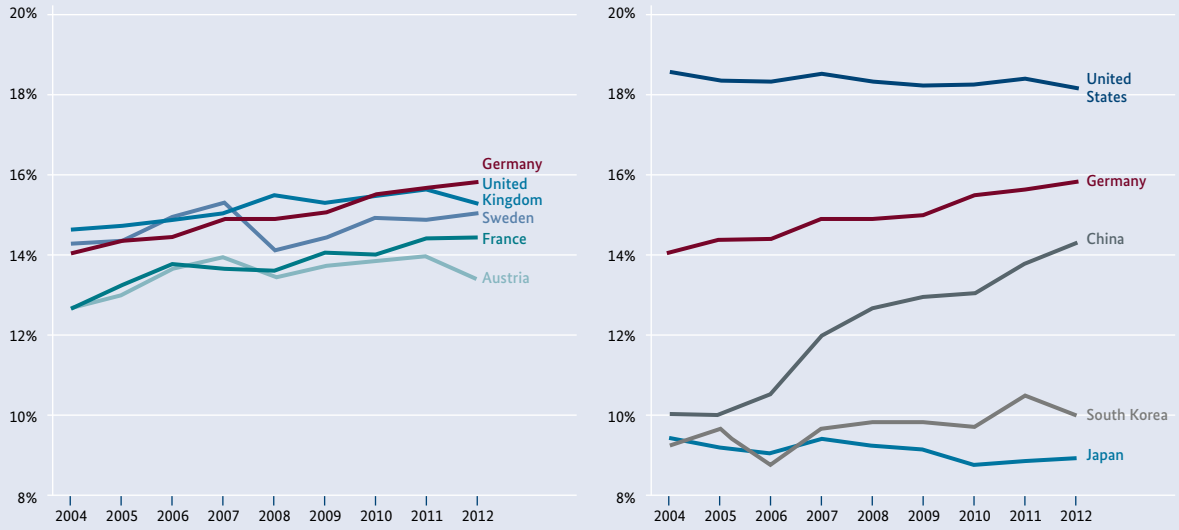
Patents

Patents are frequently used as indicators of technological performance. Data in this category, while readily available, are not always easy to interpret with regard to the impact of R&D results 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. These patents are especially significant for Germany's export-oriented industry because they make it possible to protect inventions outside the home market. World-market or transnational patents are also regarded as an indicator of expansion objectives in terms of innovative markets.

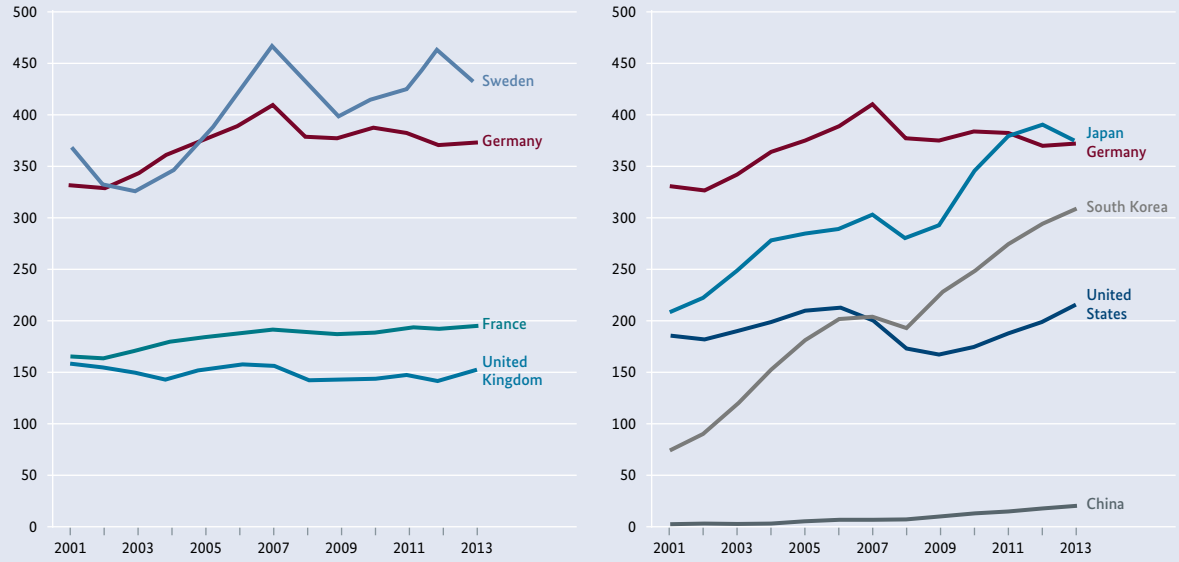
From 2003 to 2013, the increase in patents with world market potential per million inhabitants amounted to approximately 9%. Thus, in 2013, the number of triadic patents in Germany per million inhabitants was more than 240% – and thus well above – the EU-28 average.

Fig. II-20: Excellence rate (percentage of publications included in the 10% of the most cited papers worldwide, of the total number of publications) by international comparison, over time



Source: Web of Science, calculations of the Fraunhofer ISI, cf. Gruber/Frietsch/Neuhäusler (2016): Performance and Structures of the German Science System 2015. Studien zum deutschen Innovationssystem, no. 5-2016, Berlin: EFI

Fig. II-21: Patents relevant to the world market (per million inhabitants) by international comparison, over time



Source: BMBF's Data Portal, table 1.8.4

In Europe, apart from Germany, Sweden also has a high patent intensity (cf. also Fig.II-21). Compared to the United States, Germany has about twice as many transnational patents per million inhabitants. Japan has been catching up in this regard: its patent intensity rose by 52% over the period 2003-2013 and is now even slightly above Germany's level.

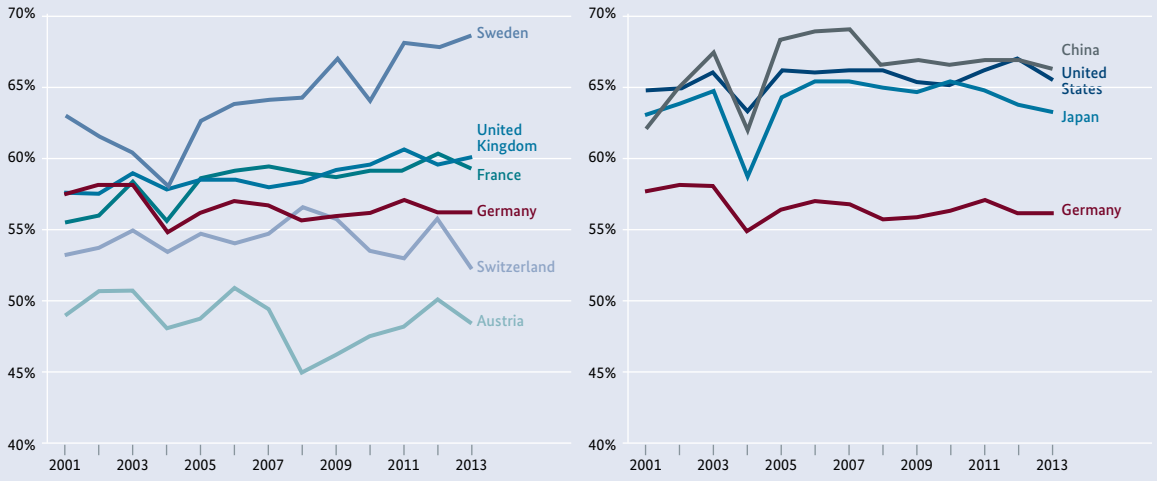
Particular importance is accorded to patents in the research-intensive industry sectors. Sweden, the United States, Japan, Korea and, not least, China are exceptionally strong performers in this category (cf. also Fig. II-22). In research-intensive industry, Germany has comparatively low percentages of cutting-edge technology patents (in areas such as computers, electronics or pharmaceuticals); however, it has pronounced strengths in advanced technologies (in the automotive and mechanical engineering sectors, for example).

Product and process innovations in German industry

Investments in R&D by both the private sector and the science sector can be translated into economic benefits when companies implement R&D results to introduce new or improved products and services or realise productivity increases: in short, they yield innovations.

Several groups of indicators are now commonly used in empirical innovation research to assess the extent to which, and how successfully, companies translate inventions (i.e. technical and scientific inventions) into innovations. These indicators are compiled for Germany by the *Centre for European Economic Research* (ZEW) as part of the pan-European *Community Innovation Survey* (CIS), coordinated by *Eurostat*. The innovator rate expresses the percentage share of companies that have introduced at least one new product or process innovation within the previous three-year period. The innovation intensity expresses innovation expenditure as a fraction of revenue. Ultimately, the

Fig. II-22: Percentage of patents in research-intensive industries of all patent applications, by international comparison, over time



Source: Neuhäusler/Rothengatter/Frietsch (2016): Patent Applications - Structures, Trends and Recent Developments 2015, Studien zum deutschen Innovationssystem, no. 4-2016, Berlin, EFI

percentage of revenue that companies generate with product innovations may be classified as innovation success.

Germany is showing a downward trend in the innovator rate, both with regard to product and process innovations. Similar trends can be observed in most other European Member States. In terms of innovative companies as a share of all companies, Germany is still the European leader. [11] In 2013, around 45% of all companies in the manufacturing sector were regarded as innovators, while the corresponding innovator rate for business-related services was around 33%.

The highest product innovator rate can be seen in the manufacturing sector (including mining), which has varied between 38% and 46% in recent years. In the area of knowledge-intensive, business-related services, it has ranged from 30% to 37%, while in other business-related services it has fluctuated from 15% to 27%. Apart from a sudden drop in the 2009-2010 crisis year, there has been a general decline in the product innovator rate, although it has recently climbed to relatively high levels again. In 2011, the product innovator rate decreased in all three business sectors – quite considerably, in some cases. In 2013, the downward trend continued in the manufacturing industry (including mining) and the knowledge-intensive services; by contrast, the rate has increased again slightly in other services since 2011.

With regard to participating in process innovations, the manufacturing sector (including mining) and knowledge-intensive, business-related services show process innovation rates of approximately 24%, and thus outperform other business-related services (around 19.4%) in this category. After having reached relatively high levels in 2008, the process innovation rate decreased in all three business sectors in 2009 and 2010. In 2011 and 2013, the rate increased slightly in other business-related services only. A downward trend was observed in the manufacturing sector (including mining) and in knowledge-intensive, business-related services over the period of 2011 to 2013.

In 2014, German companies' innovation expenditure was 145 billion euros, thereby matching the peak rate of the previous year. Germany's industry recently recorded turnover of 662 billion euros with product innovations. 8% of all German companies were the first suppliers to launch certain market innovations.

Furthermore, innovation intensity – in other words, the ratio of innovation expenditure to revenue of the German private sector – was 2.84% in 2014 and thus on a par with the previous year. It consequently matched the record high of 2006 (2.8%). Nevertheless, the higher level of innovation expenditure is offset by the stagnating success of new products and processes.

11 Cf. Eurostat, Community Innovation Survey, CIS.

Further information is available online

In order to create comparable data on the innovation activities in the OECD Member States, the OECD published the Oslo Manual jointly with Eurostat in 2005 to provide important guidelines for collecting and interpreting technological innovation data: www.oecd.org/sti/inno/2367580.pdf

On the innovation behaviour of the German economy (only available in German): www.zew.de/de/publikationen/innovationsverhalten-der-deutschen-wirtschaft-indikatorenbericht-zur-innovationserhebung-2015/?cHash=fd3b44e68df010fb6ad247ac5abee92d

Data on the Community Innovation Survey (CIS): http://ec.europa.eu/eurostat/web/microdata/community-innovation-survey

This means that financing future innovation activities on the revenue generated by past innovations is becoming increasingly difficult. In 2014, the ratio of turnover with new products to overall turnover was virtually unchanged at 12.8%.

The German private sector has a particularly high percentage of revenue with product innovations in the R&D-intensive sectors (vehicle manufacturing, the electrical industry, mechanical engineering and the chemical and pharmaceutical industries).

Small and medium-sized enterprises have been increasingly restrained in their innovation activities. In 2014, SMEs with fewer than 500 employees spent 32.2 billion euros on innovation; this represents 22% of the total innovation expenditure of German industry. In 2007, this figure was 29%, even peaking at over 35% during the latter half of the 1990s. Although the absolute innovation expenditure of Germany's small and medium-sized enterprises has been stagnating for years, SMEs are earmarking higher innovation budgets for 2015 und 2016, with increases of 4% and 6% respectively. This growth rate even surpasses that of large companies.

Turnover and trade volumes

The competitiveness of knowledge-based economies on the international markets for innovative products and services is also reflected in trade in research-intensive goods. Global trade in research-intensive goods has increased steadily in the past. However, owing to the greater participation of some newly industrialised countries in world trade, the share of trade in research-intensive products has been declining slightly over time. In 2012, the world-trade share of technology goods was nearly 43% or about six percentage points below the corresponding level in 2000. Cutting-edge technologies have been especially affected by this structural change (2000: 18.6%, 2012: 13.9%). By contrast, the world-trade share of advanced technology goods remains relatively stable, at about 30%.

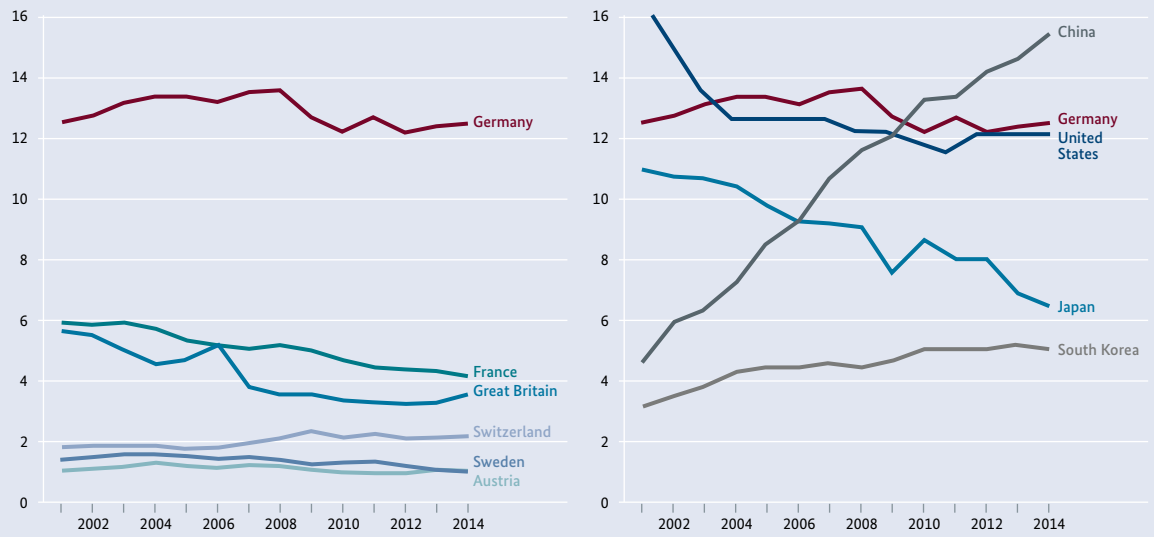
Further information is available online

Gehrke, B.; Frietsch, R.; Neuhäusler, P.; Rammer, C. (2013): Re-definition of research-intensive industries and goods – NIW/ISI /ZEW-Lists 2012, Studien zum deutschen Innovationssystem, 8-2013, Berlin: www.e-fi.de/fileadmin/Innovationsstudien_2013/StuDIS_08-2013-NIW_ISI_ZEW_engl.pdf

Schasse, U. et al. (2016): Forschung und Entwicklung in Staat und Wirtschaft, Studien zum deutschen Innovationssystem, 2-2016, Berlin (only available in German): www.e-fi.de/fileadmin/Innovationsstudien_2016/StuDIS_02_2016.pdf

Gehrke, B.; Schiersch, A. (2016): FuE-intensive Industrien und wissensintensive Dienstleistungen im internationalen Vergleich, Studien zum deutschen Innovationssystem, 6-2016, Berlin (only available in German): www.e-fi.de/fileadmin/Innovationsstudien_2016/StuDIS_06-2016.pdf

Fig. II-23: Shares of world trade in research-intensive goods, for selected countries over time (in %)



Source: Gehrke, B.; Schiersch, A. (2016): FuE-intensive Industrien und wissensintensive Dienstleistungen im internationalen Vergleich, Studien zum deutschen Innovationssystem, no. 6-2016, Berlin: EFI

Although the newly industrialised countries have significantly increased their shares of trade in research-intensive goods since 2000, Germany – unlike other traditional industrial nations – has managed to keep its share of world trade in research-intensive goods largely stable over the past decade. In fact, it was even able to increase its share compared to 2000, whereas, for example, the United States and Japan recorded declining shares. Today, Germany's share of world trade in research-intensive goods is higher than the United States and well ahead of Japan (cf. also Fig. II-23). In terms of this indicator, Germany outperforms all other European countries.[12]

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

4.2 The German research and innovation system in an international overall context

A large number of determinants together define an economy's capacity for innovation. The selective analysis of individual indicators fails to do justice to the complex, multi-dimensional nature of the R&D system as they only reflect certain aspects. Therefore, the results of rankings that are based on innovation indices are often utilised to make comparisons between countries. These indices collate the expression of central input and output indicators for selected countries and consolidate them in an overall index (composite indicator). Key indicators like the Innovation Scoreboard 2015 attest to the high performance of Germany's innovation system. Along with the Scandinavian EU Member States, Germany is one of the so-called Innovation Leaders.

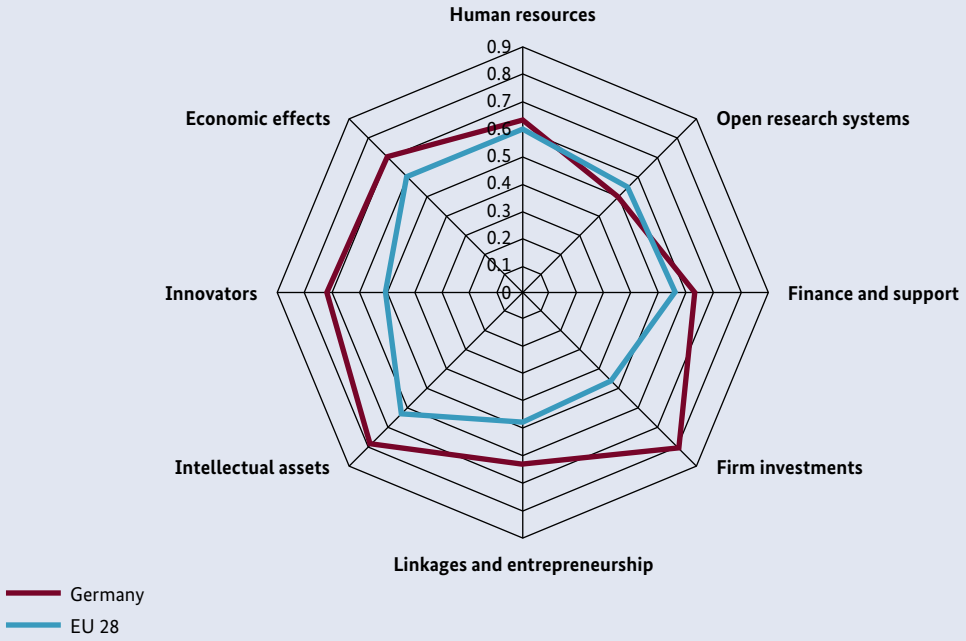
Recent years have seen the emergence of a number of these composite innovation indicators. The previous chapter presented some of the individual indicators that make up the composite indicators. Four of these indicators, the Innovation Union Scoreboard, the acatech/BDI Innovation Indicator, the Global Innovation Index and the Global Competitiveness Index, have taken on a special significance over the last few years and are now recognised internationally. They have been developed by prestigious research and science institutes for some years, usually on an annual basis.

Innovation Union Scoreboard

Established in 2001, the Innovation Union Scoreboard (IUS) is an instrument of the European Commission to measure progress in reaching the targets of the *Europe 2020* Strategy. The IUS assesses the innovation performance of the 28 Member States of the European Union, as well as some other European countries, who are not EU Member States. However, the IUS is limited to Europe; therefore, unlike other indices, it analyses a smaller number of countries and takes account of the lowest number of indicators (25).

According to the findings of the IUS, Germany ranks among the top country group of ‚Innovation Leaders', whose performance considerably exceeds the EU average. Apart from Germany, only Sweden, Denmark and Finland are included in this country group. In the IUS 2015, Germany is in fourth place among all EU-28 countries. By contrast, the United Kingdom ranks eighth, for example, while France has come in twelfth since 2010.

Fig. II-24: Innovation dimensions of the Innovation Union Scoreboard 2015



Source: Innovation Union Scoreboard 2015

Over time, and taking the development of all Member States into consideration, it can be seen that Germany has maintained its leading position for several years, even managing to improve its index score slightly.

The IUS 2015 underlines the high performance of the German innovation system and affirms Germany's current standing as an attractive location of scientific developments. The relative strengths of Germany's innovation system lie in the output dimensions of 'Firm investments' and 'Linkages and entrepreneurship' (cf. also Fig. II-24). Compared to the previous year, performance has improved most strongly in the individual dimensions 'License and patent revenues from abroad', 'Non-R&D innovation expenditures' and 'International scientific co-publications'. Moreover, in the scientific field, the strengths of the German innovation system lie in 'New doctorate graduates'. According to the IUS 2015, relative weaknesses are in the number of 'Non-EU doctorate students' and the amount of 'Venture capital investments'.

Further information is available online

OECD (editor), 2008: Handbook on constructing composite indicators: methodology and user guide, Paris: www.oecd.org/els/soc/handbookonconstructingcompositeindicatorsmethodologyanduserguide.htm

Grupp, H.; Mogee, M. E., 2004: Indicators for national science and technology policy: how robust are composite indicators? in: Research Policy, 33, pp. 1373 ff: www.sciencedirect.com/science/journal/00487333/33/9

Innovation Indicator: National Academy of Science and Engineering (acatech)/Federation of German Industries (BDI)

The Innovation Indicator measures the innovative ability of 35 countries, once again European for the most part, compared to the world's largest economies and important emerging markets. Based on 38 individual indicators, the index has compiled these every year since 2005.[13]

With an index score of 56 points in 2015, Germany also occupies a leading position in the top contenders of this indicator among the 35 countries analysed. Compared to other European countries, Germany ranks fifth, well ahead of Great Britain (in twelfth place) and France (18th); across the globe, it beats the United States (eighth), Korea (13th) and Japan (20th place).

The 38 individual indicators are compiled for five sub-systems (sub-indicators). The Innovation Indicator report also ranks the countries' performance according to these sub-indicators. From this viewpoint, Germany scored particularly highly in the sub-systems of industry and government.

13 However, there was a change in the scientific project partners in 2009 (from the German Institute for Economic Research (DIW) to a consortium headed by Fraunhofer ISI with the Centre for European Economic Research (ZEW)). This also led to a restructuring of the index's methodology concept. A further methodological adaptation took place in 2014, when the number of countries analysed was increased and the set of indicators partly revised.

Global Innovation Index

The Global Innovation Index (GII) has been co-published since 2007 by Johnson Cornell University in the United States, INSEAD in France and the World Intellectual Property Organization (WIPO). In terms of the number of indicators evaluated, the GII represents the most comprehensive methodological approach to measuring the performance of national R&I systems: based on 79 indicators (in 2015), it captures index scores for 141 economies. However, the methodology of calculating the index scores was refined as of 2011; thus, the development over time can only be illustrated from 2011 onwards.

This index also recognises Germany as a global leader, reporting an upward trend in its index scores over time since 2011. According to these analyses, Germany's specific weaknesses mainly lie in the restrained dynamism of its start-up sector and the percentage of R&D expenditure that is financed from abroad.

By contrast, its special strengths include the high percentage of the private sector's contribution to the financing of national R&D activities and the level

Further information is available online

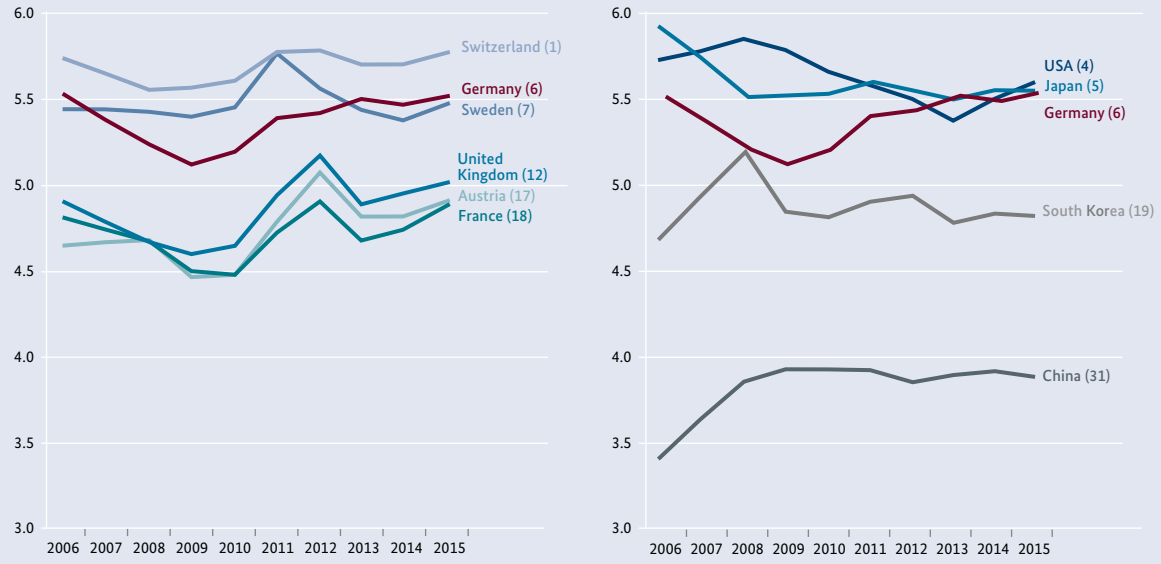
Innovation Union Scoreboard (IUS):
http://ec.europa.eu/growth/industry/innovation/facts-figures/scoreboards/index_en.htm

Innovation Indicator (II):
www.innovationsindikator.de/fileadmin/2015/PDF/Innovationsindikator_2015_Web_en.pdf

Global Innovation Index (GII):
www.globalinnovationindex.org/home

Global Competitiveness Index (GCI):
http://reports.weforum.org/global-competitiveness-report-2015-2016/

Fig. II-25: Index scores over time of selected countries in the Global Competitiveness Index (for the Innovation pillar) and 2015 position



Source: Global Competitiveness Reports

of patenting. Lastly, the standing and significance of clusters in the R&D process in Germany are rated favourably.[14]

Global Competitiveness Index

Besides these three indices, which specifically evaluate innovation factors, the World Economic Forum also produces the Global Competitiveness Index (GCI). Since 2004, it has assessed the competitiveness landscape of 140 economies, documenting its findings in the Global Competitiveness Report. The index is calculated on the basis of 114 indicators, which are divided into twelve pillars of competitiveness. Three of these pillars (Higher education and training, Technological readiness and Business sophistication) relate indirectly to innovation, while one (Innovation) makes direct reference. The majority of these indicators are based on expert assessments, which are captured in the annual Executive Opinion Survey (EOS). On average, 90 experts complete the survey for each country.

According to the Index Component of innovation, Germany is in the top league of economies, currently in 6th place in the global rankings, and has recorded strong development since 2009 (cf. also Fig. II-25).[15]

14 Global Innovation Index 2015, p. 207.

15 Own representation; source: Global Competitiveness Report (versions 2006–2007, 2008–2009, 2009–2010, 2010–2011, 2011–2012, 2012–2013, 2013–2014, 2014–2015, 2015–2016). Note: The 2007–2008 Report is no longer in the public domain. Therefore, the scores for 2007 were calculated as an average of the scores in the previous and subsequent years.

III The Federal Government's research and innovation policy

At a glance

Much of the funding of research, development and innovation in Germany is provided by the Federal Government, which coordinates its research and innovation policy with the *Länder*. Its primary objective is to spur research and development in companies and research institutes by providing targeted support. The Federal Government's research and innovation policy is implemented according to the core elements of the *High-Tech Strategy*. Since 2006, the Federal Government has been using this format to consolidate its research and innovation activities across departmental boundaries: instead of focusing on individual technologies or research topics, the *High-Tech Strategy* covers the entire value chain from basic research through to applications.

The new *High-Tech Strategy – Innovations for Germany* takes a systematic view of the entire innovation chain, from the creative idea through to its implementation in the shape of new products and services, thereby combining all the aspects and stakeholders involved in the innovation process. The main goal is to translate bright ideas more rapidly into applications and develop forward-thinking solutions for the challenges facing society. Therefore, the *High-Tech Strategy* is based on five pillars: the priority tasks for value creation and quality of life boost Germany's competitiveness and enhance prosperity. Networking and transfer improve cooperation and promote implementation. Innovation dynamism in industry boosts innovative strength and increases value creation. Favourable conditions for innovation lay the foundation for creativity and innovative strength. Transparency and participation arouse curiosity with a more future-oriented approach.

1 Research priorities

Research and innovation strengthen Germany as an economic location and contribute substantially to the well-being of the population. Excellent research helps in finding solutions to global challenges and in developing strategies for sustainable growth. Research makes it possible to strike out in new directions, to discover the unknown and improve the status quo. The German research and science landscape enjoys an excellent reputation all over the world.

With its *High-Tech Strategy,* the Federal Government has set thematic priorities in research and innovation. One core element is its focus on priority tasks; driven by an impressive innovative momentum, these tasks will continue to provide invaluable impetus, thereby boosting economic growth and prosperity (cf. also the info box *Priority tasks for prosperity and quality of life*). The goal of the *High-Tech Strategy* is for Germany to blaze a trail in these fields, finding solutions to global challenges and offering satisfactory answers to the pressing questions of the 21st century. In addition, Germany is reinforcing the innovative strength and growth potential of its economy, while guaranteeing qualified, future-proof jobs.

The Federal Government's research and innovation policy also advocates the advancement of key technologies and basic scientific research, together with the development of important cross-cutting issues in the fields of education and society, like demographic change and integration through education.

Priority tasks for prosperity and quality of life

The starting point of the *High-Tech Strategy* is investigating the sources of our future prosperity (How do we intend to maintain our economic strength?) and our quality of life (How do we want to live in tomorrow's world?). Thus, the Federal Government is addressing innovative solutions that are driven by a strong scientific and technical dynamic or high innovation potential, which will give Germany a head start in innovation terms in the international arena.

In many sectors, product cycles have been appreciably shortened, the requirements of system solutions have been tightened and the necessary development input has increased relative to the potential innovative return. Especially in times of unprecedented global change, Germany's competitiveness, its potential for value creation and employment, are increasingly in the focus of attention. Simply implementing technological innovations in production processes is no longer enough. Being innovative requires a great deal more: greater emphasis is being placed on sustainable patterns of consumption and behaviour, and on processes of social change like introducing resource-optimised forms of production and lifestyles. Therefore, the Federal Government is not merely relying on technological innovations, but is also focusing on new organisational solutions, as well as social and service innovations.

The Federal Government is concentrating its thematically oriented research and innovation policy on six priority tasks:

1. The digital economy and society: searching for innovative solutions to the challenges of digitalisation and exploiting opportunities for value creation and prosperity in Germany.

2. Sustainable economic activity and energy: improving the environmental performance, resource efficiency and social compatibility of production methods and consumption patterns, thereby increasing their sustainability.

3. Innovative working environment: scrutinising the profound changes taking place in the modern working world because decent work is a prerequisite for creative ideas and commercial innovations.

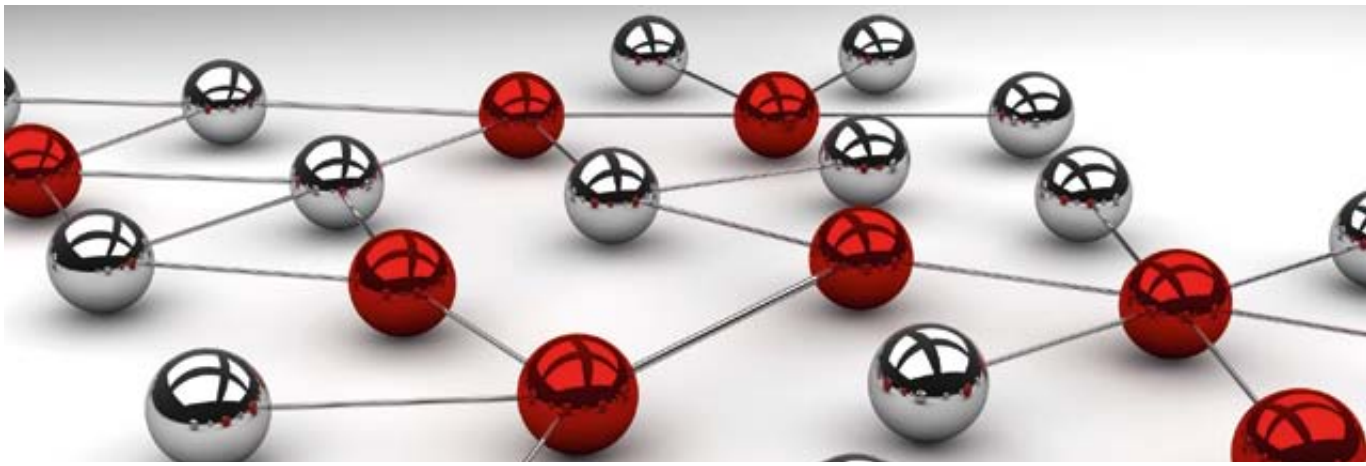
4. Healthy lifestyle: stepping up research for a healthy, active and self-determined lifestyle.

5. Intelligent mobility: research for an integrated transport policy that optimises the efficiency and performance of the individual transport operators, together with their interaction.

6. Civil security: everyday life depends on the trouble-free functioning of the complex systems and infrastructures that govern our energy supply, communication, mobility, health care or logistics.

2 Networking and transfer

Targeted initiatives that pool complementary expertise and resources in collaborations, clusters and networks facilitate the efficient, comprehensive translation of research results into applications. By encouraging the mutual transfer of ideas, knowledge and technology between enterprises, universities, non-university research institutes and other social stakeholders, these initiatives strengthen Germany's standing as an innovation hub.



The Federal Government underpins the universities' endeavours to introduce new cooperation strategies in the regions and provides support in establishing and developing innovative cooperation formats. This boosts the profile of German universities as attractive innovation partners for industry and society. Based on strategic programmes and guidelines, specific measures aim to reinforce and intensify the cooperation of universities and research institutes with industry and society. Together with the *Länder,* an agreement was signed to extend the *Pact for Research and Innovation* until 2020, thereby stepping up the networking and transfer activities carried out by science and research organisations. The *Leading-Edge Cluster Competition,* the *go-cluster* project and the *Research Campus* initiative all foster theme-oriented, results-based strategic cooperation between academia, companies and society. In order to fully utilise universities' innovation potential, the BMBF launched the programme for *research at universities of applied science*, thereby supporting R&D alliances between universities and companies and encouraging the qualification of early career scientists.

The goal is to streamline and accelerate the transfer of research findings onto the market or into applications that benefit society. Closing the innovation gap between preliminary research findings and possible applications is a top priority in this regard. The BMBF's VIP+ funding programme, *Validation of the technological and social innovation potential of scientific research,* assists researchers in validating the innovation potential of their research findings at an early stage in order to develop relevant economic or social applications. In early 2016, the BMWi pooled its patenting and standardisation activities in the *Knowledge and technology transfer via patents and standards (WIPANO)* measure in order to step up commercialisation and the technology transfer.

Integrating all German stakeholders involved in the innovation process in international knowledge flows and networks is crucial to upholding Germany's competitiveness and capacity for innovation. Besides the *go-cluster* initiative, which seeks to internationalise regional innovation clusters, the *Internationalisation of Leading-Edge Clusters, Forward-Looking Projects and Comparable Networks* measure has been facilitating international networking activities since 2015.

3 Innovation dynamism in industry

The high performance and creativity of German enterprises vitalise the innovative dynamism of the country's economy. In reference to large companies with a strong R&D commitment, innovation potential must be leveraged first and foremost in the *Mittelstand,* the skilled trade sector and technology-based spin-offs, and have a regional focus. Therefore, government research and innovation funding is particularly aimed at increasing the number of innovative, high-growth small and medium-sized enterprises by means of appropriate measures.

German companies, and SMEs in particular, receive backing in the form of a coordinated, effective system of research and innovation funding. Technology-neutral programmes, like the *Central Innovation Programme for SMEs,* und the technology-specific measures introduced as part of *SME innovative* assist SMEs in their research and development endeavours. Furthermore, other specialised programmes place particular emphasis on the involvement of SMEs.

The start-up activity of an economy has an enormous impact on its innovative momentum. Although start-ups in research and knowledge-intensive sectors contribute disproportionately to growth and employment, they often have inadequate funding at the outset. Programmes like *EXIST, INVEST, GOBio*, *IKT Innovativ,* the *High-Tech Start-Up Fund,* the *ERP-Startfonds* and its successor *coparion* stimulate the growth of a new start-up dynamism, especially in the early stages of new technological developments, thereby strengthening Germany's position as a competitive location for venture capital.

Unlocking the innovation potential of structurally weak regions enhances their innovative strength, economic growth and employment level. Ongoing efforts in the East German *Länder* are stimulating the development of technological, scientific and economic capacity, and the networking thereof. With several successful programme formats, *Entrepreneurial Regions - the Innovation Initiative for the New German Länder* promotes the development of internationally competitive centres of excellence and clusters with highly dynamic innovation capabilities. The regional grants awarded under the *Joint Scheme for the Improvement of Regional Economic Structures* aid structurally weak regions in both East and West to reach technology and investment policy goals.

4 Favourable conditions for innovation

Fierce competition is the key driver of innovations. Therefore, the Federal Cartel Office and the Federal Network Agency protect competition between market players. In addition, the Federal Government is committed to ensuring that conditions are favourable for innovation. In particular, these include securing the skilled labour base, guaranteeing adequate financing options, while maintaining fair competitive conditions and innovation-friendly regulations. If conditions are favourable for innovation, then bright ideas will emerge and go on to become economic success stories.

Securing the skilled labour base is one of Germany's priority tasks. Along with politics and society, companies and social partners now have to take action. As part of the Skilled Workers Concept, the Federal Government is pursuing a comprehensive, systematic approach, with various interdepartmental initiatives aimed at securing the skilled labour base.

As a location for venture capital investment, Germany must be competitive on an international scale. With a range of measures, outlined in the key issues paper on *Venture Capital – Germany needs a new era of rapid industrial expansion*, the Federal Government has created further incentives for investing in innovative companies and ideas.

Standardisation and effective legal metrology are integral elements of economic and innovation policy. The elimination of non-tariff trade barriers and the international harmonisation of standards and norms are the subject of ongoing multi- and bilateral negotiations. The metrology system was restructured under the 2015 German Weights and Measures Act and systematically adapted to comply with European guidelines.

With its high volume of over 300 billion euros per year, public procurement can provide powerful incentives for greater innovation in industry. Funded by the BMWi, a competence centre advises public procurers to demand more innovation on the market, thereby setting innovation incentives for the economy.

5 Transparency and participation

New developments and technologies are the subject of candid, open debate in Germany in which the chances and risks are weighed without bias. This cultivates a society that is interested in social and technological progress, that comes up with ideas of its own and plays an active role in the innovation process. In its *High-Tech Strategy*, the Federal Government advocates the greater involvement of all stakeholders – from academia to industry, right down to the citizens – in shaping innovation processes. To this end, it is strengthening key elements like citizens' openness to new technologies, citizen participation and social innovations. Moreover, it aims to use programmes to implement participatory research more rigorously in Germany and encourage active exchange in the research sector and with the general public.

Having substantiated information at your fingertips is essential when directing the progress of new technologies and developments and for initiating open dialogue at an early stage. With a focus on the next five years, the *innovation and technology analysis* (ITA) presents the opportunities and challenges of

new technologies in a neutral, transparent and comprehensive manner. The results of the *Strategic Foresight* illustrate how society could change in the long term.

Scientific communiction is tasked with presenting research results and innovation processes in a readily comprehensible form. Dialogue formats play a key role in this respect and are increasingly dominating the *Science Years*. The *Science Year 2015 – City of the Future* invited interested citizens to become actively involved by offering nationwide participation and mobilisation programmes to help design the city of tomorrow, while conveying the central role of science and research for future urban development in a practical way. The *Science Year 2016*2017 – Seas and Oceans* demonstrates how science and research contribute to protecting and using the seas and oceans sustainably.

By engaging in dialogue with the citizens and encouraging transdisciplinarity in the research sector, the Federal Government seeks to entrench innovations in the very heart of society. As a platform to guide the prospective focus of research and development, the *Future Forums* enable citizens to contribute the wealth of their experience more directly to policy-making.

Agenda processes ensure that innovation and research programmes are demand-oriented. In addition, scientists provide input to help identify priorities, thereby raising the acceptance and awareness of the funding programmes, which increase innovative capabilities in turn.

The task of promoting science and research is not just shared by the state, industry and society; in fact, the Federal Government and the *Länder* work hand in hand in this respect. The amendment to the Basic Law of 23 December 2014 brought about enhanced opportunities for cooperation between the Federal Government and the *Länder*, thereby paving the way for the future framework of the German science system.

In Germany's federal system, the responsibility for promoting science and research only falls into the exclusive remit of the Federal Government in a few cases. For example, the Federal Government is invested with legislative powers in the regulation of educational and training grants and the promotion

IV The cooperation between the Federal Government and the *Länder*

of research (Art. 74 1 (13) GG); by contrast, the higher education sector is predominantly the responsibility of the *Länder* (Art. 70 GG).

Nevertheless, pursuant to Art. 91b (1) GG and as a result of agreements on the promotion of science, research and teaching, the Federal Government and the *Länder* may agree to cooperate in cases of supra-regional importance.

The Federal Government/*Länder* agreements aim to underpin the joint emphases and profile development, thereby increasing the achievement capacity of the German science landscape. Around ten years ago, the Federal Government and the *Länder* together launched the science pacts – the *Initiative for Excellence,* the *Pact for Research and Innovation* and the *Higher Education Pact* – to meet these goals. Thanks to their major impetus, the science pacts have tangibly enhanced the performance and capabilities of the German science system. In December 2014, therefore, Chancellor Merkel and the leaders of the *Länder* governments agreed to an extension of the pacts.

V International cooperation in research and innovation

At a glance

A successful research and innovation system must have a strong international focus in order to benefit from knowledge bases around the world. This also applies to Germany. Guiding the rapid ongoing internationalisation of innovation processes has thus become a central political task. The success of the German research and innovation system depends on policy-makers' ability to establish a framework for international action that is conducive to science and innovation, thereby facilitating the development of global knowledge resources. Internationalisation is an absolute prerequisite for excellent research and innovative strength in Germany.

The Federal Government addressed these global challenges in its 2008 *Strategy for the Internationalisation of Science and Research* and its 2014 conclusions in the *International Cooperation action plan*. Along with the new *High-Tech Strategy,* the *Pact for Research and Innovation* and the *Initiative for Excellence*, the internationalisation strategy is a core element of German research policy.

The creation of the European Research Area (ERA) provides an important framework for the alignment of international research policy; therefore, the Federal Government is actively pursuing the integration of its endeavours in the European context. Joint, concerted action on the part of important EU Member States enhances Europe's visibility, giving it added weight vis-à-vis the world's other major innovation regions. *Horizon 2020,* the European framework programme for research and innovation, was designed to complement national research programmes; with a total funding volume of 77 billion euros, it is the world's largest self-contained funding programme.

Particular mention should also be made here of the European mobility programme *Erasmus+*, which runs from 2014 to 2020 and has a budget of 14.8 billion euros. The programme, whose overarching goal is the promotion of mobility for learning purposes, is administered in Germany by four National Agencies (NA) according to specific target groups. Germany implements European cohesion policy through the *European Structural & Investment Funds (ESIFs)* at both Federal Government and *Länder* levels, whereas the *European Social Fund (ESF)* deserves special attention with regard to labour market and qualification aspects.

Germany is boosting its bilateral cooperation with important partner countries around the world. This applies especially to countries with dynamic growth and significant emerging markets; it is also of strategic importance in terms of access to attractive partners, locations and sources of knowledge. Germany's active involvement in multilateral initiatives and institutions, as well as informal forums, is conceived as a long-term investment in the future. Shining examples are its participation in the Organization for Economic Cooperation and Development (OECD), the United Nations Educational, Scientific and Cultural Organization (UNESCO) and its membership of G7 and G20.

1 Objectives and priorities of the internationalisation of research and innovation

Global challenges, like climate change, can only be overcome by committing to partnerships. At the same time, international collaboration in the fields of education, research and innovation enhances Germany's attractiveness as a location. There is often only a thin line between cooperation and competition. Therefore, having defined strategic priorities and developed instruments to maintain Germany's international competitiveness, the Federal Government is thus also accepting global responsibility for the sustainable development of the economy.

Reinforcing Germany's role in the global knowledge society – with this goal in mind, the Federal Government rolled out its *Strategy for the Internationalisation of Science and Research*. This established a reference framework to optimise the increasing cross-border networking of research and innovation in line with Germany's interests. The strategy defined four target areas: research excellence, innovation, collaboration with developing countries and global challenges.

In 2014, the BMBF introduced an important milestone in the process: the *International Cooperation action plan* determined Germany's position in the global competition and assessed what further action had been necessitated by the changing global environment.

The stiffer competition from fast-growing emerging economies, the far-reaching developments inherent in digitalisation, the dynamism of new economic, ecological and social challenges – all these questions call for contemporary solutions.

The Federal Government has a vast array of instruments at its disposal to help achieve the defined objectives, ranging from targeted observation and analysis, bringing researchers together in cross-border teams right through to establishing specific projects, partnerships and joint research infrastructures.

2 Germany's role in Europe

The scientific excellence, commercial success and international competitiveness of the European research landscape all hinge on the cooperation between member states, their research institutes and enterprises. As a political process, the *European Research Area* creates a unified space in which scientific knowledge, technology and researchers circulate freely. It forms the basis of the cooperation, together with the *EU's research framework programmes* as management tools and funding instruments. The EU Member States are actively pursuing the realisation of the European Research Area with the aim of maximising competitiveness and boosting employment. The overarching goal is researcher mobility and the optimal transfer of scientific knowledge. A good education policy is crucial in responding to challenges like globalisation. Therefore, the Member States have been collaborating on a voluntary basis for many years to promote academic mobility or prepare young people for the labour market.

Europe's transformation into a political, economic and social union – while preserving its cultural diversity – has been marked by great success and major challenges. Education, science, research and innovation are prerequisites for the emergence of fresh ideas and solutions to the major challenges facing society and also for developing new products, services and processes that will eventually find their way into the global marketplace. Innovative solutions safeguard prosperity and create jobs and security for the people of Europe.

With effect as of December 2009, the Treaty of Lisbon enshrines the goal of establishing the European Research Area in the primary legislation of the EU. The European Research Area will guarantee a number of privileges similar to the fundamental freedoms of the internal market – freedom of movement for researchers and the free exchange of scientific findings and technologies. The European Research Area is more than the sum of the activities carried out by Member States. The Member States, the EU institutions and the research organisations have joined forces to improve the framework conditions and facilitate a research landscape that works smoothly across European borders. To this end, the *Strategy of the Federal Government on the European Research Area* was adopted in July 2014.

In 2009, the education ministers endorsed the strategic framework for European cooperation in education and training until 2020 (*ET 2020*), which was reviewed and updated in 2015. The strategic objectives are to improve the quality of individual areas of education and to enhance creativity and mobility, to name but a few. Furthermore, the EU programme *Erasmus+* is also fostering mobility (2014–2020).

3 Worldwide cooperation

Traditionally, Germany's research landscape and its stakeholders boast an outstanding international network. German scientists have always been and continue to be mobile, while researchers from other countries are regularly hosted in Germany. This international exchange is rapidly moving to the next level. Its many forms of cooperation worldwide elevate Germany's standing, making it a key player in a globalised world.

Germany has created a reliable framework for cooperation with numerous partners around the world. Collaboration takes place at both government level, among administrative bodies and intermediary organisations, as well as at the level of the research organisations and universities. It is imperative that each individual alliance be tailored to both the respective partner countries and Germany's interests. Accordingly, Germany uses highly variable cooperation instruments, refining them continuously.

Germany's research and innovation policy aims to maintain a strong presence in countries whose science and technology resources are of strategic importance in order to develop close alliances with them. This applies to both industrial nations and newly industrialised countries. Cooperation will be increasingly relevant with those countries that improve their development status rapidly and dynamically.

The most important basis for bilateral alliances are *agreements on Science & Technology Cooperation* (STC) or on collaboration in vocational training. Regular intergovernmental consultations take place with a number of countries that are international cooperation priorities, in which education and research play a key role.

In its research and educational cooperation with regions of the world (ASEAN, MENA, African Union, MERCOSUR), Germany places greater emphasis on regional approaches and specially tailored measures. Furthermore, by bringing its expertise to bear in international organisations and forums (e.g. OECD, G7, WHO, UN), programmes and initiatives, Germany acknowledges its share of global responsibility. An intensive energy research cooperation has been established within the framework of a technology network maintained by the International Energy Agency (IEA), which comprises around 6,000 experts worldwide. In addition, an international initiative, *Mission Innovation,* was launched at the 21st UN Climate Change Conference by 20 heads of government, within whose framework the participating nations intend to step up research and development activities and increase collaboration on clean energy technology research. The initiative focuses on improving partnerships with the private sector.

VI The research and innovation policy of the *Länder*

At a glance

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

The regional differences in research and innovation funding and the specific emphases of the *Länder* both contribute to strengthening the German research and innovation system as a whole.

The specific strengths of the individual regions – their technological, economical and innovation competence – are taken into consideration, together with any spatial structures and special features they might have. Therefore, the *Land*-specific funding 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 may differ from those of the Federal Government.

In keeping with their sovereignty in policy matters, the *Länder* are each presenting their research, technology and innovation policies under their own responsibility in the Federal Report on Research and Innovation 2016. In this abstract, the presentations only focus thematically on the goals and emphases of the research, technology and innovation policy of the respective *Länder*. Furthermore, in order to classify the strategic emphases, selected structural and innovation indicators are illustrated in tabular form.

Baden-Württemberg

Baden-Württemberg's research and innovation policy aims to

- set priorities and raise the *Land*'s profile under the mantle of scientific excellence
- promote cutting-edge research and high quality in the widest possible range of subjects and issues
- create sufficient autonomy and scope for researchers and teachers as preconditions for scientific creativity by ensuring reliable funding and an appropriate statutory framework.

Structural indicators	Year	Value
Gross domestic product (nominal, in millions of euros)	2014	438,267
Gross domestic product (nominal, in euros per capita)	2014	41,059
Growth rate of gross domestic product (nominal, mean change compared to previous year, in %)	2009–2014	4.35
Share of manufacturing sector of gross value added (in %)	2014	32.5
Export ratio in the manufacturing sector (in %)	2014	54.28

Input innovation indicators	Year	Value
R&D expenditure as a percentage of GDP	2013	4.80
R&D expenditure in the government sector and private non-profit institutions as a percentage of GDP	2013	0.42
R&D expenditure in the higher education sector as a percentage of GDP	2013	0.52
R&D expenditure in the economic sector as a percentage of GDP	2013	3.86

Output innovation indicators	Year	Value
Scientific publications per million inhabitants	2013	1,473
Patent applications per million inhabitants	2013	1,370

In addition, the *Land*'s strategic objectives consist in promoting young scientists and improving their opportunities for independent research, in enhancing the international orientation of both the research sector and scientific personnel, as well as fostering cross-border cooperation and participation in EU programmes.

Other key issues include the expansion of digital research infrastructures, further improvements in knowledge and technology transfer between universities and non-university research institutes, industry and society, a strict focus on quality, performance and competition, plus the creation of a research-friendly, innovation-oriented environment.

Under the new financial pact *Perspective 2020,* the universities in Baden-Württemberg are to receive an additional 3% of basic funding per year until 2020. Thus, Baden-Württemberg was the first *Land* to implement the recommendation of the German Council of Science and Humanities.

The universities enjoy substantial autonomy and take responsibility for developing their own profiles. Apart from funding, research-friendly framework conditions notably mean providing assistance in appointing leading scientists from both Germany and abroad as well as support in developing new research priorities.

With its cluster and network strategy, the government facilitates the networking of science, industry and other stakeholders involved in the innovation process, while promoting cooperative research projects.

Free State of Bavaria

In May 2011, the Bavarian government endorsed an *overall concept for research, technology and innovation policy*, which outlines the framework and strategic objectives for proper governance in these fields as part of the RIS3 strategy.

Bavaria's research and innovation policy aims to raise social awareness of science and research, create optimal framework conditions for science on the basis of an attractive research and working environment and modern infrastructures, and to undergird companies' growth and competitiveness by means of targeted technology funding instruments.

Current areas of focus of Bavarian research and technology policy include digitalisation, energy, health, materials and mobility.

These emphases are not just underpinned by investments in research projects and structural measures, but also by comprehensive location strategies, like the interdepartmental future strategy *Bayern Digital*, with which the Bavarian government is endeavouring to consolidate the *Land*'s pole position as a key location for high technology in Europe and establish Bavaria as the home of the digital future.

Bavaria has achieved both national and international renown for its diverse, outstanding research landscape, which is built on the foundation of its higher education sector.

Moreover, by virtue of its universities and scientific institutes, Bavaria offers attractive framework conditions for young researchers. At the same time, the *Land*'s science system boasts a long tradition of excellent non-university research.

With respect to research and development in industry, Bavaria's technology-based funding programmes play a vital role. By facilitating innovations, these programmes aim to boost the international competitiveness of the private sector, improve growth potential, safeguard qualified employment and create new job opportunities.

Structural indicators	Year	Value
Gross domestic product (nominal, in millions of euros)	2014	521,932
Gross domestic product (nominal, in euros per capita)	2014	41,266
Growth rate of gross domestic product (nominal, mean change compared to previous year, in %)	2009–2014	4.17
Share of manufacturing sector of gross value added (in %)	2014	26.5
Export ratio in the manufacturing sector (in %)	2014	51.18

Input innovation indicators	Year	Value
R&D expenditure as a percentage of GDP	2013	3.16
R&D expenditure in the government sector and private non-profit institutions as a percentage of GDP	2013	0.32
R&D expenditure in the higher education sector as a percentage of GDP	2013	0.43
R&D expenditure in the economic sector as a percentage of GDP	2013	2.41

Output innovation indicators	Year	Value
Scientific publications per million inhabitants	2013	994
Patent applications per million inhabitants	2013	1,177

Berlin

Scientific excellence, collaboration in innovation-oriented, cross-border clusters and strengthening the knowledge-based economy and lively start-up scene: such are the goals and emphases of Berlin's research and innovation policy.

Apart from diverse technology-based research activities, Berlin boasts an extraordinary breadth of social sciences and humanities research, which helps in tackling economic and social problems, including at international level, and keeps the capital region supplied with a steady stream of new ideas.

Structural indicators	Year	Value
Gross domestic product (nominal, in millions of euros)	2014	117,271
Gross domestic product (nominal, in euros per capita)	2014	34,033
Growth rate of gross domestic product (nominal, mean change compared to previous year, in %)	2009–2014	3.45
Share of manufacturing sector of gross value added (in %)	2014	9.1
Export ratio in the manufacturing sector (in %)	2014	53.62

Input innovation indicators	Year	Value
R&D expenditure as a percentage of GDP	2013	3.58
R&D expenditure in the government sector and private non-profit institutions as a percentage of GDP	2013	1.23
R&D expenditure in the higher education sector as a percentage of GDP	2013	0.85
R&D expenditure in the economic sector as a percentage of GDP	2013	1.50

Output innovation indicators	Year	Value
Scientific publications per million inhabitants	2013	2,460
Patent applications per million inhabitants	2013	262

Thus, Berlin's research and innovation policy specifically addresses future priorities, in which technological potential must be reconciled with the needs of society. Digitalisation research and development, Smart City, Industry 4.0 and electromobility are turning the city into an experimental ground and urban application laboratory.

The *Land*'s innovation policy is augmented by a number of funding instruments that underpin the innovative capacity and activity of Berlin-based companies in different ways.

The *Programme to promote research, innovation and technologies (Pro FIT)* plays a lynchpin role in this respect. The programme aims to boost the intensity of research, development and innovation in Berlin's economy by promoting sophisticated, innovative projects. The support focuses primarily on the clusters that were defined in the *Joint innovation strategy of the States Berlin and Brandenburg (innoBB)* of 2011. Although the five clusters of ICT, media and the creative industries, life sciences and healthcare, energy technology, photonics and mobility are at the heart of innoBB, cross-cluster topics like Smart City or Industry 4.0 are also being actively promoted.

Cross-cutting themes such as clean technologies, security, materials and production, and automation engineering also facilitate the cluster development process.

Brandenburg

Brandenburg's primary research policy objective is to uphold the superior quality of its research sector and enhance its national and international competitiveness. A further governmental priority is to boost the research-based innovative strength of the *Land* as it is a decisive location factor in attaining Brandenburg's economic goals.

The cooperation between science and industry is a valuable asset in the development of Brandenburg and the capital region. Together with the targeted support of companies, this is the core element of the State of *Brandenburg's regional innovation strategy (innoBB plus),* which complements the *Joint innovation strategy of the States Berlin and Brandenburg (innoBB)* of 2011, particularly Brandenburg's special economic structure as a territorial state.

Structural indicators	Year	Value
Gross domestic product (nominal, in millions of euros)	2014	61,897
Gross domestic product (nominal, in euros per capita)	2014	25,228
Growth rate of gross domestic product (nominal, mean change compared to previous year, in %)	2009–2014	2.90
Share of manufacturing sector of gross value added (in %)	2014	12.7
Export ratio in the manufacturing sector (in %)	2014	28.03

Input innovation indicators	Year	Value
R&D expenditure as a percentage of GDP	2013	1.55
R&D expenditure in the government sector and private non-profit institutions as a percentage of GDP	2013	0.73
R&D expenditure in the higher education sector as a percentage of GDP	2013	0.37
R&D expenditure in the economic sector as a percentage of GDP	2013	0.45

Output innovation indicators	Year	Value
Scientific publications per million inhabitants	2013	641
Patent applications per million inhabitants	2013	131

Against this backdrop, Brandenburg's research and innovation policy focuses on the strategic development of research consortia and cooperation between universities, non-university research facilities and companies in the context of active networking.

Moreover, it places emphasis on the active transfer of research findings, especially in the form of interdisciplinary patent exploitation and start-up support.

Objectives include quality assurance of Brandenburg's research landscape by national and international standards, raising its profile to strengthen basic research – plus application-oriented and technological research from now on – at institutions of higher education and the greater internationalisation of the research sector.

Other key issues on the agenda are attracting and actively encouraging early career scientists by means of joint career advancement and by opening up post-doc career opportunities, the further development of the exceptionally family-friendly policies of the *Land*'s universities and research institutes, and the active promotion of female scientists and researchers.

Free Hanseatic City of Bremen

The main goals of Bremen's regional policy include increasing the number of university graduates, and thus the supply of highly qualified personnel in the region, improving the excellence of its science and its young researchers, and continuing to intensify the transfer of knowledge.

The thematic and structural cornerstone of the science system in Bremen and Bremerhaven are the *Land*'s five core scientific areas: marine sciences; materials science including aerospace; information, cognitive and communication sciences including logistics and robotics; social sciences and health sciences. These five areas serve as guides for the research sector, teaching and knowledge transfer including the promotion of young researchers, appointments policy and organisation structures that also take non-university research institutes into account.

The core scientific areas are highly congruent with the *Land*'s commercial innovation fields and with the high-profile areas at the University of Bremen.

Supported by target agreements with Bremen's universities and non-university research facilities, the focus here is on those areas that already demonstrate, or are able to attain, a high degree of scientific quality and excellence, and which also have a regional economic impact; thus, they help to strengthen the financial basis by attracting third-party funding or encourage the training of highly qualified employees.

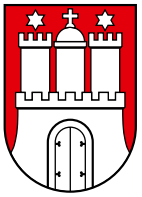
Major innovation policy activities are aimed at fostering synergies by forging even closer, sustainable links between intramural and non-university stakeholders in the regional science system and outstanding scientific cooperation partners, both supra-regional and international, as well as at forming clusters of science and industry. The *Innovation Program 2020* and the subsequent *Cluster Strategy 2020* for sustainable growth and employment currently form the framework for Bremen's innovation and cluster policy.

Structural indicators	Year	Value
Gross domestic product (nominal, in millions of euros)	2014	30,236
Gross domestic product (nominal, in euros per capita)	2014	45,837
Growth rate of gross domestic product (nominal, mean change compared to previous year, in %)	2009–2014	3.67
Share of manufacturing sector of gross value added (in %)	2014	18.8
Export ratio in the manufacturing sector (in %)	2014	56.19

Input innovation indicators	Year	Value
R&D expenditure as a percentage of GDP	2013	2.69
R&D expenditure in the government sector and private non-profit institutions as a percentage of GDP	2013	0.96
R&D expenditure in the higher education sector as a percentage of GDP	2013	0.72
R&D expenditure in the economic sector as a percentage of GDP	2013	1.00

Output innovation indicators	Year	Value
Scientific publications per million inhabitants	2013	2,618
Patent applications per million inhabitants	2013	244

Free and Hanseatic City of Hamburg



The main objectives and priorities of Hamburg's current science policy are creating favourable framework conditions for research and innovation.

This includes establishing other non-university research institutes, extending and restructuring research funding, granting additional subsidies to Hamburg's two research clusters under the *Initiative for Excellence* and streamlining the cooperation between the science community and Hamburg-based industry.

A further fundamental goal is to overhaul the universities by calling on external expertise. The *Land* has commissioned the German Council of Science and Humanities to review the STEM disciplines at Hamburg's universities. Due to be published in early 2016, the findings will provide important insight for the further development of the universities.

Another focus is the city's successful participation in the follow-up project to the *Initiative for Excellence* of the Federal Government and the *Länder*. To date, Hamburg has been represented in the *Initiative for Excellence* with two clusters of excellence (physics and climate research) at Universität Hamburg and its cooperation partners. These clusters are to be upgraded with the goal of transferring them to an institutional funding measure of the Federal Government and the *Länder*.

Other central issues on the agenda are opening up the universities and increasing the permeability of the various education sectors. This includes the systematic utilisation of opportunities arising from making higher education accessible for qualified professionals and supporting individual refugees recently arrived in Germany who are capable of studying for a degree.

In addition, Hamburg aims to carry out the necessary structural modifications to modernise its universities and create a state-of-the-art scientific infrastructure that offers outstanding teaching, learning and research conditions. Moreover, the instruments of the cluster and innovation policy are designed to raise the region's profile as a technology leader, create future-proof jobs and facilitate sustainable urban development.

Structural indicators	Year	Value
Gross domestic product (nominal, in millions of euros)	2014	103,145
Gross domestic product (nominal, in euros per capita)	2014	58,786
Growth rate of gross domestic product (nominal, mean change compared to previous year, in %)	2009–2014	2.48
Share of manufacturing sector of gross value added (in %)	2014	12.3
Export ratio in the manufacturing sector (in %)	2014	25.71

Input innovation indicators	Year	Value
R&D expenditure as a percentage of GDP	2013	2.33
R&D expenditure in the government sector and private non-profit institutions as a percentage of GDP	2013	0.47
R&D expenditure in the higher education sector as a percentage of GDP	2013	0.52
R&D expenditure in the economic sector as a percentage of GDP	2013	1.34

Output innovation indicators	Year	Value
Scientific publications per million inhabitants	2013	2,735
Patent applications per million inhabitants	2013	424

HESSEN

Hesse

Hesse has an established system of state and private universities, coupled with high-performance non-university research facilities. The promotion of education, research and science is the foundation of Hesse's regional politics and an important investment in the future.

The *Land* government has extended the autonomy of the universities by reinforcing their scientific and economic independence. This broadened capacity to act serves the purpose of safeguarding national and international competitiveness in the long term.

The non-university research facilities are integrated to a significant extent in these processes in the context of strategic partnerships.

The objective of university development planning is to establish prestigious research priorities at the universities as a competitive tool. At present, approximately 90 of these priorities have been established; they cover all relevant fields of science and increasingly involve interdisciplinary approaches that also focus on their application.

The enhanced intramural networking is reflected externally in the form of structured consortia. The knowledge-based, thematic collaboration between science and industry is put into practice in key areas according to the so-called 'House of' concept in the form of public-private partnerships.

Besides the *House of Finance,* the *House of IT,* the *House of Logistics and Mobility* and *House of Pharma and Healthcare,* which are already established, the *House of Energy* was launched in 2015.

A whole host of non-university research facilities is located in Hesse. It is regional policy's avowed goal to interlink these institutes as closely as possible with the *Land*'s universities. The broad range of disciplines offered at non-university research facilities and their differing research structures are to be maintained and developed further.

Moreover, emphasis is placed on a sustainable, professional innovation policy and on fostering the transfer of knowledge and technology.

Structural indicators	Year	Value
Gross domestic product (nominal, in millions of euros)	2014	250,494
Gross domestic product (nominal, in euros per capita)	2014	41,270
Growth rate of gross domestic product (nominal, mean change compared to previous year, in %)	2009–2014	2.72
Share of manufacturing sector of gross value added (in %)	2014	18.7
Export ratio in the manufacturing sector (in %)	2014	50.84

Input innovation indicators	Year	Value
R&D expenditure as a percentage of GDP	2013	2.83
R&D expenditure in the government sector and private non-profit institutions as a percentage of GDP	2013	0.23
R&D expenditure in the higher education sector as a percentage of GDP	2013	0.42
R&D expenditure in the economic sector as a percentage of GDP	2013	2.18

Output innovation indicators	Year	Value
Scientific publications per million inhabitants	2013	1,808
Patent applications per million inhabitants	2013	358

Mecklenburg-Western Pomerania

Research and innovation policy is a top priority for the government of Mecklenburg-Western Pomerania. Its goal is the efficient structuring of the existing research landscape and a stronger focus in order to prevail in national and international competition. The government aims to achieve this goal by the targeted funding of particular research priorities (e.g. plasma physics including its technological application spectrum, biotechnology, information and communications technology, marine, environmental, climate and atmospheric research, sensors, medical research, marine systems technology, materials research and agricultural research).

Structural indicators	Year	Value
Gross domestic product (nominal, in millions of euros)	2014	38,477
Gross domestic product (nominal, in euros per capita)	2014	24,081
Growth rate of gross domestic product (nominal, mean change compared to previous year, in %)	2009–2014	2.32
Share of manufacturing sector of gross value added (in %)	2014	11.8
Export ratio in the manufacturing sector (in %)	2014	30.84

Input innovation indicators	Year	Value
R&D expenditure as a percentage of GDP	2013	1.83
R&D expenditure in the government sector and private non-profit institutions as a percentage of GDP	2013	0.71
R&D expenditure in the higher education sector as a percentage of GDP	2013	0.65
R&D expenditure in the economic sector as a percentage of GDP	2013	0.48

Output innovation indicators	Year	Value
Scientific publications per million inhabitants	2013	2,671
Patent applications per million inhabitants	2013	113

The government's research and innovation policy is summarised in the *Regional Innovation Strategy (RIS),* which focuses on mechanical engineering, health, nutrition, information and communications technology, energy and mobility.

These research priorities extend beyond the traditional profile, thereby opening up new technological and industrial opportunities. This also includes the systematic strengthening of excellence-based research and the profiling of young academics to ensure their optimal career development.

As a key area of responsibility for interdepartmental political action, the research landscape and research priorities are honed and developed on an ongoing basis.

In addition to implementing the *Pact for Research and Innovation*, the focus is on intensifying networking between universities, non-university research facilities and industry.

By supporting application- and market-oriented projects, the government seeks to encourage excellence in research and development, raise the profile of research and scientific institutes, enhance their competitiveness in attracting third-party funding and cultivate international academic contacts. Furthermore, it aims to strengthen basic research at its universities in accordance with the development goals that have been agreed with the *Land*.

Lower Saxony

Lower Saxony has a diverse research landscape with clear priorities, which boasts a close cooperation between universities and non-university institutes. These include 21 public universities, 18 supra-regional non-university research institutes, 14 other research institutes that are jointly funded by the Federal Government and the *Land*, as well as numerous innovative enterprises.

Structural indicators	Year	Value
Gross domestic product (nominal, in millions of euros)	2014	253,623
Gross domestic product (nominal, in euros per capita)	2014	32,480
Growth rate of gross domestic product (nominal, mean change compared to previous year, in %)	2009–2014	3.87
Share of manufacturing sector of gross value added (in %)	2014	22.9
Export ratio in the manufacturing sector (in %)	2014	45.01

Input innovation indicators	Year	Value
R&D expenditure as a percentage of GDP	2013	2.84
R&D expenditure in the government sector and private non-profit institutions as a percentage of GDP	2013	0.39
R&D expenditure in the higher education sector as a percentage of GDP	2013	0.52
R&D expenditure in the economic sector as a percentage of GDP	2013	1.92

Output innovation indicators	Year	Value
Scientific publications per million inhabitants	2013	1,343
Patent applications per million inhabitants	2013	375

With topics from the disciplines of the life sciences, energy, mobility, marine and climate research, production technology, the humanities and social sciences, and agricultural sciences, Lower Saxony's research policy emphasises the systematic involvement of the scientific community in pressing issues of social relevance. Gender and diversity aspects are taken into account on an ongoing basis.

Specific funding policy adopts a two-pronged approach in supporting the diverse research landscape in Lower Saxony, comprising internationally renowned institutes dedicated to basic research, universities with different profiles, institutes of higher education and universities of applied science that are firmly rooted in the region and research institutes that are administered by the *Land*: firstly, participation is encouraged in the major calls for tender and programmes of the EU's research funding, for example. Secondly, the *Land* maps out its own funding policy course, for instance, with regard to research for sustainable development or topics of particular interest to the *Land*, like innovation and economic development.

Sustainability in research and teaching is one of the guiding principles of its higher education development.

Moreover, Lower Saxony is committed to increasing the research capabilities of its universities of applied science and developing its research infrastructure. Technology funding and transfer are major issues, featuring heavily in the *Land*'s research, structural and economic policies. A key objective is to improve innovation and competitive potential, particularly that of small and medium-sized enterprises.

Networks and cooperation projects between universities, research institutes and companies have proven to be highly successful instruments.

North Rhine-Westphalia

Having undertaken to foster its development as a high-performance science and research hub, North Rhine-Westphalia has joined forces with its universities and research institutes in pursuing this goal. Basic research and applied research and development (R&D) are placed on an equal footing as both are conducive to upholding the *Land*'s innovative strength.

Structural indicators	Year	Value
Gross domestic product (nominal, in millions of euros)	2014	624,668
Gross domestic product (nominal, in euros per capita)	2014	35,482
Growth rate of gross domestic product (nominal, mean change compared to previous year, in %)	2009–2014	2.62
Share of manufacturing sector of gross value added (in %)	2014	19.5
Export ratio in the manufacturing sector (in %)	2014	43.12

Input innovation indicators	Year	Value
R&D expenditure as a percentage of GDP	2013	1.94
R&D expenditure in the government sector and private non-profit institutions as a percentage of GDP	2013	0.33
R&D expenditure in the higher education sector as a percentage of GDP	2013	0.50
R&D expenditure in the economic sector as a percentage of GDP	2013	1.11

Output innovation indicators	Year	Value
Scientific publications per million inhabitants	2013	874
Patent applications per million inhabitants	2013	403

With 72 universities, approximately 730,000 students and over 50 non-university research facilities, North Rhine-Westphalia boasts the densest scientific and research landscape in Europe.

In addition, there are around 100 university-affiliated research institutes and seven medical faculties and university hospitals.

With its research strategy *Progress NRW,* North Rhine-Westphalia is setting a new course for its research and innovation policy. It is focusing on social and technical innovations that help to increase prosperity and improve our well-being, all the while safeguarding the ecological, economic, social and cultural foundations of our existence.

Progress NRW addresses the major challenges facing society, concentrating on key topics like climate protection, energy supply, resource efficiency or demographic change.

By encouraging interdisciplinary research for sustainable development and involving the relevant social players, the government seeks to bring about economic, ecological and social progress for all mankind.

This aim is also conveyed by the *Innovation Award of North Rhine-Westphalia:* endowed with the sum of 150,000 euros, it is one of Germany's major research prizes.

Established in 2015 under the new University Future Act (*Hochschulzukunftsgesetz*), the NRW higher education development plan (*Landeshochschulentwicklungsplan*, LHEP) seeks to implement cross-cutting *Land* interests in the development of universities in North Rhine-Westphalia. The *LHEP* is based on planning principles, approved by the *Landtag* (parliament), which formulate the thematic and structural objectives in the higher education sector. Scheduled for resolution in summer 2016, the *LHEP* will be in effect for a period of five years.

Rhineland-Palatinate

With its research and innovation policy, Rhineland-Palatinate adopts a holistic approach between the poles of science and industry throughout the entire innovation process.

Its innovation strategy aims to stimulate the pursuit of knowledge and reinforce the competitiveness of the companies within its territory – with a particular focus on the small and medium-sized enterprises. The idea is to pool the expertise of universities and research institutes with the practical competence of the private sector to expedite the development of marketable solutions.

Structural indicators	Year	Value
Gross domestic product (nominal, in millions of euros)	2014	127,614
Gross domestic product (nominal, in euros per capita)	2014	31,880
Growth rate of gross domestic product (nominal, mean change compared to previous year, in %)	2009–2014	3.30
Share of manufacturing sector of gross value added (in %)	2014	25.2
Export ratio in the manufacturing sector (in %)	2014	53.07

Input innovation indicators	Year	Value
R&D expenditure as a percentage of GDP	2013	2.14
R&D expenditure in the government sector and private non-profit institutions as a percentage of GDP	2013	0.17
R&D expenditure in the higher education sector as a percentage of GDP	2013	0.43
R&D expenditure in the economic sector as a percentage of GDP	2013	1.55

Output innovation indicators	Year	Value
Scientific publications per million inhabitants	2013	983
Patent applications per million inhabitants	2013	259

In developing its science landscape, the *Land* sets great store by coordinated measures in targeting its emphases and growth cores. For example, it was successful in attracting the best researchers in key areas, in establishing and expanding research infrastructure and in securing its universities' foothold in the academic arena by supporting their profile development process.

Numerous instruments and funding programmes underpin the cooperation between science and industry, thereby strengthening cutting-edge research, applied research, knowledge and technology transfer, high-tech start-ups, clusters and networks; in turn, these attract more and more young scientists to the region. By implementing adequately financed, long-term initiatives, the *Land* has joined forces with its universities and non-university research facilities to accelerate developments that raise its profile on both the national and international level, at the same time guaranteeing the scientific institutions a high degree of financial security.

The *Land* is thus creating optimal framework conditions to attract the élite and remain competitive on the global level.

The *Rhineland-Palatinate Innovation Strategy (RIS)* brings together the strategic approaches taken by the *Land* in pursuit of its innovation policy, to form one holistic approach.

In terms of smart specialisation, the *RIS* primarily addresses the areas of potential with the greatest regional competitive advantages and unique selling points.

Saarland

The key focus fields of Saarland's current research and innovation policy are the result of renewing its Regional Innovation Strategy for Smart Specialisation.

As a central element of the *Land*'s further development and organisation, the I*nnovation and Technology Strategy Saarland (2016–2023)* plays a major role in the evolution of innovation potential in new and traditional sectors. Along with other approaches, like university development planning, the new Innovation Strategy is being combined to form an overarching concept for the future of Saarland.

Structural indicators	Year	Value
Gross domestic product (nominal, in millions of euros)	2014	33,548
Gross domestic product (nominal, in euros per capita)	2014	33,891
Growth rate of gross domestic product (nominal, mean change compared to previous year, in %)	2009–2014	3.25
Share of manufacturing sector of gross value added (in %)	2014	26.0
Export ratio in the manufacturing sector (in %)	2014	46.57

Input innovation indicators	Year	Value
R&D expenditure as a percentage of GDP	2013	1.42
R&D expenditure in the government sector and private non-profit institutions as a percentage of GDP	2013	0.41
R&D expenditure in the higher education sector as a percentage of GDP	2013	0.46
R&D expenditure in the economic sector as a percentage of GDP	2013	0.55

Output innovation indicators	Year	Value
Scientific publications per million inhabitants	2013	908
Patent applications per million inhabitants	2013	254

Besides boosting and enhancing research at the universities and non-university research institutes, the Strategy focuses on

- stimulating private R&D and other innovative activities
- increasing real net output ratios
- generating cross-innovations in the region's key sectors of ICT, Automotive/Manufacturing and Life Sciences and Materials.

The main priorities in these fields include Industry 4.0 and the digitalisation of production, computer science (e.g. IT security, reliability of IT systems, visual computing, Semantic Web), intelligent sensor and transport systems, production/manufacturing technology and assembly processes, pharmacy and pharmaceutical services, medical technology (e.g. laboratory technology, cryobanking, neuroscience), personalised medicine, healthcare and Ambient Assisted Living, materials science and material technology.

In recent years, Saarland has gone to great lengths to strengthen the universities in line with the requirements of highly competitive research, excellent teaching and the structural change in the region. The new university development plan outlined fundamental decisions for the development of the higher education system until 2020.

Furthermore, considerable non-university research potential has come to the fore in Saarland over the past 20 years. Having evolved from the universities' key areas of focus, the research institutes still maintain close ties with them.

Free State of Saxony

The primary research and innovation policy objective of the government of Saxony is a flourishing science and research landscape. Saxony is committed to increasing research efficiency by means of networking, greater flexibility and autonomy. Thus, Saxony's research policy places enormous emphasis on enhancing the performance of the existing research institutes.

Structural indicators	Year	Value
Gross domestic product (nominal, in millions of euros)	2014	108,653
Gross domestic product (nominal, in euros per capita)	2014	26,822
Growth rate of gross domestic product (nominal, mean change compared to previous year, in %)	2009–2014	3.57
Share of manufacturing sector of gross value added (in %)	2014	18.5
Export ratio in the manufacturing sector (in %)	2014	37.50

Input innovation indicators	Year	Value
R&D expenditure as a percentage of GDP	2013	2.74
R&D expenditure in the government sector and private non-profit institutions as a percentage of GDP	2013	0.81
R&D expenditure in the higher education sector as a percentage of GDP	2013	0.82
R&D expenditure in the economic sector as a percentage of GDP	2013	1.11

Output innovation indicators	Year	Value
Scientific publications per million inhabitants	2013	1,967
Patent applications per million inhabitants	2013	239

The continued networking between universities and research institutes, as well as with industry, is crucial in achieving this goal. This is the only way they can retain their foothold in the global competition and succeed in attracting EU grants, the importance of which is increasing steadily.

The government is making every effort to shape its innovation and technology policy in such a way as to improve the competitiveness of Saxony's companies, particularly small and medium-sized enterprises. The central goal of technology funding is to facilitate R&D projects that would otherwise not be possible. It aims to give companies financial flexibility, granting them the necessary leeway to entrust young scientists and highly qualified personnel with additional R&D and innovation tasks.

The existing barriers to acquiring technology transfer expertise are to be removed. Companies and research institutes must be in a position to participate on an even greater scale in national programmes and networks, as well as in European technology partnerships.

In order to prepare the ground for commercialisation, the market launch of innovative products is encouraged. Other goals include supporting start-ups, particularly science start-ups, and strengthening technology-oriented networks and clusters.

The government regards key technologies as key catalysts for innovations.

Pilot lines have been set up to focus the diverse interrelationships between research and development on the one hand and industrial production on the other.

Saxony-Anhalt

In 2005, Saxony-Anhalt restructured its research by launching the initiative on *Networks of Scientific Excellence.* Research funding mechanisms were focused on research priorities, cooperation networks and location profiles over and above the regular university budget; the universities were encouraged to align their development concepts accordingly. This approach leads to scientific excellence and thus has a positive impact on the partnership between science and industry.

Structural indicators	Year	Value
Gross domestic product (nominal, in millions of euros)	2014	55,617
Gross domestic product (nominal, in euros per capita)	2014	24,828
Growth rate of gross domestic product (nominal, mean change compared to previous year, in %)	2009–2014	2.73
Share of manufacturing sector of gross value added (in %)	2014	19.9
Export ratio in the manufacturing sector (in %)	2014	27.59

Input innovation indicators	Year	Value
R&D expenditure as a percentage of GDP	2013	1.43
R&D expenditure in the government sector and private non-profit institutions as a percentage of GDP	2013	0.50
R&D expenditure in the higher education sector as a percentage of GDP	2013	0.51
R&D expenditure in the economic sector as a percentage of GDP	2013	0.42

Output innovation indicators	Year	Value
Scientific publications per million inhabitants	2013	1,298
Patent applications per million inhabitants	2013	102

In order to ensure continuity, the *Research and Innovation* framework agreement between the government and the universities was renewed for a further five years from 2011; it aims to consolidate the initial development towards strengthening research priorities and networks.

In the *Regional Innovation Strategy 2014–2020 (RIS),* which highlights the common goals and the course of strategic action in the region, Saxony-Anhalt underlined its commitment to increasing its market-oriented research and development funding, to focusing the funding on identified scientific and economic emphases in lead markets, and also to stepping up its activities to attract businesses with internal R&D activities, encouraging them to settle in the region.

As a result, the *RIS* outlines all established core competencies of the research sector and industry.

The main objective is to place the research and development work conducted in universities and business-related non-university research facilities even more effectively at the disposal of the private sector and to intensify knowledge and technology transfer across the board in the interests of sustainable growth.

Most activities focus on the five lead markets that were defined as being particularly significant for Saxony-Anhalt's economy – energy, machines and plant construction/resource efficiency, health and medical science, mobility and logistics, chemistry and biotechnology and, lastly, food and agriculture – which, in turn, display pronounced future potential and the advantages of specialisation necessary for further expansion.

Schleswig-Holstein

The research and innovation policy of the government of Schleswig-Holstein follows from the understanding that the outstanding achievements of its scientific institutes are based on a stable research spectrum on a broad scale. This is complemented by targeted measures that focus on areas of high potential and open up sustainable courses of action for industry and society.

Structural indicators	Year	Value
Gross domestic product (nominal, in millions of euros)	2014	84,021
Gross domestic product (nominal, in euros per capita)	2014	29,759
Growth rate of gross domestic product (nominal, mean change compared to previous year, in %)	2009–2014	3.04
Share of manufacturing sector of gross value added (in %)	2014	15.0
Export ratio in the manufacturing sector (in %)	2014	40.59

Input innovation indicators	Year	Value
R&D expenditure as a percentage of GDP	2013	1.47
R&D expenditure in the government sector and private non-profit institutions as a percentage of GDP	2013	0.37
R&D expenditure in the higher education sector as a percentage of GDP	2013	0.35
R&D expenditure in the economic sector as a percentage of GDP	2013	0.74

Output innovation indicators	Year	Value
Scientific publications per million inhabitants	2013	810
Patent applications per million inhabitants	2013	165

Schleswig-Holstein's universities and non-university research facilities are not just part of an excellent network within the *Land*, but also have close links with numerous national and international partners, for example, in the clusters of excellence for medicine and marine research.

Schleswig-Holstein accounts for a considerable share of Germany's scientific cooperation with the Scandinavian countries, particularly with the neighbouring country, Denmark.

The government's technology and innovation policy serves to improve its capacity for innovation as well as the technological infrastructure and technology transfer – particularly with regard to technology-oriented small and medium-sized enterprises.

The government primarily fosters new impulses in its own business programme, *Landesprogramm Wirtschaft*. Clear emphasis is placed on extending the infrastructure for research and innovation to include future growth areas and on facilitating the transfer of scientific knowledge into commercial applications.

The cluster policy is based on the *Regional Innovation Strategy Schleswig-Holstein.* Five priority areas have been identified, which are regarded as particularly innovative growth engines for the *Land*. These are maritime industry, life sciences, renewable energy, the food industry and information technologies, telecommunications and media.

Financed with funds provided by the *Land* and the *European Regional Development Fund (ERDF),* the programme is a superordinate funding instrument and thus plays a key role in implementing the *Land*'s Innovation Strategy (as an element of priority axis 1 'Strengthening regional innovation potential').

Free State of Thuringia

The government's research and innovation policy emphasises the coherent development of Thuringia as a centre of research, science and technology. On the one hand, the necessary strategic objectives and priorities are determined by Thuringia's research strategy, which was conceived in close collaboration with the universities and research institutes in 2007. Updated on an ongoing basis ever since, the strategy outlines the primary fields of action and research priorities in Thuringia.

Structural indicators	Year	Value
Gross domestic product (nominal, in millions of euros)	2014	54,328
Gross domestic product (nominal, in euros per capita)	2014	25,166
Growth rate of gross domestic product (nominal, mean change compared to previous year, in %)	2009–2014	3.63
Share of manufacturing sector of gross value added (in %)	2014	22.4
Export ratio in the manufacturing sector (in %)	2014	30.62

Input innovation indicators	Year	Value
R&D expenditure as a percentage of GDP	2013	2.20
R&D expenditure in the government sector and private non-profit institutions as a percentage of GDP	2013	0.52
R&D expenditure in the higher education sector as a percentage of GDP	2013	0.64
R&D expenditure in the economic sector as a percentage of GDP	2013	1.04

Output innovation indicators	Year	Value
Scientific publications per million inhabitants	2013	1,565
Patent applications per million inhabitants	2013	248

On the other hand, the *Higher Education Strategy Thuringia 2020,* which came into force in 2014, defines the orientation of its universities in national and international competition.

Also launched in 2014 was the *Regional Research and Innovation Strategy for Smart Specialisation for Thuringia (RIS3 Thuringia),* which sets the course for Thuringia's research and innovation policy until 2020. It focuses on five central fields of action, in which Thuringia currently boasts advantages of specialisation or has the potential to develop them.

The objective in the area of ‚Innovation' is to reinforce the *Mittelstand* in the innovation system, while 'Investment' addresses the promotion of corporate culture and start-ups. The field of action 'Infrastructure for innovation processes' aims to increase the potential of the research and science sectors in Thuringia, develop existing transfer structures and provide needs-based services via clusters and networks, particularly for SMEs.

The goals of the 'Internationalisation' field of action are to enhance international cooperation in education and research, and to help Thuringian companies make greater use of the opportunities on international markets, in other words, to be proactive in developing international value chains.

Finally, 'Integration of all talents' is aimed at strengthening the education system as a whole, securing the skilled labour base both now and in the future and at ensuring equal opportunities for men and women.

Tables

(The table numbers used in the long version of the 2016 Federal Report on Research and Innovation are given in brackets)

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

Performing sectors[1, 2]	Millions of euros					
	1981	1991	1995	2000	2005	2008
Business enterprise sector[3]						
Funding sectors						
Business enterprise sector	10 945	22 845	23 470	32 333	35 585	42 211
Government sector	2 260	2 640	2 742	2 448	1 723	2 073
Private non-profit sector	30	76	20	71	66	79
Abroad	159	685	584	748	1 278	1 710
Total	**13 394**	**26 246**	**26 817**	**35 600**	**38 651**	**46 073**
Government and private non-profit sector[4]						
Funding sectors						
Business enterprise sector	35	71	214	151	777	865
Government sector	2 601	5 214	5 890	6 444	6 524	7 847
Private non-profit sector	49	120	83	137	98	128
Abroad	27	53	79	141	469	507
Total	**2 712**	**5 457**	**6 266**	**6 873**	**7 867**	**9 346**
Higher education sector						
Funding sectors						
Business enterprise sector	59	433	673	986	1 363	1 674
Government sector	3 255	5 713	6 620	7 169	7 707	9 048
Private non-profit sector	–	–	–	–	–	–
Abroad	.	.	78	198	342	453
Total	**3 313**	**6 145**	**7 371**	**8 352**	**9 412**	**11 175**
Gross domestic expenditure on R&D						
Funding sectors						
Business enterprise sector	11 039	23 348	24 357	33 470	37 725	44 750
Government sector	8 116	13 567	15 252	16 061	15 953	18 967
Private non-profit sector	78	196	104	208	164	207
Abroad	186	738	741	1 086	2 089	2 670
Total	**19 420**	**37 848**	**40 454**	**50 825**	**55 930**	**66 594**
GERD in % of GDP[5]	2.43	2.47	2.19	2.40	2.43	2.60

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, the data up to 1991 are only partly comparable with data from later publications.
2) Figures for even years are estimates.
3) Companies and institutions for co-operative research; intramural R&D expenditures (OECD concept) of business enterprises; until 1990, including non-apportionable government funding; as of 1992, government R&D funding for business enterprises pursuant to figures of funding institutions -- Federal Government and Länder. Until 2010 the funding source data of the Stifterverband Wissenschaftsstatistik, which have been obtained from R&D-performing reporting units, differ from this, since the performing reporting units are not always able to clearly identify the original funding source.
4) Non-university institutions. Government: federal, Länder and municipal (research) institutions; as of 1981, Federal Government institutions; as of 1985, Länder institutions with their R&D shares only. As of 1992, modified survey procedure; in 1995, the reporting scope was expanded; in 2005, modified calculation method.
5) Revision February 2015.

Source: Stifterverband Wissenschaftsstatistik; Federal Statistical Office; Federal Ministry of Education and Research
BMBF's Data Portal: www.datenportal.bmbf.de/portal/en/Table-1.1.1.html

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

Performing sectors[1, 2]	Millions of euros				
	2009	2010	2011	2012	2013
Business enterprise sector[3]					
Funding sector					
Business enterprise sector	41 662	43 183	46 659	49 137	48 958
Government sector	2 022	2 096	2 221	2 339	1 800
Private non-profit sector	39	40	133	140	105
Abroad	1 553	1 610	2 064	2 174	2 703
Total	**45 275**	**46 929**	**51 077**	**53 790**	**53 566**
Government and private non-profit sector[4]					
Funding sectors					
Business enterprise sector	976	927	1 019	1 174	1 222
Government sector	8 302	8 805	9 286	9 421	9 864
Private non-profit sector	137	124	131	168	141
Abroad	517	498	539	579	635
Total	**9 932**	**10 354**	**10 974**	**11 341**	**11 862**
Higher education sector					
Funding sectors					
Business enterprise sector	1 690	1 763	1 884	1 961	1 996
Government sector	9 673	10 360	11 078	11 351	11 534
Private non-profit sector	–	–	–	–	–
Abroad	508	609	555	668	771
Total	**11 871**	**12 731**	**13 518**	**13 980**	**14 302**
Gross domestic expenditure on R&D					
Funding sectors					
Business enterprise sector	44 327	45 873	49 562	52 272	52 176
Government sector	19 997	21 260	22 585	23 111	23 198
Private non-profit sector	176	164	263	307	246
Abroad	2 578	2 716	3 158	3 420	4 110
Total	**67 078**	**70 014**	**75 569**	**79 110**	**79 730**
GERD in % of GDP[5]	2.73	2.72	2.80	2.88	2.84

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, the data up to 1991 are only partly comparable with data from later publications.
2) Figures for even years are estimates.
3) Companies and institutions for co-operative research; intramural R&D expenditures (OECD concept) of business enterprises; until 1990, including non-apportionable government funding; as of 1992, government R&D funding for business enterprises pursuant to figures of funding institutions -- Federal Government and Länder. Until 2010 the funding source data of the Stifterverband Wissenschaftsstatistik, which have been obtained from R&D-performing reporting units, differ from this, since the performing reporting units are not always able to clearly identify the original funding source.
4) Non-university institutions. Government: federal, Länder and municipal (research) institutions; as of 1981, Federal Government institutions; as of 1985, Länder institutions with their R&D shares only. As of 1992, modified survey procedure; in 1995, the reporting scope was expanded; in 2005, modified calculation method.
5) Revision February 2015.

Source: Stifterverband Wissenschaftsstatistik; Federal Statistical Office; Federal Ministry of Education and Research
BMBF's Data Portal: www.datenportal.bmbf.de/portal/en/Table-1.1.1.html

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

Year	Financed by				Total R&D expenditure
	Territorial authorities[2]		Business enterprises[4]	Private non-profit institutions[5]	
	Millions of euros	in % of the overall government budget[3]	Millions of euros		Millions of euros
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**
2003	17 136	2.8	38 060	176	**55 372**
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	**70 053**
2011	23 446	3.0	51 448	264	**75 158**
2012[6]	23 567	3.0	54 109	307	**77 983**
2013	24 412	3.1	54 569	246	**79 227**

1) Data from surveys for the relevant domestic funding sectors. Until 1990, the former Federal Republic of Germany; as of 1991, all of Germany. Discrepancies from the figures in Table 1 result from use of different surveys (Table 2: survey of funding sectors; Table 1: survey of performing sectors).
2) Federal Government and the Länder. Funding for Federal research institutions, as of 1981; funding for Länder research institutions, as of 1983, but only shares for R&D. Figures revised in comparison to figures from earlier publications, as of 1991.
3) Data from surveys of the Stifterverband Wissenschaftsstatistik; from 1981 to 1989, figures include data for the R&D-staff-cost subsidy programme (German Federation of Industrial Co-operative 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) have received from business enterprises. Due to revision of the calculation method, as of 1991, figures are not comparable to data from earlier publications.
4) Financed from own funds. Some figures are estimates.
5) Net expenditure without social insurance. As of 1998, excluding hospitals and university clinics with commercial accounting procedures."
6) Differences from previously published documents due to subsequent changes in the allocation to R&D.

Source: Stifterverband Wissenschaftsstatistik; Federal Statistical Office; Federal Ministry of Education and Research
BMBF's Data Portal: www.datenportal.bmbf.de/portal/en/Table-1.1.2.html

Tab. 3 Regional distribution of R&D expenditure in the Federal Republic of Germany[1]

Federal *Land*	Performing of R&D									
	2000		2005		2010		2012		2013	
	Millions of euros	Share (%)	Millions of euros	Share (%)	Millions of euros	Share (%)	Millions of euros	Share (%)	Millions of euros	Share (%)
Baden-Wuerttemberg	11 616	22.9	13 697	24.5	17 049	24.4	20 335	25.7	20 204	25.4
Bavaria	10 126	19.9	11 485	20.6	13 622	19.5	15 306	19.4	15 942	20.0
Berlin	2 911	5.7	3 044	5.5	3 541	5.1	3 774	4.8	4 021	5.0
Brandenburg	641	1.3	573	1.0	796	1.1	975	1.2	937	1.2
Bremen	472	0.9	538	1.0	705	1.0	755	1.0	793	1.0
Hamburg	1 310	2.6	1 554	2.8	1 972	2.8	2 198	2.8	2 318	2.9
Hesse	4 769	9.4	5 218	9.3	6 775	9.7	7 174	9.1	6 865	8.6
Mecklenburg-Western Pomerania	307	0.6	449	0.8	689	1.0	770	1.0	683	0.9
Lower Saxony	4 211	8.3	4 379	7.8	5 723	8.2	6 746	8.5	7 009	8.8
North Rhine-Westphalia	8 289	16.3	8 762	15.7	11 004	15.7	12 189	15.4	11 761	14.8
Rhineland-Palatinate	2 076	4.1	1 676	3.0	2 303	3.3	2 465	3.1	2 655	3.3
Saarland	246	0.5	293	0.5	391	0.6	470	0.6	462	0.6
Saxony	1 829	3.6	2 010	3.6	2 642	3.8	2 838	3.6	2 871	3.6
Saxony-Anhalt	596	1.2	558	1.0	720	1.0	758	1.0	780	1.0
Schleswig-Holstein	693	1.4	775	1.4	961	1.4	1 140	1.4	1 198	1.5
Thuringia	685	1.3	811	1.5	1 041	1.5	1 130	1.4	1 158	1.5
***Länder*, total**	**50 777**	**100.0**	**55 822**	**100.0**	**69 931**	**100.0**	**79 023**	**100.0**	**79 656**	100.0
Of which: Eastern German *Länder* and Berlin	6 968	13.7	7 445	13.3	9 427	13.5	10 245	13.0	10 450	13.1
German institutions based abroad	48	.	57	.	82	.	89	.	83	.
Total[2]	**50 825**		**55 879**		**70 014**		**79 110**		**79 730**	.

1) Estimated in some cases.
2) Including non-apportionable government funding.
Source: Stifterverband Wissenschaftsstatistik; Federal Statistical Office; Federal Ministry of Education and Research
BMBF's Data Portal: www.datenportal.bmbf.de/portal/en/Table-1.1.3.html

Tab. 4 1/3 Federal government expenditure on science, research and development, by departments

Government department[1]	Millions of euros							
	ACTUAL							
	1995		2000		2005		2009	
	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[2]	228.6	63.0	233.0	69.7	283.3	91.5	300.3	78.5
Federal Foreign Office	181.3	122.9	177.8	121.7	179.3	123.2	250.2	182.4
Federal Ministry of the Interior	86.4	52.4	68.4	39.6	90.1	49.8	78.8	57.1
Federal Ministry of Justice and Consumer Protection	1.3	1.3	1.5	1.5	1.9	1.9	2.5	2.5
Federal Ministry of Finance	0.0	0.0	3.4	3.4	1.4	1.4	1.6	1.6
Federal Ministry for Economic Affairs and Energy[3]	2 028.4	1 875.4	1 977.5	1 834.7	2 009.6	1 855.1	2 698.6	2 498.8
Federal Ministry of Labour and Social Affairs	49.9	21.1	59.0	27.9	70.6	39.5	66.1	29.6
Federal Ministry of Food and Agriculture	308.6	232.6	313.5	217.0	310.2	217.1	546.2	469.5
Federal Ministry of Defence	1 556.0	1 469.5	1 305.6	1 192.0	1 247.6	1 087.5	1 286.5	1 121.1
Federal Ministry for Family Affairs, Senior Citizens, Women and Youth	19.9	19.9	16.7	16.7	20.9	20.9	24.1	24.1
Federal Ministry of Health	168.6	94.7	246.0	91.5	228.7	99.6	267.8	129.4
Federal Ministry of Transport and Digital Infrastructure	186.3	90.4	200.7	88.8	228.9	109.6	274.3	143.0
Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety	268.3	144.5	245.7	127.9	268.9	114.1	320.8	148.9
Federal Ministry of Education and Research[4]	5 192.0	4 107.1	5 671.3	4 552.6	6 113.5	5 125.8	8 222.9	6 974.2
Federal Ministry for Economic Cooperation and Development	27.4	25.4	28.2	25.9	36.9	35.1	35.7	33.2
General Fiscal Administration[5]	79.5	79.5	68.3	68.3	56.2	56.2	85.4	78.8
Total expenditure	**10 382.5**	**8 399.7**	**10 616.6**	**8 479.2**	**11 148.2**	**9 028.3**	**14 461.8**	**11 972.5**

1) In cases of reallocating tasks, expenditures assignments have been implemented retroactively, for purposes of comparison.
2) Including expenditures of the Federal Government's Commissioner for Cultural and Media Affairs.
3) As of 2012, differences from previously published documents due to subsequent changes in the allocation to R&D.
4) Planned expenditure including the share for the total reduction in expenditure for science, R&D (2015: 404.2 millions of euros, 2016: 260.2 millions of euros).
5) Including payments for universities, and for projects at industry-sector research institutions, in connection with German reunification (1991 and 1995). As of 2008, abolition of payments to the Volkswagen Foundation. 2009 to 2011, including investment and redemption fund excluding allocations to the Länder (economic stimulus package – Konjunkturpaket II). As from 2011, including „Energy and climate fund". As from 2012, research funding in the area of electro mobility is financed by the „Energy and climate fund". As of 2016, including future investments.

Source: Federal Ministry of Education and Research
BMBF's Data Portal: www.datenportal.bmbf.de/portal/en/Table-1.1.4.html

Tab. 4 2/3 Federal government expenditure on science, research and development, by departments

Government department[1]	Millions of euros					
	ACTUAL					
	2012		2013		2014	
	Total	Of which, R&D	Total	Of which, R&D	Total	Of which, R&D
Federal Chancellor and Federal Chancellery[2]	303.7	89.7	307.9	96.4	306.9	95.6
Federal Foreign Office	263.6	171.7	277.4	172.3	268.0	167.2
Federal Ministry of the Interior	59.6	35.0	61.0	36.5	63.7	40.3
Federal Ministry of Justice and Consumer Protection	2.6	2.6	3.2	3.2	5.4	4.7
Federal Ministry of Finance	1.0	1.0	1.4	1.4	1.4	1.4
Federal Ministry for Economic Affairs and Energy[3]	3 079.9	2 842.5	3 194.8	2 966.4	3 178.0	2 935.2
Federal Ministry of Labour and Social Affairs	84.8	36.9	87.3	42.2	88.2	40.9
Federal Ministry of Food and Agriculture	640.8	545.9	628.6	537.8	631.9	540.6
Federal Ministry of Defence	1 100.4	937.2	1 292.1	1 113.8	1 086.6	913.2
Federal Ministry for Family Affairs, Senior Citizens, Women and Youth	23.5	23.2	25.0	24.3	26.3	26.2
Federal Ministry of Health	300.1	132.1	315.4	133.5	370.9	175.0
Federal Ministry of Transport and Digital Infrastructure	326.9	190.8	315.0	187.2	319.1	190.2
Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety	362.5	153.6	355.8	130.4	359.2	152.4
Federal Ministry of Education and Research[4]	10 553.8	8 036.4	11 584.0	8 340.8	11 724.6	8 458.7
Federal Ministry for Economic Cooperation and Development	38.3	36.7	41.6	39.9	42.1	40.4
General Fiscal Administration[5]	185.0	185.0	448.8	448.8	406.9	406.8
Total expenditure	**17 326.6**	**13 420.2**	**18 939.4**	**14 275.0**	**18 879.1**	**14 188.7**

1) In cases of reallocating tasks, expenditures assignments have been implemented retroactively, for purposes of comparison.
2) Including expenditures of the Federal Government's Commissioner for Cultural and Media Affairs.
3) As of 2012, differences from previously published documents due to subsequent changes in the allocation to R&D.
4) Planned expenditure including the share for the total reduction in expenditure for science, R&D (2015: 404.2 millions of euros, 2016: 260.2 millions of euros).
5) Including payments for universities, and for projects at industry-sector research institutions, in connection with German reunification (1991 and 1995). As of 2008, abolition of payments to the Volkswagen Foundation. 2009 to 2011, including investment and redemption fund excluding allocations to the Länder (economic stimulus package – Konjunkturpaket II). As from 2011, including „Energy and climate fund". As from 2012, research funding in the area of electro mobility is financed by the „Energy and climate fund". As of 2016, including future investments.

Source: Federal Ministry of Education and Research
BMBF's Data Portal: www.datenportal.bmbf.de/portal/en/Table-1.1.4.html

Tab. 4 3/3 Federal government expenditure on science, research and development, by departments

Government department[1]	Millions of euros			
	TARGET			
	2015		2016	
	Total	Of which, R&D	Total	Of which, R&D
Federal Chancellor and Federal Chancellery[2]	342.6	103.9	386.7	130.1
Federal Foreign Office	288.7	181.7	295.7	79.0
Federal Ministry of the Interior	67.5	43.4	78.6	54.1
Federal Ministry of Justice and Consumer Protection	6.3	6.3	6.4	6.4
Federal Ministry of Finance	1.9	1.9	2.5	2.5
Federal Ministry for Economic Affairs and Energy[3]	3 364.2	3 136.4	3 609.2	3 372.9
Federal Ministry of Labour and Social Affairs	96.5	45.3	98.3	45.6
Federal Ministry of Food and Agriculture	705.8	590.5	771.4	652.2
Federal Ministry of Defence	1 030.3	856.3	980.3	802.6
Federal Ministry for Family Affairs, Senior Citizens, Women and Youth	28.4	28.4	27.3	27.3
Federal Ministry of Health	365.2	170.4	367.0	184.0
Federal Ministry of Transport and Digital Infrastructure	376.7	219.3	437.0	285.6
Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety	413.1	188.0	436.6	203.6
Federal Ministry of Education and Research[4]	12 188.8	8 861.1	13 167.4	9 467.8
Federal Ministry for Economic Cooperation and Development	50.6	48.6	50.2	48.2
General Fiscal Administration[5]	419.1	419.1	469.9	439.9
Total expenditure	**19 745.7**	**14 900.5**	**21 184.7**	**15 801.9**

1) In cases of reallocating tasks, expenditures assignments have been implemented retroactively, for purposes of comparison.
2) Including expenditures of the Federal Government's Commissioner for Cultural and Media Affairs.
3) As of 2012, differences from previously published documents due to subsequent changes in the allocation to R&D.
4) Planned expenditure including the share for the total reduction in expenditure for science, R&D (2015: 404.2 millions of euros, 2016: 260.2 millions of euros).
5) Including payments for universities, and for projects at industry-sector research institutions, in connection with German reunification (1991 and 1995). As of 2008, abolition of payments to the Volkswagen Foundation. 2009 to 2011, including investment and redemption fund excluding allocations to the Länder (economic stimulus package – Konjunkturpaket II). As from 2011, including „Energy and climate fund". As from 2012, research funding in the area of electro mobility is financed by the „Energy and climate fund". As of 2016, including future investments.

Source: Federal Ministry of Education and Research
BMBF's Data Portal: www.datenportal.bmbf.de/portal/en/Table-1.1.4.html

Tab. 5 1/6 Federal government expenditure on science, research and development, by funding areas and funding priorities[1, 2]

Funding area / Funding priority		Millions of euros			
		ACTUAL			
		2013		2014	
		Total	Of which, R&D[4]	Total	Of which, R&D[4]
A	**Health research and health industry**	**2 095.1**	**1 854.9**	**2 209.3**	**1 956.1**
AA	Health research and health industry	2 027.5	1 837.3	2 141.8	1 937.2
AB	Radiation protection	67.6	17.6	67.5	18.9
B	**Bioeconomy**	**274.3**	**274.2**	**264.8**	**264.7**
C	**Civil security research**	**99.5**	**94.0**	**95.1**	**88.6**
D	**Nutrition, agriculture and consumer protection**	**721.1**	**624.4**	**736.0**	**636.7**
DA	Nutrition	28.9	18.5	30.3	19.6
DB	Sustainable agricultural economy and rural areas	450.8	414.4	471.5	438.8
DC	Health and economic consumer protection	241.4	191.4	234.2	178.2
E	**Energy research and energy technologies**	**1 439.6**	**1 148.0**	**1 500.2**	**1 172.0**
EA	Efficient energy conversion	503.1	501.5	513.9	512.3
EB	Renewable energy	366.4	364.8	372.4	369.2
EC	Nuclear safety and waste management	218.7	125.4	217.4	124.1
ED	Decommissioning of nuclear facilities	211.0	16.6	249.4	20.0
EF	Fusion research	140.4	139.7	147.1	146.4
F	**Climate, environment, sustainability**	**1 359.9**	**1 145.9**	**1 353.9**	**1 154.8**
FA	Climate, climate protection; global change	266.1	263.7	254.0	252.2
FB	Coast, marine and polar research, geosciences	444.6	395.5	455.1	409.4
FC	Environmental and sustainability research	338.2	242.1	310.1	222.2
FD	Ecology, nature conservation, sustainable use	311.1	244.6	334.7	271.1
G	**Information and communication technologies**	**798.9**	**766.2**	**758.3**	**726.9**
GA	Software systems; knowledge technologies	194.9	194.2	195.4	194.7
GB	Communication technologies and services	104.2	102.5	98.7	97.1
GC	Electronic, electronic systems	291.6	288.6	267.2	264.2
GD	Microsystems technology	115.5	114.7	100.9	100.1
GE	Multimedia - development of convergent information and communication technology	92.7	66.2	96.1	70.8

1) According to the Federal Government's planning system 2009. Expenditure was implemented in accordance with the Federal Government's planning system 2009. Expenditure of non-university research organisations are distributed among funding areas and funding priorities.
2) Including "Energy and climate fund". As from 2012, research funding in the area of electro mobility is financed by the "Energy and climate fund". As of 2016, including future investments.
3) Distribution among funding areas and funding priorities partly estimated or extrapolated.
4) As of 2012, differences from previously published documents due to subsequent changes in the allocation to R&D.
5) Including universities of the federal armed forces and the Federal University of Applied Administrative Sciences.
6) ACTUAL figures are needed to break down the BMBF's total expenditure reduction by funding areas and funding priorities.
7) Discrepancies with regard to earlier publications are due to subsequent changes of assignments to funding areas and funding priorities.

Source: Federal Ministry of Education and Research
BMBF's Data Portal: www.datenportal.bmbf.de/portal/en/Table-1.1.5.html

Tab. 5 2/6 Federal government expenditure on science, research and development, by funding areas and funding priorities[1, 2]

Funding area / Funding priority		Millions of euros			
		ACTUAL			
		2013		2014	
		Total	Of which, R&D[4]	Total	Of which, R&D[4]
H	**Vehicle and traffic technologies including maritime technologies**	**369.8**	**290.4**	**370.0**	**287.0**
HA	Vehicle and traffic technologies	318.4	247.6	317.9	244.2
HB	Maritime technologies	51.4	42.8	52.2	42.8
I	**Aerospace**	**1 394.0**	**1 391.7**	**1 407.3**	**1 404.7**
IA	Aviation	235.7	235.4	237.1	236.5
IB	National space research and space technology	508.9	508.2	524.3	523.6
IC	European Space Agency (ESA)	649.3	648.1	645.9	644.6
J	**Research and development to improve working conditions and in the service sector**	**125.0**	**73.8**	**128.3**	**74.9**
JA	Research to improve working conditions	96.9	50.1	103.0	54.0
JB	Research in the service sector	28.1	23.8	25.3	21.0
K	**Nanotechnologies and materials technologies**	**542.2**	**522.7**	**537.4**	**511.8**
KA	Nanotechnologies	185.5	179.9	183.6	178.9
KB	Materials technologies	356.7	342.7	353.9	332.9
L	**Optical technologies**	**186.2**	**181.7**	**169.9**	**165.4**
M	**Production technologies**	**212.5**	**210.2**	**222.8**	**220.5**
N	**Regional planning and urban development; construction research**	**82.5**	**80.5**	**93.7**	**91.1**
NA	Regional planning, urban development, housing	19.0	18.8	23.4	23.4
NB	Construction research	63.5	61.7	70.3	67.7
O	**Innovations in education**	**768.8**	**460.0**	**784.5**	**483.2**
OA	Educational reporting, international assessments	439.1	251.1	432.3	247.9
OB	Educational research	316.4	195.6	341.6	224.7
OC	New media in the education	13.3	13.3	10.6	10.6
P	**Humanities; economics and social sciences**	**1 167.4**	**917.5**	**1 173.7**	**923.7**
PA	Humanities research	728.0	502.7	740.0	512.2
PB	Social scientific research	224.6	202.3	230.6	210.6
PC	Economic and finance scientific research	78.3	78.3	81.4	81.4
PD	Infrastructures	136.5	134.2	121.8	119.5

1) According to the Federal Government's planning system 2009. Expenditure was implemented in accordance with the Federal Government's planning system 2009. Expenditure of non-university research organisations are distributed among funding areas and funding priorities.
2) Including "Energy and climate fund". As from 2012, research funding in the area of electro mobility is financed by the "Energy and climate fund". As of 2016, including future investments.
3) Distribution among funding areas and funding priorities partly estimated or extrapolated.
4) As of 2012, differences from previously published documents due to subsequent changes in the allocation to R&D.
5) Including universities of the federal armed forces and the Federal University of Applied Administrative Sciences.
6) ACTUAL figures are needed to break down the BMBF's total expenditure reduction by funding areas and funding priorities.
7) Discrepancies with regard to earlier publications are due to subsequent changes of assignments to funding areas and funding priorities.

Source: Federal Ministry of Education and Research
BMBF's Data Portal: www.datenportal.bmbf.de/portal/en/Table-1.1.5.html

Tab. 5 3/6 Federal government expenditure on science, research and development, by funding areas and funding priorities[1, 2]

Funding area / Funding priority		Millions of euros			
		ACTUAL			
		2013		2014	
		Total	Of which, R&D[4]	Total	Of which, R&D[4]
Q	**Innovation funding for SMEs**	**1 088.0**	**1 066.8**	**1 032.2**	**1 012.1**
QA	Start-up support	68.2	68.2	60.2	60.2
QB	Technology support for SMEs	616.3	612.5	594.1	590.2
QC	Technology transfer and innovation consulting	206.4	189.5	174.5	158.8
QD	Research infrastructure SMEs	197.1	196.7	203.3	202.9
R	**Innovation-relevant underlying conditions and other cross-cutting activities**	**478.3**	**392.6**	**485.6**	**402.3**
RA	Technology Assessment	5.5	5.5	5.8	5.8
RB	Structural cross-cutting activities	62.9	43.1	59.9	40.5
RC	Demographical change	43.9	43.9	56.5	56.5
RD	Sports promotion and sports research	20.4	20.4	21.2	21.2
RE	Others	345.6	279.7	342.1	278.3
T	**Funding organisations, restructuring of the research field in acceding areas; construction of universities and primarily university-specific special programmes[4]**	**3 538.5**	**649.7**	**3 565.5**	**683.7**
TA	Basic funding of research institutions	0.5	0.3	0.5	0.3
TB	Others	3 538.0	649.4	3 565.0	683.4
U	**Large-scale equipment for basic research**	**1 042.0**	**1 041.7**	**1 042.2**	**1 041.9**
Z	**Global reduced expenditure; budget reserve[5]**	**0.0**	**0.0**	**0.0**	**0.0**
Total of civil funding areas		**17 783.7**	**13 186.8**	**17 930.5**	**13 302.4**
S	**Military scientific research**	**1 155.7**	**1 088.2**	**948.6**	**886.3**
SA	Military medical and military psychological research	45.9	13.5	44.1	11.8
SB	Defense technological research	1 087.7	1 069.9	880.2	862.6
SC	Social scientific research	4.7	1.6	2.1	2.1
SD	Military historical research	5.0	2.0	8.6	8.6
SE	Geoscientific research	12.4	1.1	13.5	1.2
Total expenditure[6]		**18 939.4**	**14 275.0**	**18 879.1**	**14 188.7**

1) According to the Federal Government's planning system 2009. Expenditure was implemented in accordance with the Federal Government's planning system 2009. Expenditure of non-university research organisations are distributed among funding areas and funding priorities.
2) Including "Energy and climate fund". As from 2012, research funding in the area of electro mobility is financed by the "Energy and climate fund". As of 2016, including future investments.
3) Distribution among funding areas and funding priorities partly estimated or extrapolated.
4) As of 2012, differences from previously published documents due to subsequent changes in the allocation to R&D.
5) Including universities of the federal armed forces and the Federal University of Applied Administrative Sciences.
6) ACTUAL figures are needed to break down the BMBF's total expenditure reduction by funding areas and funding priorities.
7) Discrepancies with regard to earlier publications are due to subsequent changes of assignments to funding areas and funding priorities.

Source: Federal Ministry of Education and Research
BMBF's Data Portal: www.datenportal.bmbf.de/portal/en/Table-1.1.5.html

Tab. 5 4/6: Federal government expenditure on science, research and development, by funding areas and funding priorities[1, 2]

Funding area / Funding priority		Millions of euros			
		TARGET[3]			
		2015		2016	
		Total	Of which, R&D[4]	Total	Of which, R&D
A	**Health research and health industry**	**2 331.3**	**2 071.7**	**2 478.7**	**2 228.9**
AA	Health research and health industry	2 261.3	2 057.9	2 406.5	2 214.9
AB	Radiation protection	70.0	13.8	72.1	14.0
B	**Bioeconomy**	**290.1**	**290.0**	**281.9**	**281.8**
C	**Civil security research**	**108.4**	**102.8**	**109.7**	**104.1**
D	**Nutrition, agriculture and consumer protection**	**841.4**	**719.2**	**916.0**	**789.9**
DA	Nutrition	40.8	31.1	44.3	33.9
DB	Sustainable agricultural economy and rural areas	521.9	495.7	584.6	555.3
DC	Health and economic consumer protection	278.7	192.5	287.0	200.7
E	**Energy research and energy technologies**	**1 670.0**	**1 246.8**	**1 736.4**	**1 310.0**
EA	Efficient energy conversion	487.6	486.0	751.5	750.0
EB	Renewable energy	445.3	442.8	244.4	241.9
EC	Nuclear safety and waste management	235.2	133.9	239.7	134.8
ED	Decommissioning of nuclear facilities	339.0	21.7	339.2	22.4
EF	Fusion research	163.0	162.4	161.6	160.9
F	**Climate, environment, sustainability**	**1 464.1**	**1 254.1**	**1 527.7**	**1 319.8**
FA	Climate, climate protection; global change	279.2	276.3	283.1	280.3
FB	Coast, marine and polar research, geosciences	476.3	423.6	516.0	462.8
FC	Environmental and sustainability research	396.4	306.4	362.1	272.4
FD	Ecology, nature conservation, sustainable use	312.1	247.8	366.5	304.3
G	**Information and communication technologies**	**809.4**	**779.1**	**944.3**	**906.2**
GA	Software systems; knowledge technologies	227.7	227.1	237.9	237.3
GB	Communication technologies and services	107.8	106.3	123.9	122.4
GC	Electronic, electronic systems	268.4	265.5	281.5	278.6
GD	Microsystems technology	105.1	104.3	181.3	180.5
GE	Multimedia - development of convergent information and communication technology	100.4	75.9	119.7	87.4

1) According to the Federal Government's planning system 2009. Expenditure was implemented in accordance with the Federal Government's planning system 2009. Expenditure of non-university research organisations are distributed among funding areas and funding priorities.
2) Including "Energy and climate fund". As from 2012, research funding in the area of electro mobility is financed by the "Energy and climate fund". As of 2016, including future investments.
3) Distribution among funding areas and funding priorities partly estimated or extrapolated.
4) As of 2012, differences from previously published documents due to subsequent changes in the allocation to R&D.
5) Including universities of the federal armed forces and the Federal University of Applied Administrative Sciences.
6) ACTUAL figures are needed to break down the BMBF's total expenditure reduction by funding areas and funding priorities.
7) Discrepancies with regard to earlier publications are due to subsequent changes of assignments to funding areas and funding priorities.

Source: Federal Ministry of Education and Research
BMBF's Data Portal: www.datenportal.bmbf.de/portal/en/Table-1.1.5.html

Tab. 5 5/6 Federal government expenditure on science, research and development, by funding areas and funding priorities[1, 2]

Funding area / Funding priority		Millions of euros			
		TARGET[3]			
		2015		2016	
		Total	Of which, R&D[4]	Total	Of which, R&D
H	**Vehicle and traffic technologies including maritime technologies**	**435.7**	**336.2**	**492.2**	**391.2**
HA	Vehicle and traffic technologies	381.3	293.4	431.3	342.0
HB	Maritime technologies	54.4	42.7	60.9	49.2
I	**Aerospace**	**1 480.1**	**1 477.7**	**1 656.9**	**1 654.5**
IA	Aviation	280.1	279.6	282.5	282.0
IB	National space research and space technology	557.7	557.0	583.7	583.0
IC	European Space Agency (ESA)	642.3	641.1	790.7	789.5
J	**Research and development to improve working conditions and in the service sector**	**150.5**	**93.5**	**154.1**	**95.7**
JA	Research to improve working conditions	117.6	64.7	121.0	66.7
JB	Research in the service sector	32.9	28.8	33.1	29.0
K	**Nanotechnologies and materials technologies**	**560.4**	**531.1**	**580.2**	**551.1**
KA	Nanotechnologies	205.2	199.5	206.9	201.3
KB	Materials technologies	355.2	331.6	373.2	349.8
L	**Optical technologies**	**187.5**	**183.2**	**192.9**	**188.6**
M	**Production technologies**	**220.9**	**218.8**	**232.2**	**230.0**
N	**Regional planning and urban development; construction research**	**103.7**	**100.4**	**144.8**	**111.6**
NA	Regional planning, urban development, housing	27.4	27.4	62.9	32.9
NB	Construction research	76.2	73.0	81.9	78.7
O	**Innovations in education**	**910.7**	**601.8**	**955.0**	**468.2**
OA	Educational reporting, international assessments	452.6	267.6	453.2	163.1
OB	Educational research	446.2	322.3	490.0	293.3
OC	New media in the education	11.8	11.8	11.8	11.8
P	**Humanities; economics and social sciences**	**1 281.5**	**1 001.4**	**1 404.7**	**1 097.9**
PA	Humanities research	793.1	543.0	883.7	614.8
PB	Social scientific research	246.2	218.3	262.1	226.4
PC	Economic and finance scientific research	85.3	85.3	89.8	89.8
PD	Infrastructures	157.0	154.8	169.1	166.9

1) According to the Federal Government's planning system 2009. Expenditure was implemented in accordance with the Federal Government's planning system 2009. Expenditure of non-university research organisations are distributed among funding areas and funding priorities.
2) Including "Energy and climate fund". As from 2012, research funding in the area of electro mobility is financed by the "Energy and climate fund". As of 2016, including future investments.
3) Distribution among funding areas and funding priorities partly estimated or extrapolated.
4) As of 2012, differences from previously published documents due to subsequent changes in the allocation to R&D.
5) Including universities of the federal armed forces and the Federal University of Applied Administrative Sciences.
6) ACTUAL figures are needed to break down the BMBF's total expenditure reduction by funding areas and funding priorities.
7) Discrepancies with regard to earlier publications are due to subsequent changes of assignments to funding areas and funding priorities.

Source: Federal Ministry of Education and Research
BMBF's Data Portal: www.datenportal.bmbf.de/portal/en/Table-1.1.5.html

Tab. 5 6/6 Federal government expenditure on science, research and development, by funding areas and funding priorities[1, 2]

Funding area / Funding priority		Millions of euros			
		TARGET[3]			
		2015		2016	
		Total	Of which, R&D[4]	Total	Of which, R&D
Q	**Innovation funding for small and medium-sized enterprises**	**1 124.8**	**1 114.7**	**1 140.9**	**1 130.8**
QA	Start-up funding	70.9	70.9	84.0	84.0
QB	Technology funding for small and medium-sized enterprises	657.5	653.8	658.1	654.5
QC	Technology transfer and innovation consulting	191.4	185.3	193.7	187.7
QD	Research infrastructure for small and medium-sized enterprises	205.1	204.6	205.1	204.6
R	**Innovation-relevant underlying conditions and other cross-cutting activities**	**553.5**	**457.9**	**535.0**	**427.0**
RA	Technology assessment	6.4	6.4	6.5	6.5
RB	Structural cross-cutting activities	68.6	45.8	77.4	54.9
RC	Demographic change	72.8	72.8	0.0	0.0
RD	Sport funding and sport research	24.5	24.5	27.5	27.5
RE	Other	381.1	308.4	423.6	338.1
T	**Funding organisations, restructuring of the research field in acceding areas; construction of universities and primarily university-specific special programmes[5]**	**3 532.7**	**694.2**	**3 845.6**	**723.6**
TA	Basic funding for research institutes	0.5	0.3	0.5	0.3
TB	Other	3 532.2	693.9	3 845.1	723.3
U	**Large appliances in the basic research field**	**1 200.5**	**1 200.3**	**1 275.6**	**1 275.3**
Z	**Global reduced expenditure; budget reserve[6]**	**-404.2**	**-404.2**	**-260.2**	**-260.2**
Total of civil funding areas		**18 853.1**	**14 070.6**	**20 344.5**	**15 026.1**
S	**Military science research**	**892.6**	**829.9**	**840.2**	**775.8**
SA	Military medicine and military psychology research	44.4	14.7	43.6	13.9
SB	Defence research	823.6	810.0	771.9	756.6
SC	Social science research	5.2	1.8	5.2	1.8
SD	Military history research	5.5	2.1	5.5	2.1
SE	Geoscientific research	13.8	1.2	13.8	1.2
Total expenditure[6]		**19 745.7**	**14 900.5**	**21 184.7**	**15 801.9**

1) According to the Federal Government's planning system 2009. Expenditure was implemented in accordance with the Federal Government's planning system 2009. Expenditure of non-university research organisations are distributed among funding areas and funding priorities.
2) Including "Energy and climate fund". As from 2012, research funding in the area of electro mobility is financed by the "Energy and climate fund". As of 2016, including future investments.
3) Distribution among funding areas and funding priorities partly estimated or extrapolated.
4) As of 2012, differences from previously published documents due to subsequent changes in the allocation to R&D.
5) Including universities of the federal armed forces and the Federal University of Applied Administrative Sciences.
6) ACTUAL figures are needed to break down the BMBF's total expenditure reduction by funding areas and funding priorities.
7) Discrepancies with regard to earlier publications are due to subsequent changes of assignments to funding areas and funding priorities.

Source: Federal Ministry of Education and Research
BMBF's Data Portal: www.datenportal.bmbf.de/portal/en/Table-1.1.5.html

Tab. 6 1/2 Federal government expenditure on science, research and development, by recipient groups

Recipient group		Millions of euros			
		ACTUAL			
		2009[1]		2012[1]	
		Total	Of which, R&D	Total	Of which, R&D
1.	**Territorial authorities**	**4 075.8**	**2 191.9**	**5 956.7**	**2 770.7**
1.1	Federal Government	1 873.9	891.0	2 168.0	1 033.1
1.1.1	Federal Government-owned research institutions[2]	1 631.2	832.5	1 886.5	940.3
1.1.2	Other institutions of Federal administration[3]	242.8	58.5	281.5	92.8
1.2	*Länder* and communities	2 201.8	1 300.9	3 788.7	1 737.7
1.2.1	Research institutions of the *Länder*	99.2	94.8	126.9	121.1
1.2.2	Universities and university hospitals[4]	1 338.7	1 144.2	2 879.5	1 542.2
1.2.3	Other institutions of the *Länder*	734.3	35.4	736.4	38.0
1.2.4	Communities, local authority and special-purpose associations	29.7	26.6	45.8	36.4
2.	**Private non-profit organisations[5]**	**6 738.1**	**6 351.4**	**7 662.6**	**7 180.1**
2.1	Research funding organisations (e.g. MPG, FhG, DFG)[6]	3 268.0	3 109.2	3 721.4	3 524.4
2.2	Helmholtz Associations of German Research Centres (HGF)	2 379.8	2 332.9	2 722.6	2 624.7
2.3	Other non-profit science organisations	991.7	832.8	1 100.1	947.7
2.4	Other non-profit organisations	98.6	76.5	118.4	83.3
3.	**Business enterprise sector[7]**	**2 454.2**	**2 288.2**	**2 446.6**	**2 271.7**
3.1	Business enterprises	1 737.5	1 591.6	1 731.9	1 584.4
3.2	Services if rendered by companies and the professions	716.7	696.5	714.6	687.4
4.	**Abroad**	**1 189.8**	**1 138.3**	**1 254.4**	**1 196.8**
4.1	Payments to business enterprises abroad	150.6	146.9	104.9	96.8
4.2	Contributions to international organisations and other payments to recipients abroad	1 039.2	991.4	1 149.5	1 099.9
5.	**Cross-group positions**	**3.9**	**2.7**	**6.4**	**0.8**
Total expenditure[8]		**14 461.8**	**11 972.5**	**17 326.7**	**13 420.2**
	For information:				
	Business enterprise sector[7]	2 454.2	2 288.2	2 446.6	2 271.7
	Of which, Federal Ministry for Economic Affairs and Energy	910.6	904.2	976.6	972.0
	Of which, Federal Ministry of Defence	645.2	645.2	496.9	496.9
	Of which, Federal Ministry of Education and Research	701.6	542.7	697.6	532.2

1) 2009 to 2011, including investment and redemption fund excluding allocations to the Länder (economic stimulus package – Konjunkturpaket II). As from 2011, including "Energy and climate fund". As from 2012, research funding in the area of electro mobility is financed by the "Energy and climate fund".
2) As of 2012, differences from previously published documents due to subsequent changes in the allocation to R&D.
3) 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 expenditures for university expansion and construction.
4) Not including basic funding for DFG and funding for collaborative research centres.
5) Not including funding of international organisations abroad.
6) Including basic funding for DFG and funding for collaborative research centres.
7) Including funding to promote contract research; differentiation in keeping with the classification of economic activities; not including funding for business enterprises abroad.
8) Minor discrepancies with regard to earlier publications are due to subsequent data collection or retroactive revision of the allocation to recipient groups.

Source: Federal Ministry of Education and Research
BMBF's Data Portal: www.datenportal.bmbf.de/portal/en/Table-1.1.8.html

Tab. 6 2/2 Federal government expenditure on science, research and development, by recipient groups

Recipient group		Millions of euros			
		ACTUAL			
		2013[1]		2014[1]	
		Total	Of which, R&D	Total	Of which, R&D
1.	**Territorial authorities**	**6 876.3**	**2 921.5**	**6 852.1**	**2 885.4**
1.1	Federal Government	2 243.4	1 108.7	2 307.0	1 146.5
1.1.1	Federal Government-owned research institutions[2]	1 891.9	960.2	1 961.9	1 003.0
1.1.2	Other institutions of Federal administration[3]	351.5	148.5	345.1	143.5
1.2	*Länder* and communities	4 632.9	1 812.8	4 545.1	1 738.9
1.2.1	Research institutions of the *Länder*	145.0	138.6	141.2	134.5
1.2.2	Universities and university hospitals[4]	3 706.2	1 602.0	3 631.6	1 536.7
1.2.3	Other institutions of the *Länder*	735.6	36.7	732.3	32.8
1.2.4	Communities, local authority and special-purpose associations	46.1	35.5	40.1	35.0
2.	**Private non-profit organisations[5]**	**8 031.5**	**7 567.7**	**8 332.3**	**7 860.0**
2.1	Research funding organisations (e.g. MPG, FhG, DFG)[6]	3 923.3	3 726.1	4 071.1	3 877.0
2.2	Helmholtz Associations of German Research Centres (HGF)	2 863.3	2 791.7	2 990.0	2 905.3
2.3	Other non-profit science organisations	1 101.9	947.4	1 131.5	978.6
2.4	Other non-profit organisations	143.0	102.5	139.7	99.1
3.	**Business enterprise sector[7]**	**2 629.0**	**2 450.3**	**2 407.3**	**2 217.4**
3.1	Business enterprises	1 854.9	1 712.9	1 681.5	1 522.7
3.2	Services if rendered by companies and the professions	774.0	737.4	725.9	694.8
4.	**Abroad**	**1 397.3**	**1 332.7**	**1 286.7**	**1 226.1**
4.1	Payments to business enterprises abroad	107.9	98.3	82.1	71.4
4.2	Contributions to international organisations and other payments to recipients abroad	1 289.4	1 234.5	1 204.5	1 154.6
5.	**Cross-group positions**	**5.4**	**2.7**	**0.7**	**-0.2**
Total expenditure[8]		**18 939.4**	**14 275.0**	**18 879.1**	**14 188.7**
	For information:				
	Business enterprise sector[7]	2 629.0	2 450.3	2 407.3	2 217.4
	Of which, Federal Ministry for Economic Affairs and Energy	1 028.2	1 018.4	980.0	969.4
	Of which, Federal Ministry of Defence	526.5	526.5	432.7	432.7
	Of which, Federal Ministry of Education and Research	696.8	538.7	647.8	472.4

1) 2009 to 2011, including investment and redemption fund excluding allocations to the Länder (economic stimulus package – Konjunkturpaket II). As from 2011, including "Energy and climate fund". As from 2012, research funding in the area of electro mobility is financed by the "Energy and climate fund".
2) As of 2012, differences from previously published documents due to subsequent changes in the allocation to R&D.
3) 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 expenditures for university expansion and construction.
4) Not including basic funding for DFG and funding for collaborative research centres.
5) Not including funding of international organisations abroad.
6) Including basic funding for DFG and funding for collaborative research centres.
7) Including funding to promote contract research; differentiation in keeping with the classification of economic activities; not including funding for business enterprises abroad.
8) Minor discrepancies with regard to earlier publications are due to subsequent data collection or retroactive revision of the allocation to recipient groups.

Source: Federal Ministry of Education and Research
BMBF's Data Portal: www.datenportal.bmbf.de/portal/en/Table-1.1.8.html

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

Country	Year[1]	R&D expenditure		Financed by			Performed by			
		Mio. US-$[2]	Share of GDP in %	Business enterprise sector	Government sector	Other national sources and abroad	Business enterprise sector	Government sector	Higher education sector[3]	PNP-sector[4]
				Share %						
Germany	2009	82 795.6	2.72	66.1	29.8	4.1	67.6	14.8	17.7	.
	2011	96 282.5	2.79	65.6	29.8	4.5	67.7	14.5	17.9	.
	2012	100 697.1	2.87	66.1	29.2	4.7	68.0	14.3	17.7	.
	2013	102 573.0	2.83	65.4	29.1	5.5	67.2	14.9	17.9	.
	2014	106 780.8	2.84	.	.	.	67.9	14.8	17.3	.
Finland	2009	7 512.4	3.75	68.1	24.0	7.9	71.4	9.1	18.9	0.6
	2011	7 892.1	3.64	67.0	25.0	8.0	70.5	8.9	20.0	0.7
	2012	7 486.2	3.42	63.1	26.7	10.3	68.7	9.0	21.6	0.7
	2013	7 321.7	3.30	60.8	26.0	13.1	68.9	8.9	21.5	0.7
	2014	7 050.8	3.17	53.5	27.5	19.0	67.7	8.7	22.9	0.8
France	2009	49 741.1	2.21	52.3	38.7	9.0	61.7	16.3	20.8	1.2
	2011	53 428.4	2.19	55.0	35.2	9.8	64.0	13.9	21.0	1.3
	2012	54 829.9	2.23	55.3	35.4	9.3	64.6	13.2	20.8	1.4
	2013	57 986.8	2.24	55.0	35.2	9.8	64.7	13.0	20.8	1.5
	2014	58 750.3	2.26	.	.	.	64.8	13.1	20.6	1.5
Italy	2009	24 640.9	1.22	44.2	42.2	13.7	53.3	13.1	30.3	3.3
	2011	25 769.3	1.21	45.1	41.9	13.0	54.6	13.4	28.6	3.3
	2012	27 164.4	1.27	44.3	42.6	13.2	54.2	14.8	28.0	3.0
	2013	28 128.1	1.31	45.2	41.4	13.4	54.7	14.0	28.3	3.0
	2014	27 744.4	1.29	.	.	.	55.7	14.5	26.9	2.9
Sweden	2009	12 720.7	3.45	59.5	27.0	13.5	70.9	4.4	24.6	0.1
	2011	13 419.7	3.25	57.6	27.5	14.9	69.1	4.3	26.3	0.3
	2012	13 879.5	3.28	.	.	.	67.8	4.8	27.1	0.3
	2013	14 304.1	3.31	61.0	28.3	10.8	69.0	3.7	27.1	0.2
	2014	13 882.8	3.16	.	.	.	67.0	3.8	29.0	0.2

1) Nominal expenditures converted into US dollar purchasing power parities.
2) Including general funding for higher education research.
3) PNP: private non-profit institutions.
4) Some figures are revised, provisional, estimated, under- or overestimated, or only partly comparable with figures from previous years or include other sectors (see original edition of "Main Science and Technology Indicators 2016/1").
5) From 1981 to 1990, including extramural R&D expenditure.
6) From 1981 to 1991, performance data of the government and PNP sectors exclude R&D in the social sciences and humanities. From 1981 to 2004, performance data of the government sector cover central government's expenditure only. In 1995, performance data of the higher education sector exclude most or all capital expenditure.
7) From 1981 to 1995, national results are adjusted by the secretariat to meet OECD norms. Share of GDP: compiled according to the System of National Accounts 1993.
8) Share of performance by the business enterprise sector excluding R&D in the social sciences and humanities.
9) Until 2006, excluding R&D in the social sciences and humanities.
10) Excludes most or all capital expenditure. Up to 2008, government sector R&D performance covers only federal government activities.
Source: OECD, Main Science and Technology Indicators 2016/1; German Centre for Higher Education Research and Science Studies, calculations BMBF's Data Portal: www.datenportal.bmbf.de/portal/en/Table-1.3.1.html

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

Country	Year[1]	R&D expenditure		Financed by			Performed by			
		Mio. US-$[2]	Share of GDP in %	Business enterprise sector	Government sector	Other national sources and abroad	Business enterprise sector	Government sector	Higher education sector[3]	PNP-sector[4]
				Share %						
United Kingdom	**2009**	39 420.2	1.74	44.5	32.6	22.9	60.4	9.2	28.0	2.5
	2011	39 132.6	1.69	45.9	30.5	23.7	63.6	8.6	26.0	1.8
	2012	38 811.9	1.62	45.6	28.7	25.7	63.3	8.1	26.7	1.9
	2013	41 743.4	1.66	46.2	29.1	24.7	63.9	7.9	26.4	1.8
	2014	44 174.1	1.70	46.5	28.8	24.7	64.4	7.8	26.1	1.7
Japan	**2009**	136 954.0	3.36	75.3	17.7	7.1	75.8	9.2	13.4	1.6
	2011	148 389.2	3.38	76.5	16.4	7.1	77.0	8.4	13.2	1.5
	2012	152 325.6	3.34	76.1	16.8	7.1	76.6	8.6	13.4	1.4
	2013	162 347.2	3.47	75.5	17.3	7.2	76.1	9.2	13.5	1.3
	2014	166 861.3	3.58	77.3	16.0	6.7	77.8	8.3	12.6	1.3
Canada[5]	**2009**	25 046.8	1.92	48.5	34.6	16.9	53.2	10.5	35.9	0.4
	2011	25 674.6	1.80	49.0	34.0	17.0	53.1	9.4	37.2	0.4
	2012	26 279.0	1.79	47.1	34.3	18.6	51.1	8.9	39.6	0.5
	2013	26 303.8	1.69	45.7	34.7	19.7	50.1	9.6	39.8	0.5
	2014	25 813.6	1.61	45.4	34.6	20.0	49.9	9.2	40.4	0.5
United States[6]	**2009**	406 405.0	2.82	57.9	32.7	9.4	69.5	12.0	14.0	4.5
	2011	428 745.0	2.76	58.5	31.1	10.4	68.6	12.6	14.6	4.3
	2012	436 078.0	2.70	59.4	29.8	10.9	69.3	12.0	14.5	4.2
	2013	456 977.0	2.74	60.9	27.8	11.4	70.6	11.2	14.2	4.1
	2014	.	.	.	.	.	.	.	.	.

1) Nominal expenditures converted into US dollar purchasing power parities.
2) Including general funding for higher education research.
3) PNP: private non-profit institutions.
4) Some figures are revised, provisional, estimated, under- or overestimated, or only partly comparable with figures from previous years or include other sectors (see original edition of "Main Science and Technology Indicators 2016/1").
5) From 1981 to 1990, including extramural R&D expenditure.
6) From 1981 to 1991, performance data of the government and PNP sectors exclude R&D in the social sciences and humanities. From 1981 to 2004, performance data of the government sector cover central government's expenditure only. In 1995, performance data of the higher education sector exclude most or all capital expenditure.
7) From 1981 to 1995, national results are adjusted by the secretariat to meet OECD norms. Share of GDP: compiled according to the System of National Accounts 1993.
8) Share of performance by the business enterprise sector excluding R&D in the social sciences and humanities.
9) Until 2006, excluding R&D in the social sciences and humanities.
10) Excludes most or all capital expenditure. Up to 2008, government sector R&D performance covers only federal government activities.

Source: OECD, Main Science and Technology Indicators 2016/1; German Centre for Higher Education Research and Science Studies, calculations BMBF's Data Portal: www.datenportal.bmbf.de/portal/en/Table-1.3.1.html

Tab. 8 1/4 Employees, turnover and intramural R&D expenditure of enterprises, by economic activities and employment size classes[1]

Economic activity[3]			2009					
			Employees[2]	Turnover[2]	Intramural R&D expenditure			
					Total	Per employee	Share of turnover	In the eastern German *Länder* and Berlin, total
			1,000	Millions of euros		euro 1 000	Share (%)	Millions of euros
A	**01–03**	**Agriculture, forestry and 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	Food products, beverages and tobacco products	120	48 784	318	2.7	0.7	19
	13–15	Textiles, apparel, leather	29	5 914	126	4.3	2.1	22
	16–18	Wood products, paper products, printing	56	15 074	176	3.1	1.2	29
	19	Coke and refined petroleum products	9	38 975	93	10.3	0.2	1
	20	Chemicals and chemical products	246	84 595	3 198	13.0	3.8	114
	21	Basic pharmaceutical products and pharmaceutical preparations	114	42 812	3 896	34.2	9.1	312
	22	Rubber and plastic products	144	29 690	847	5.9	2.9	26
	23	Glass, ceramics and non-metallic mineral products	68	13 021	288	4.2	2.2	29
	24	Basic metals	152	52 279	495	3.3	0.9	26
	25	Fabricated metal products	187	34 266	712	3.8	2.1	66
	26	Computer, electronic and optical products	382	75 357	5 815	15.2	7.7	743
	27	Electrical equipment	161	33 294	1 333	8.3	4.0	63
	28	Machinery and equipment	551	116 632	4 499	8.2	3.9	340
	29	Motor vehicles, trailers and semi-trailers	718	263 035	13 821	19.2	5.3	147
	30	Other transport equipment	104	26 741	2 056	19.8	7.7	51
	31–33	Other manufacturing of products	105	22 562	1 039	9.9	4.6	169
D, E	**35–39**	**Electricity supply; water supply, waste management**	**148**	**139 235**	**216**	**1.5**	**0.2**	**35**
F	**41–43**	**Construction**	**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 activities**	**72**	**57 671**	**335**	**4.7**	**0.6**	**0**
M	**69–75**	**Professional, scientific and technical 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) Employees and turnover of enterprises with internal and/or external R&D expenditure.
3) Classification of economic activities, 2008 edition (based on NACE 2008 – Nomenclature statistique des activités économiques dans la Communauté européenne).

Source: Stifterverband Wissenschaftsstatistik
BMBF's Data Portal: www.datenportal.bmbf.de/portal/en/Table-1.5.2.html

Tab. 8 2/4 Employees, turnover and intramural R&D expenditure of enterprises, by economic activities and employment size classes[1]

Employment size classes	2009					
			Intramural R&D expenditure			
	Employees[2]	Turnover[2]	Total	Per employee	Share of turnover	In the eastern German *Länder* and Berlin, total
	1,000	Millions of euros		euro 1 000	Share (%)	Millions of euros
less than 100 employees	232	38 316	2 372	10.2	6.2	816
100 to 249 employees	315	64 063	2 335	7.4	3.6	458
250 to 499 employees	337	81 129	2 330	6.9	2.9	180
Sub-total less than 100 to 499 employees	**884**	**183 508**	**7 037**	**8.0**	**3.8**	**1 454**
500 to 999 employees	348	99 355	2 688	7.7	2.7	262
1,000 to 1,999 employees	430	119 763	4 101	9.5	3.4	131
2,000 to 4,999 employees	505	168 463	5 766	11.4	3.4	479
5,000 to 9,999 employees	387	180 942	5 640	14.6	3.1	123
10,000 and more employees	1 505	526 831	19 751	13.1	3.7	959
Sub-total 500 to 10,000 and more employees	**3 175**	**1 095 354**	**37 946**	**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) Employees and turnover of enterprises with internal and/or external R&D expenditure.
3) Classification of economic activities, 2008 edition (based on NACE 2008 – Nomenclature statistique des activités économiques dans la Communauté européenne).

Source: Stifterverband Wissenschaftsstatistik
BMBF's Data Portal: www.datenportal.bmbf.de/portal/en/Table-1.5.2.html

Tab. 8 3/4 Employees, turnover and intramural R&D expenditure of enterprises, by economic activities and employment size classes[1]

Economic activity[3]			2013					
			Employees[2]	Turnover[2]	Intramural R&D expenditure			
					Total	Per employee	Share of turnover	In the eastern German *Länder* and Berlin, total
			1,000	Millions of euros		euro 1 000	Share (%)	Millions of euros
A	**01–03**	**Agriculture, forestry and fishing**	**6**	**1 903**	**144**	**24.0**	**7.6**	**20**
B	**05–09**	**Mining and quarrying**	**21**	**4 187**	**15**	**0.7**	**0.4**	**2**
C	**10–33**	**Manufacturing**	**3 253**	**1 097 832**	**46 049**	**14.2**	**4.2**	**2 716**
	10–12	Food products, beverages and tobacco products	112	45 153	315	2.8	0.7	14
	13–15	Textiles, apparel, leather	28	6 532	113	4.0	1.7	19
	16–18	Wood products, paper products, printing	53	15 559	227	4.3	1.5	38
	19	Coke and refined petroleum products	7	38 373	94	13.4	0.2	0
	20	Chemicals and chemical products	239	115 466	3 346	14.0	2.9	97
	21	Basic pharmaceutical products and pharmaceutical preparations	117	43 302	4 075	34.8	9.4	647
	22	Rubber and plastic products	146	33 748	970	6.6	2.9	28
	23	Glass, ceramics and non-metallic mineral products	72	15 183	292	4.1	1.9	29
	24	Basic metals	160	75 017	530	3.3	0.7	16
	25	Fabricated metal products	186	37 328	743	4.0	2.0	69
	26	Computer, electronic and optical products	378	86 346	7 342	19.4	8.5	858
	27	Electrical equipment	203	44 370	2 130	10.5	4.8	75
	28	Machinery and equipment	609	147 779	5 388	8.8	3.6	302
	29	Motor vehicles, trailers and semi-trailers	733	335 826	17 187	23.4	5.1	152
	30	Other transport equipment	87	28 005	2 018	23.2	7.2	157
	31–33	Other manufacturing of products	124	29 845	1 279	10.3	4.3	213
D, E	**35–39**	**Electricity supply; water supply, waste management**	**151**	**231 366**	**209**	**1.4**	**0.1**	**27**
F	**41–43**	**Construction**	**69**	**14 935**	**80**	**1.2**	**0.5**	**22**
J	**58–63**	**Information and communication**	**251**	**54 603**	**3 170**	**12.6**	**5.8**	**530**
K	**64–66**	**Financial and insurance activities**	**83**	**231 208**	**290**	**3.5**	**0.1**	**0**
M	**69–75**	**Professional, scientific and technical activities**	**234**	**64 636**	**2 930**	**12.5**	**4.5**	**636**
G–I, L, N–U		**Remaining categories**	**954**	**268 126**	**408**	**0.4**	**0.2**	**41**
Total			**5 022**	**1 968 795**	**53 296**	**10.6**	**2.7**	**3 993**

1) Not including institutions for cooperative industrial research and experimental development.
2) Employees and turnover of enterprises with internal and/or external R&D expenditure.
3) Classification of economic activities, 2008 edition (based on NACE 2008 – Nomenclature statistique des activités économiques dans la Communauté européenne).

Source: Stifterverband Wissenschaftsstatistik
BMBF's Data Portal: www.datenportal.bmbf.de/portal/en/Table-1.5.2.html

Tab. 8 4/4 Employees, turnover and intramural R&D expenditure of enterprises, by economic activities and employment size classes[1]

Employment size classes	2013					
	Employees[2]	Turnover[2]	Intramural R&D expenditure			
			Total	Per employee	Share of turnover	In the eastern German *Länder* and Berlin, total
	1,000	Millions of euros		euro 1 000	Share (%)	Millions of euros
less than 100 employees	268	57 487	2 860	10.7	5.0	863
100 to 249 employees	304	65 429	2 098	6.9	3.2	367
250 to 499 employees	318	83 659	2 611	8.2	3.1	221
Sub-total less than 100 to 499 employees	**890**	**206 575**	**7 569**	**8.5**	**3.7**	**1 451**
500 to 999 employees	394	130 792	3 215	8.2	2.5	192
1,000 to 1,999 employees	458	144 365	5 222	11.4	3.6	433
2,000 to 4,999 employees	569	279 451	6 480	11.4	2.3	452
5,000 to 9,999 employees	402	152 761	5 051	12.6	3.3	84
10,000 and more employees	2 310	1 054 853	25 760	11.2	2.4	1 381
Sub-total 500 to 10,000 and more employees	**4 133**	**1 762 222**	**45 728**	**11.1**	**2.6**	**2 541**
Total	**5 023**	**1 968 795**	**53 296**	**10.6**	**2.7**	**3 993**

1) Not including institutions for cooperative industrial research and experimental development.
2) Employees and turnover of enterprises with internal and/or external R&D expenditure.
3) Classification of economic activities, 2008 edition (based on NACE 2008 – Nomenclature statistique des activités économiques dans la Communauté européenne).

Source: Stifterverband Wissenschaftsstatistik
BMBF's Data Portal: www.datenportal.bmbf.de/portal/en/Table-1.5.2.html

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. Business enterprise 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
	2009	**332 491**	183 214	88 002	61 275
	2011	**357 129**	190 696	115 495	50 941
	2012	**367 478**	199 623	117 499	50 356
	2013	**360 375**	198 585	113 935	47 855
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
	2009	**86 633**	49 241	12 274	25 118
	2011	**93 663**	54 185	12 634	26 844
	2012	**95 882**	55 597	12 972	27 313
	2013	**98 161**	56 755	13 799	27 607
3. Higher education 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
	2009	**115 851**	84 852	11 384	19 615
	2011	**124 308**	93 811	11 386	19 111
	2012	**127 900**	97 199	10 895	19 807
	2013	**130 079**	99 123	11 036	19 919
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**
	2009	**534 975**	**317 307**	**111 660**	**106 008**
	2011	**575 100**	**338 692**	**139 515**	**96 896**
	2012	**591 261**	**352 419**	**141 366**	**97 476**
	2013	**588 615**	**354 463**	**138 770**	**95 382**

1) Figures for even years up to 2010 are estimates; as of 2012: technicians and other R&D personnel for even years are estimates. Figures for the business enterprise sector in East German *Länder* and Berlin for even years are estimates.
2) From 2000 to 2010: for even years, distribution of personnel staff as in the previous year. Rounding differences.
3) Government institutions and private non-profit science organisations financed primarily by the government.
4) From 2003 onwards, the breakdown by technicians and other personnel was modified for methodical reasons. Hence, figures since 2003 are only partially comparable with previous years.
5) Figures for the higher education sector refer to full-time staff of private and state universities (ACTUAL), calculated in accordance with the procedure agreed by the Conference of Ministers of Education and Cultural Affairs, the German Council of Science and Humanities, the Federal Ministry of Education and Research (BMBF) and the Federal Statistical Office.

Source: Stifterverband Wissenschaftsstatistik and Federal Statistical Office
BMBF's Data Portal: www.datenportal.bmbf.de/portal/de/Tabelle-1.7.1.html

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

Sector (OECD differentiation)	Year (ACTUAL)	Full-time equivalents			
		Total	Of which:		
			Researchers	Technicians	Others
of which: Eastern German *Länder* and Berlin					
1. Business enterprise 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
	2009	**33 190**	19 385	8 642	5 164
	2011	**36 126**	19 982	12 055	4 090
	2012	**37 173**	20 567	12 404	4 202
	2013	**34 581**	19 577	11 516	3 488
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
	2009	**25 741**	15 421	3 096	7 224
	2011	**28 589**	17 234	3 424	7 931
	2012	**29 336**	17 898	3 284	8 154
	2013	**29 654**	17 886	3 533	8 235
3. Higher education 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
	2009	**26 350**	19 600	2 367	4 383
	2011	**27 732**	21 255	2 221	4 256
	2012	**29 080**	22 265	2 178	4 637
	2013	**29 375**	22 517	2 194	4 664
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**
	2009	**85 281**	**54 406**	**14 105**	**16 771**
	2011	**92 446**	**58 471**	**17 700**	**16 277**
	2012	**95 589**	**60 730**	**17 866**	**16 993**
	2013	**93 610**	**59 980**	**17 243**	**16 387**

1) Figures for even years up to 2010 are estimates; as of 2012: technicians and other R&D personnel for even years are estimates. Figures for the business enterprise sector in East German *Länder* and Berlin for even years are estimates.
2) From 2000 to 2010: for even years, distribution of personnel staff as in the previous year. Rounding differences.
3) Government institutions and private non-profit science organisations financed primarily by the government.
4) From 2003 onwards, the breakdown by technicians and other personnel was modified for methodical reasons. Hence, figures since 2003 are only partially comparable with previous years.
5) Figures for the higher education sector refer to full-time staff of private and state universities (ACTUAL), calculated in accordance with the procedure agreed by the Conference of Ministers of Education and Cultural Affairs, the German Council of Science and Humanities, the Federal Ministry of Education and Research (BMBF) and the Federal Statistical Office.

Source: Stifterverband Wissenschaftsstatistik and Federal Statistical Office
BMBF's Data Portal: www.datenportal.bmbf.de/portal/de/Tabelle-1.7.1.html

Tab. 10 1/2 R&D personnel in EU countries and selected OECD countries, by personnel groups and sectors (full-time equivalents)[1]

Country	Year	Full-time equivalents						
		Researchers	Technical and other personnel	Total		Of which, working in the		
						Business enterprise sector	Higher education sector	Government and PNP sector[2]
		Number			per 1,000 labour force	Share (%)		
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
	2009	317 307	217 668	**534 975**	12.8	62.2	21.7	16.2
	2013	354 463	234 152	**588 615**	14.1	61.2	22.1	16.7
	2014	359 640	241 060	**600 700**	14.3	61.8	21.8	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
	2009	40 849	15 220	**56 069**	20.8	57.5	29.4	13.1
	2013	39 196	13 776	**52 972**	19.7	57.4	29.7	13.0
	2014	38 281	13 850	**52 130**	19.3	56.9	30.8	12.4
France[4]	**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
	2009	234 366	155 847	**390 214**	13.9	57.9	26.9	15.2
	2013	266 222	151 919	**418 141**	14.6	60.1	26.3	13.6
	2014	269 377	153 075	**422 452**	14.8	59.7	26.4	13.8
Italy	**1995**	75 536	66 253	**141 789**	6.1	42.5	34.2	23.3
	2000	66 110	83 956	**150 066**	6.3	42.7	36.5	20.8
	2009	101 840	124 686	**226 527**	9.2	48.5	33.1	18.5
	2013	116 163	130 601	**246 764**	9.8	50.6	31.2	18.3
	2014	119 977	126 446	**246 423**	9.7	51.5	29.9	18.6
Sweden[5]	**1995**	33 665	28 970	**62 635**	13.8	66.5	27.6	5.9
	2000	–	–	**–**	–	–	–	–
	2009	47 308	30 055	**77 363**	15.8	72.1	24.4	3.5
	2013	64 194	16 763	**80 957**	15.8	69.7	25.9	4.4
	2014	66 643	16 830	**83 473**	16.1	68.7	26.8	4.5

1) Some figures are revised, provisional, estimated, underestimated, overestimated or only partly comparable with figures from previous years (see original edition of "Main Science and Technology Indicators 2016/1").
2) PNP: private non-profit institutions.
3) From 1983 to 2003, higher education graduates instead of researchers.
4) In 2008 and 2009: defence excluded (all or mostly).
5) From 1985 to 1991, higher education graduates instead of researchers.
6) From 1981 to 1995, secretariat estimates or projections based on national sources.
7) In the business enterprise sector excluding R&D personnel in the social sciences and humanities.

Source: OECD, Main Science and Technology Indicators 2016/1; German Centre for Higher Education Research and Science Studies, calculations
BMBF's Data Portal: www.datenportal.bmbf.de/portal/en/Table-1.7.11.html

Tab. 10 2/2 R&D personnel in EU countries and selected OECD countries, by personnel groups and sectors (full-time equivalents)[1]

Country	Year	Full-time equivalents						
		Researchers	Technical and other personnel	Total		Of which, working in the		
						Business enterprise sector	Higher education sector	Government and PNP sector[2]
		Number			per 1,000 labour force	Share (%)		
United Kingdom	**1995**	145 673	131 184	**276 857**	9.9	52.4	–	–
	2000	170 554	118 044	**288 599**	10.0	50.4	–	–
	2009	256 124	91 362	**347 486**	11.1	43.6	48.6	7.8
	2013	267 699	109 644	**377 343**	11.7	47.2	47.1	5.7
	2014	273 560	114 373	**387 934**	12.0	48.7	45.8	5.5
Japan[6]	**1995**	551 990	274 666	**826 656**	12.4	69.4	20.5	10.1
	2000	647 572	249 275	**896 847**	13.3	64.9	25.4	9.7
	2009	655 530	222 888	**878 418**	13.2	70.2	21.1	8.7
	2013	660 489	205 034	**865 523**	13.2	67.5	24.0	8.5
	2014	682 935	212 350	**895 285**	13.6	68.3	23.4	8.4
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	62.4	26.9	10.8
	2009	150 220	86 540	**236 760**	12.9	65.5	25.4	9.0
	2013	159 190	67 430	**226 620**	11.9	58.4	33.0	8.6
	2014	–	–	**–**	–	–	–	–
United States	**1995**	795 274	–	–	–	–	–	–
	2000	983 208	–	–	–	–	–	–
	2009	1 250 984	–	–	–	–	–	–
	2013	–	–	–	–	–	–	–
	2014	–	–	–	–	–	–	–

1) Some figures are revised, provisional, estimated, underestimated, overestimated or only partly comparable with figures from previous years (see original edition of "Main Science and Technology Indicators 2016/1").
2) PNP: private non-profit institutions.
3) From 1983 to 2003, higher education graduates instead of researchers.
4) In 2008 and 2009: defence excluded (all or mostly).
5) From 1985 to 1991, higher education graduates instead of researchers.
6) From 1981 to 1995, secretariat estimates or projections based on national sources.
7) In the business enterprise sector excluding R&D personnel in the social sciences and humanities.

Source: OECD, Main Science and Technology Indicators 2016/1; German Centre for Higher Education Research and Science Studies, calculations
BMBF's Data Portal: www.datenportal.bmbf.de/portal/en/Table-1.7.11.html

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