RESEARCH, INNOVATION
AND TECHNOLOGICAL
PERFORMANCE IN GERMANY

COMMISSION OF EXPERTS
FOR RESEARCH
AND INNOVATION

EFI

REPORT

2017

2018 2019
2020 2021 2022
2023 2024 2025

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AND TECHNOLOGICAL
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REPORT 2017

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The Commission of Experts wishes to emphasise that the positions expressed in the report do not necessarily represent the opinions of the aforementioned persons.

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Foreword

In 2017, the Commission of Experts on Research and Innovation is submitting its 10th Annual Report. This is an opportunity to review the last ten years of German research and innovation policy (R&I policy). The Commission of Experts identifies fundamental developments in R&I policy, acknowledges important advances, and develops key recommendations for action with regard to upcoming challenges. In the election year 2017, it is even more important to provide citizens with information on clearly defined options for R&I-policy measures over the next legislative periods. The Commission of Experts wishes to make a contribution to this end.

In the introductory chapter A0, the Commission of Experts identifies challenges for R&I policy and derives objectives for the year 2025: an increase in research and development (R&D) expenditure to 3.5 percent of the gross domestic product (3.5 percent target); a significant improvement in the international visibility of German universities; doubling the amount of venture capital available in Germany; a leading international position in the field of digital infrastructure; doubling the share of funds allocated to research and knowledge transfer in the domain of digital change; and a leading position in Europe in the field of e-government.

The Commission of Experts describes sets of measures for six important fields of activity that can boost Germany's innovative strength: the science system (Chapter A 1), the transfer of knowledge and technology (A 2), innovation in established companies (A 3), entrepreneurship (A 4), governance of the R&I system (A 5), and digital change (A 6). Detailed analyses of the respective fields of activity are presented, and proposals are substantiated, in the corresponding chapters B 1 to B 6.

Furthermore, the Commission of Experts submits two proposals on R&D funding through tax credits (Chapter B 7). Following an analysis of existing quantitative studies of R&D funding through tax credits in important countries, the Commission of Experts arrives at a positive recommendation: when designed appropriately, R&D tax credits are effective and lead to an increase in corporate R&D spending, particularly by small and medium-sized enterprises (SMEs). The introduction of such a funding instrument in Germany would be a sensible measure. According to the Commission of Experts, two proposals should be on the short list: a tax credit on income tax proportional to a company's internal R&D expenditures, or a tax credit on wage tax calculated on the basis of the R&D personnel costs incurred.

The Commission of Experts prefers the second option, as it reduces potential financing constraints faster and more effectively; it also directly triggers support for companies with no income-tax liability. The Commission of Experts advocates initially restricting to SMEs (according to the European Commission's definition) and subsequently expanding it to larger companies if necessary. Such a measure can be carried out with a manageable input of resources. Whichever specific design is chosen, the Commission of Experts regards R&D funding through tax credits as complementary to project funding.

In its review, the Commission of Experts on Research and Innovation expressly acknowledges the important progress achieved by German R&I policy. Overall, the development of this field of policy can be regarded as positive. Reaching the three-percent target is an exceptional achievement to which the state, science and businesses have all contributed. The German science system has been considerably strengthened by the Excellence Initiative and various 'pacts'. The Commission of Experts welcomes and strongly recommends the continuation of these measures. Recent improvements in the framework for business start-ups and venture capital also deserve special recognition; e.g. improvements in the offset of losses, the continuation of the High-Tech Gründerfonds (HTGF), the INVEST subsidy for business angels, and the planned creation of a new stock-market segment for young companies. In the Annual Report for 2016, the Commission of Experts sharply criticised the lack of efficiency and user-friendliness of Germany's e-government services. In the meantime, important legislative steps have been taken to remedy these shortcomings. However, one should bear in mind that a lot of the measures initiated cannot yet claim to be ultimately successful. Rather, they must now be properly implemented.

Apart from the achievements, it is evident that there remains a considerable backlog in Germany, above all in the fields of digital technologies and business models. Despite some positive individual developments, there has been no breakthrough so far. Furthermore, there is an urgent need on the political side for a stronger concentration of responsibilities. A reorganisation should be sought here. Managing digital change also represents a major challenge for science organisations, companies, other actors of civil society, and every citizen – digital change is not just a question of technologies and business models but requires openness and adaptability on the part of everyone involved.

In view of the willingness to innovate in Germany, the Commission of Experts is optimistic that these challenges can be mastered. In the troubled waters of world politics, R&I policy will remain a key political area for action in the coming legislative periods. It is essential that Germany's innovative power continues to improve, enabling it to act from a position of strength.

Berlin, 15 February 2017

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CHALLENGES AND AREAS FOR ACTION

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A Challenges and areas for action

Download data

Area for action: digital change

- Build a future-proof infrastructure
- Give SMEs support with digital change
- Expand digital education
- Introduce targeted research funding for start-ups
- Use e-government and open data as innovation drivers
- Create a future-oriented legal framework for the digital economy
- Provide more effective governance for digital policies

Challenges

- Climate change and sustainability
- Demographic development
- Equitable participation
- Energy supply
- Mobility
- Digital change
- European Research Area
- New innovation pathways
- Agile state

Area for action: the academic system

- Increase basic financing of tertiary education institutions and continue the Higher Education Pact
- Increase overhead allowances for third-party funded projects
- Increase the number of permanent professorships
- Improve career opportunities for young academics
- Refurbish university buildings and create future-proof infrastructures
- Differentiate between tertiary education institutions and modernise governance
- Further strengthen non-university research organisations – continue the Pact for Research and Innovation

Area for action: transfer

- Intensify transfer, raise transparency
- Improve the legal framework of transfer

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Area for action: governance

- Continue High-Tech Strategy, implement measures quickly
- High-Tech Strategy: clarify target hierarchies, avoid silo formation
- High-Tech Strategy: institutionalise interdepartmental cooperation
- Shape innovation policy at the European level
- Pay more attention to social innovations
- Permanently integrate transparency and participation in innovation policy
- Gear public procurement to innovations
- Develop innovation policy in an evidence-based way
- Continuously improve governance of R&I policy

Targets for the year 2025

- Spend 3.5 percent of GDP on R&D
- Establish at least three German universities among the world's 30 leaders
- Double venture capital's share of gross domestic product to 0.06 percent
- Catch up with the five leading nations in the field of digital infrastructure
- Double the share of funding in the field of digitisation
- Take on a pioneering role in e-government

Area for action: entrepreneurship

- Lower administrative costs for start-ups
- Begin early with start-up training
- Improve start-up funding, expand incentives for private investors
- End the restrictive treatment of loss carryforwards
- Secure attractive overall tax conditions for start-ups

Area for action: innovation in established companies

- Develop start-up and transfer skills
- Support market access
- Reorientate cluster policy
- Promote the diversification of R&D activities in Germany
- Use opportunities to internationalise R&D
- Strengthen the innovation activities of SMEs
- Shortage of skilled labour: incorporate hidden reserves better to boost innovation
- Shortage of skilled labour: develop the education system, increase permeability
- Gear project funding flexibly to new challenges
- Introduce R&D funding for SMEs through tax credits

Challenges A 0

Germany can look back on important successes in ist research and innovation policy (R&I policy). For example, since 2005 there have been considerable improvements in the areas of public and private R&D expenditure, in the positioning of German tertiary education and research institutions in terms of attractiveness and excellence, and in the modernisation of the German economy.

These developments are also due to the fact that R&I policy has enjoyed a high level of attention over the last ten years and that considerable resources have been directed into the fields of science, research and innovation. Germany is now significantly closer to its aim of playing a leading role as an innovation location.

At the same time, Roman Herzog's statement still applies: "The world is moving fast; it won't wait for Germany."[1] The challenges have further increased over the past few years. German R&I policy must be further developed consistently if it is to make a contribution to addressing these challenges. The Commission of Experts considers the following developments to be especially important:

Climate change and sustainability

An international convention on climate protection has been reached with the Paris Agreement. Now, top priority must be given to implementing the agreement. Research and innovation can make an essential contribution to reaching the climate targets. The policy goal of decarbonising the economy must therefore also play an important role in the deliberations of the R&I policy-makers and form an integral part of the new Federal Government's science and innovation strategy.

Demographic development

The ageing of society is creating considerable problems for social security systems. It is also aggravating the lack of skilled labour. Research and innovation can provide solutions for an increasingly ageing population in order to secure quality of life into old age and make longer participation in working life possible.

Equitable participation

R&I policy, too, is confronted with the question of whether innovation processes increasingly generate inequality. Especially in the course of the digital revolution, profound changes are to be expected which, from the citizens' point of view, involve the risk of losing jobs or prosperity. Unless the population is suitably incorporated in decision-making and able to participate equitably, science and innovation might also face growing scepticism.

Energy supply

R&I policy will play an important role in designing the future energy supply. For example, dependence on non-renewable energies must be further reduced. The aim must be to find an economically sensible path towards the almost exclusive use of renewable energy.

Mobility

In the mobility sector, a profound change is taking place from a strong focus on automobiles to multimodal systems of mobility services. The automotive sector is particularly important to the economy in Germany. The introduction of electromobility, accelerated digitisation, and the emergence of new competitors has put industry under considerable pressure. Innovations are necessary to maintain and expand the competitive position of German companies.

Digital change

Germany is not yet properly prepared for digital change. Funding schemes still do not yet sufficiently take information and communication technologies into account. R&I policy must focus more on start-ups as new innovative players. In addition to assisting and supporting established economic sectors with digital change, the development of new strengths must also be promoted. Training in the competent use of digital applications and responsible handling of personal data will play a key role.

European Research Area

R&I policy must continue to attach great importance to the further development of the European Research Area. The continuation of cooperation with the UK must be secured after Brexit, above all in the field of student and academic exchange.

New innovation pathways

Innovation processes are changing. Increasingly, basic research is leading directly to application and translation possibilities. Start-ups have become key economic players in some areas. New forms of organisation, such as crowd concepts, competition formats and real-life laboratories, are growing alongside traditional, hierarchically organised R&I processes. R&I policy in Germany should do more to embrace these new developments.

Agile state

At present, technological and economic opportunities and the political environment are changing at high speed. German R&I policy needs to be highly flexible to be able to respond quickly to these developments. The modification of structures and processes as a result of digitisation and the launch of innovation processes cannot and should not be excluded from ministries or the public administration. An agile government will be needed in the future.

Targets for the year 2025

It will be impossible to adequately meet the above (and further) challenges without a further strengthening of science, research and innovation. The Commission of Experts recommends that German research and innovation policy should formulate clear targets as a basis for measuring and evaluating further progress. In particular, the Commission makes the following proposals to the Federal Government:

Spend 3.5 percent of GDP on R&D

Private and public engagement in the field of research and development should continue to grow up to 2025. It would be a visible sign of such engagement if the Federal Republic of Germany were to reach the 3.5 percent target by 2025. National R&D intensity is currently close to 3.0 percent.

Establish at least three German universities among the world’s 30 leaders

Federal and Länder governments should specifically promote German universities and other tertiary education institutions in order to sustainably improve the international image and standing of Germany’s science system abroad. A visible expression of such a development would be for three or more German tertiary education institutions to be among the leading 30 universities in the Times Higher Education Ranking by 2025. Only one German university is currently among the world’s 30 leading tertiary education institutions.

Double venture capital’s share of gross domestic product to 0.06 percent

By 2025, venture capital should make up more than 0.06 percent of GDP – i.e. more than double the present figure (0.027 percent).

Catch up with the five leading nations in the field of digital infrastructure

The Federal Republic of Germany should strive to have one of the world's leading broadband infrastructures by 2025. R&I policy should begin by abandoning the pursuit of a static goal and agreeing on a flexible, dynamically adjusting target. It would be a visible sign of a positive development if Germany became one of the five OECD nations with a leading digital infrastructure by 2025. Compared to other countries, Germany is currently lagging behind according to almost all indicators of high-performance broadband development faster than 50 Mbit/s.

Double the share of funding in the field of digitisation

The Federal Government must also respond to the challenge of digitisation with a sustainable increase in research funding and technology transfer in this area. Its aim should be to sustainably develop new scientific, technical and economic strengths in order to be among the world's leading economies in this field by 2025. The Federal Government's share of funding in the field of digitisation flow should be rapidly doubled.

Take on a pioneering role in e-government

In e-government, Germany should be recognised in Europe as a successful model of digital government and administration by 2025. Hesitant positioning on the part of German R&I policy is no longer the way forward – the challenges are too big for that. The successes achieved up to now should encourage German R&I policy to believe it can achieve major changes if it sets itself ambitious targets.

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A 1 Area for action: the science system

A raft of policy measures over the last ten years in the tertiary education sector, and in the field of publicly funded research in general, has led to a significant improvement in research conditions, to more third-party funded research and research collaborations, as well as to an increase in the number of up-and-coming young academics (cf. Chapter B1). Germany has become significantly more attractive as a location for science. The Federal Government has substantially increased resources for publicly funded research and has thus made a significant contribution towards achieving the three-percent target for R&D spending and making the German research landscape more competitive.

The Commission of Experts now considers it necessary to set a more ambitious goal. In its 2015 Report it already called for an increase in the target for R&D spending to 3.5 percent of GDP.

The Excellence Initiative has strengthened Germany as a location for science. The Commission of Experts welcomes the agreement on the Excellence Strategy between the Federal and Länder governments adopted in 2016. Since the Higher Education Pact and the Pact for Research and Innovation will expire in 2020, decisions will also have to be taken in the next few years on whether, or in what form, these two pacts are to be continued. While the non-university research organisations achieved the budget increases of the last few years via institutional promotion with the Pact for Research and Innovation, the problem in the case of tertiary education institutions (universities and universities of applied sciences) is that a high proportion of the increase in funding was realised via temporary and earmarked funds. This creates many problems for tertiary education institutions; it also opens up a gap between financing conditions in tertiary education institutions and those at non-university research organisations.

Increase basic financing of tertiary education institutions and continue the Higher Education Pact

A key challenge in the coming years will be to substantially improve the basic financing of Germany's tertiary education institutions, to overcome their structural underfunding, and to further boost their international competitiveness. In this context, it is initially the Länder that have an obligation to invest in basic financing.

At the same time, the Commission of Experts recommends that Federal and Länder governments should initiate a follow-up programme for the Higher Education Pact. The Federal Government should continue to support the Länder in financing teaching and overhead costs. However, this must not lead to the Länder reducing their own contributions to the funding of tertiary education institutions. Assistance from the Federal Government should thus be tied to verifiable conditions.

Increase overhead allowances for third-party funded projects

The DFG Programme Allowance and the BMBF Project Allowance are usually not sufficient to finance the full indirect costs related to third-party funded research (cf. Chapter B 1-1). To avoid tertiary education institutions being forced to use more and more basic funds to cover overhead costs in view of growing volumes of third-party funding, increases in the DFG Programme Allowance and the BMBF Project Allowance are urgently needed.

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Increase the number of permanent professorships

The number of permanent professorships should be increased. At the same time, the student-to-professor ratio should be improved and individual teaching loads reduced. A combination of these measures will make the German academic system more attractive in the international competition for excellent researchers and particularly talented students. It will also improve the quality of teaching for all students.

Improve career opportunities for young academics

An increase in the number of permanent professorships also benefits the greatly increased numbers of up-and-coming young academics, because it improves their career opportunities (cf. Chapter B 1-3). Furthermore, it supports greater use of the tenure-track system.

In the context of young people's career planning, more attention must also be paid to their labour market options outside academia. Young academics' careers outside the higher-education sector represent an essential element of knowledge and technology transfer that sustainably strengthens Germany's research and innovation system.

Refurbish university buildings and create future-proof infrastructures

As regards buildings and technical facilities, many years of investment backlogs must be overcome and expansion investment carried out to improve the increasingly serious state of the general infrastructure and bring tertiary education institutions up to date with state-of-the-art technology. At the same time, the tertiary education institutions must meet the requirements of digitisation. This will require corresponding investment programmes on the part of the Federal and Länder governments.

Differentiate between tertiary education institutions and modernise governance

In addition to improving staffing and the basic provision of premises, the organisation and governance of tertiary education institutions must also be modernised. They must be given more scope for greater differentiation and experimentation with new forms of governance and priority setting; corresponding incentives are needed.

Further strengthen non-university research organisations – continue the Pact for Research and Innovation

The Commission of Experts recommends continuing the Pact for Research and Innovation for financing non-university research organisations beyond 2020. A further improvement in the performance of non-university research organisations can only be achieved if funding can be increased not only in nominal, but also in real terms.

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A 2 Area for action: transfer

Innovation is the result of the transfer and recombination of knowledge from numerous actors in academia, business and society. Tertiary education institutions and other research organisations can make major contributions here. Up to now, however, a culture of knowledge transfer has not developed to a sufficient extent in these organisations. Germany admittedly cannot afford to forgo excellent research results that are beneficial to society and the economy. Hence, both in research organisations and in R&I policy, greater importance should be attached to the objective of knowledge and technology transfer. By contrast, the promotion of clusters – in which cooperation and knowledge transfer between business and academia is often organised very effectively – is well developed. There, no further expansion of funding is required.

Intensify transfer, raise transparency

The Commission of Experts welcomes close cooperation between actors from academia, business and society. However, the actors involved act on the basis of different incentives. Nevertheless, the transfer of knowledge and technology can and should be designed in such a way that it does not conflict with freedom of research. To ensure this, such collaborations need to be based on transparency-creating regulations and self-commitment. In addition, a change in culture needs to be enforced in tertiary education and other research institutions that facilitates the use of new knowledge. A fundamental condition for this is to design organisational and incentive structures that are sufficiently flexible. Furthermore, the governance of knowledge and technology transfer in tertiary education and other research institutions should be improved.

The Commission of Experts endorses the recommendations of the German Council of Science and Humanities (Wissenschaftsrat)[2], according to which research institutions should develop and consistently implement a strategy for an improved knowledge and technology transfer.

Improve the legal framework of transfer

The framework conditions governing access to and the exchange of research findings have been improved in the last few years. The Commission of Experts expressly welcomes the recent establishment of open access as a fundamental principle in research funding. It also welcomes efforts to introduce a general exemption to copyright for academic and educational purposes, which limits copyright restrictions on the use of digital sources in academia. This will improve freedom of research and teaching. However, the Federal Government should not rest on its laurels in the coming legislative period. The Commission of Experts renews its call for the introduction of a grace period in patent law, which for researchers would mitigate conflicting goals relating to the academic and commercial exploitation of research findings.

Develop start-up and transfer skills

New ideas and know-how are often not used because researchers lack the necessary skills for communicating findings outside the academic context. Spinoffs from tertiary education institutions and other research organisations represent an important transfer channel, making it possible to exploit and apply the new knowledge generated. Currently, the potential for academic spin-offs is not being used sufficiently. Tertiary education institutions should therefore take action to introduce – or further develop – curricula at the graduate and postgraduate level that address entrepreneurship and company founding as well as the marketing of innovations. Besides the option of pursuing an academic career, there are also attractive employment opportunities in business and society, where talented academics can also apply new methods and research findings. Up to now, such career options have often been neglected in structured graduate training. In future, they should be given more backing as an additional transfer channel.

Support market access

In addition, the transfer offices of tertiary education and other research institutions should extend and professionalise their support to cover the preparatory phase to market access. They should specifically provide platforms on which research institutions can present their findings and discuss their respective needs with companies. However, it does not make sense to encourage academics in general to market their scientific findings themselves. Rather, technology transfer should be organised according to the principle of the division of labour to ensure that specialisation benefits can be reaped.

Reorientate cluster policy

Cooperation and knowledge transfer between business and science are often organised particularly effectively in clusters. Cluster-policy measures at both the federal and Länder level have become an integral part of R&I policy – although there is rarely sufficient economic justification for political market interventions beyond the formative and initial growth phases. At the same time, it is currently difficult to reliably estimate the long-term innovation effects of cluster policy. Against this background, the Commission of Experts has already warned against attaching too much importance to this instrument in the past.

Although agglomeration effects are important for innovative activities, and R&I-policy measures sustain them – they cannot be forced. Up to now, cluster funding has reached a large number of clusters. The promotional effects can be expected to gradually weaken if support is increasingly given only to clusters that are already developed. The Commission of Experts therefore recommends critically reconsidering a continuation of cluster promotion at the federal level. In particular, the Leading-Edge Cluster Competition should not be continued for the time being, despite the fact that it has shown initial positive promotional effects. Furthermore, cluster policy has hitherto run the risk of concentrating excessively on regional networks, thus leading to regional isolation.

The Commission of Experts advocates measures that prevent isolation and aim to achieve a so-called delock-in. The Commission therefore expressly welcomes the BMBF’s funding programme for the internationalisation of clusters. In the same way, measures should be developed aimed at preventing lock-in for established technologies and encouraging an orientation towards new technologies; this could also contribute to a reorientation of cluster policies.

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A 3 Area for action: innovation in established companies

As part of the so-called Lisbon Strategy, in March 2000 the European Council formulated the European Union's strategic goal "to become the most competitive and dynamic knowledge-based economy in the world".[3] Against this background, two years later in Barcelona the European Council decided to increase the R&D spending in the EU to 3 percent of gross domestic product by 2010.[4] Another stated objective was that two-thirds of the investment was to be financed by the private sector.

By 2005, Germany was a long way from this target with a figure of 2.48 percent,[5] which makes the increase over the last ten years all the more remarkable. In 2015, internal R&D as a proportion of GDP was 2.99 percent,[6] – indeed over 3 percent according to the calculation method used in 2005.[7] The strong increase over the last ten years is a great success for R&I policy, and it has led to a marked growth in publicly financed R&D.

Almost two thirds of internal R&D expenditure is financed by private companies.[8] Growth in this field is also large, albeit relatively lower. Strengthening R&D in German companies therefore remains a key challenge.

Promote the diversification of R&D activities in Germany

The R&D activities of German companies are concentrated in a few core industries. Vehicle construction alone accounted for more than a third of Germany's internal R&D expenditure in 2015.[9] The R&D activities of foreign companies in Germany reinforce this concentration. The extensive and still rising R&D activities in vehicle construction are to be welcomed. However, Germany risks being highly dependent on a core industry at a time when competitive positions are being re-defined. Germany should therefore look at ways of achieving greater diversification of its R&D activities.

Use opportunities to internationalise R&D

In the last ten years, R&D spending by German companies has increased in almost all branches of industry, both in Germany and abroad. The Commission of Experts is concerned that German corporate R&D activities are increasingly being carried out abroad incertain sectors, e.g. pharmaceuticals (cf. Chapter B 3-4).[10] The aim must be to strengthen Germany as a centre of international R&D activities with an efficient research infrastructure and research-friendly regulation.

Strengthen the innovation activities of SMEs

Up to now, state funding for innovation has not reached enough SMEs – despite well established project funding. The wide range of specific federal and state programmes makes the funding options complex for companies applying for subsidies; the amount of work associated with applications is harder to shoulder for small businesses than for larger corporations. R&D funding through tax credits, as proposed by the Commission of Experts in Chapter B 7, would therefore be an important measure that would reach many more SMEs than the current application-based project funding.

Shortage of skilled labour: incorporate hidden reserves better to boost innovation

Demographic developments represent a major challenge for companies' innovative capacity. A whole package of strategies is required to overcome it. One measure is to use hidden reserves, which are plentiful particularly in Germany. For example, the participation of women in vocational training has increased enormously, yet the percentage of women in employment is still relatively small. The aim here must be to create conditions that are conducive to higher labour force participation by women and to remove obstacles, for example tax obstacles. It is also essential in this context to keep productive older workers at work for longer. In coming pension reforms, any further decoupling of the retirement age from life expectancy must therefore be avoided. In addition, an immigration law should be introduced to reduce by means of immigration the lack of skilled labour resulting from demographic developments. Finally, the refugees who have already entered the country must be quickly trained and integrated into the German labour market.

Shortage of skilled labour: develop the education system, increase permeability

Another element is education policy. The education system should be further developed in a way that guarantees a high level of vertical and horizontal permeability – while clearly underlining the distinct profiles of the German education system's two pillars: vocational training and the tertiary education institutions. The developments in the vocational training system should be complemented by greater efforts to encourage life-long learning and corresponding incentives in the employment system.

Gear project funding flexibly to new challenges

Private innovation activities are supported by a whole range of funding instruments. Up to now, the focus has been exclusively on direct project funding, and in most cases this has also proved successful as a funding instrument. However, the question arises as to whether the allocation of funds to the individual funding areas has adapted quickly enough to new challenges, especially digitalisation.

Introduce R&D funding for SMEs through tax credits

Up to now, R&I policy in Germany has not made use of R&D funding through tax credits. The Commission of Experts advises the introduction of such an instrument, focusing on the SME sector, and makes a detailed proposal for implementation in the current annual report (cf. Chapter B 7). The effectiveness of R&D funding through tax credits has been demonstrated in numerous international studies. The promotional effects are particularly marked in the case of SMEs. The variant preferred by the Commission of Experts grants a tax credit on wage tax. The level of the credit should be proportional to the level of R&D personnel costs. Even businesses with no income-tax liability – e.g. start-ups and SMEs in a restructuring phase – could benefit regularly from the cash-flow effects of this form of tax relief. The Commission of Experts believes this would lead to a considerable intensification of R&D activities among SMEs.

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A 4 Area for action: entrepreneurship

Start-ups make an important contribution to economic growth and to maintaining a country's competitiveness. Successful start-ups create jobs through local value creation. However, the number of business start-ups in Germany is small by international comparison, especially in the knowledge-based economy.

Funding is a key challenge for young companies during both the start-up and growth phases. They need a flexible financing environment that also allows exits by going public. The venture-capital market is less well developed in Germany than in many other European countries. To remedy this situation, policy-makers have launched a wide range of funding programmes and announced further measures in the meantime. Furthermore, as repeatedly proposed by the Commission of Experts, the restrictive treatment of loss carryforwards has been newly regulated.

Despite the progress made particularly in recent times, there is still a need for action to expand start-up activities in Germany on a permanent basis. To achieve this, it is essential to reduce bureaucratic obstacles and establish planning security on financing – for both founders and investors. The framework conditions for start-ups and company growth must be designed in such a way that potential founders and their ideas do not move abroad and their potential can be used to maximum effect. Also at tertiary education institutions and non-university research organisations there is underused start-up potential which should be better deployed.

Lower administrative costs for start-ups

The administrative obstacles for start-ups are large by international comparison and must be reduced. A starting point could be the project known as Einheitlicher Ansprechpartner 2.0 (Point of Single Contact). However, this project still needs to be efficiently implemented in order to give start-ups access to all necessary information and procedural rules of the public administration. Furthermore, it is vital to take the specific interests of young companies into account in the design and implementation of funding programmes. Possible scope for discretion should be used generously in favour of young companies.

Begin early with start-up training

A greater awareness of the option of launching start-ups can now be found in study courses relating to economics, but hardly in other courses of study such as engineering, natural sciences, humanities or other social sciences. As a result, the start-up potential that exists in Germany is not being sufficiently exploited. In addition to the technical skills that are needed, start-up awareness must also be created across all disciplines, so that launching a business is perceived as a realistic option. To achieve this, it is helpful to begin start-up training early in a person's education, ideally already at school. Initial positive examples can now be found throughout Germany.

Improve start-up funding – expand incentives for private investors

Compared to other countries, too little support is provided by private funding sources in Germany for start-up funding in the early phase, and particularly during the growth phase. The Commission of Experts calls for more commitment from private players, especially from large enterprises. For example, in the context of the High-Tech Gründerfonds III, private players could contribute a much larger share of funding than in the case of its predecessor funds. Potential anchor investors – e.g. life insurers – are often hesitant because of restrictive regulations in this segment.

For this reason, the framework conditions for institutional investors in Germany should be designed in such a way that investments in venture-capital funds that finance innovative growth businesses are supported, and recognised anchor investors can emerge.

KfW's return to the market as a fund investor in 2015 should be seen as an initial positive signal, as it can make a contribution to winning over other domestic and foreign institutional investors. Policy-makers' focus should not be so much on providing additional public funding but on creating the kind of incentives that make it attractive for private investors to invest in venture-capital funds and start-ups. The INVEST programme has already been impressively successful in this.

End the restrictive treatment of loss carryforwards

Germany's 2008 corporate tax reform introduced a particularly restrictive regulation by international comparison on the use of loss carryforwards. The Act on the Further Development of Tax Loss Carryforwards for Corporations (Gesetz zur Weiterentwicklung der steuerlichen Verlustverrechnung bei Körperschaften), which was passed in December 2016, can now effect a considerable improvement in overall conditions and financing incentives. The newly introduced section 8d of the Corporation Tax Act (Körperschaftsteuergesetz) aims to ensure that unused losses (loss carryforwards) can still be used despite a change in shareholders. The precondition is that the entity's business operations are maintained after the change of shareholders, and any other use of the losses is excluded. The Expert Commission welcomes this law. However, when it is implemented, the continuation of the business must be interpreted flexibly enough, since start-ups often change their business model, customer target group or technology.

Secure attractive overall tax conditions for start-ups

In the past, the Commission of Experts has already welcomed the fact that the Federal Government does not tax capital gains on sales of free-float shares in corporations. No such tax should be introduced in the future. Furthermore, there should be no increase in the existing taxation of fund-initiators' remuneration (carried interest). To prevent distortions in cross-border tax competition, the conditions governing the establishment and management of venture-capital funds should be made internationally competitive.

A

A 5 Area for action: governance

In the new legislative period, Germany must increasingly face up to the major societal challenges of our time – including climate change, demographic development, health and food security, resource scarcity and energy supply, access to information and mobility. In order to rise to these challenges, it is decisive that the state promotes the development and use of knowledge.

Different areas and levels of policy are increasingly being affected by the breadth and complexity of societal challenges. This means that the coordination of R&I policy has an important role to play in order to avoid any negative overlapping of regulations and to tap positive synergies. Alongside developing an effective inter-departmental innovation strategy and making overall conditions innovation-friendly, however, the state is also active as an engine for innovation in innovation-oriented public procurement.

Continue High-Tech Strategy, implement measures quickly

The Commission of Experts lauds the concept of an inter-departmental coordination of policies pursued since 2006 with the so-called High-Tech Strategy (HTS). This was the first time a reliable framework was created for a higher-level innovation strategy. In the meantime, innovation is understood as an important cross-policy task. The HTS's inter-departmental approach has fundamentally proved its worth and should be continued. However, the implementation of the new HTS has been considerably delayed in the 2013-2017 legislative period, so only a limited number of new measures requiring inter-departmental coordination have been implemented to date.

High-Tech Strategy: clarify target hierarchies, avoid silo formation

The Federal Government must clarify target hierarchies and set milestones right at the beginning of the next legislative period. The promotion of internet-based technologies and business models should be a top priority in the new HTS's target hierarchy. In this context, the approaches to managing digital change should not be related to individual industries or technological areas, but geared to a wide variety of topics. The formation of thematic silos must be avoided.

The field of information and communication technology, which plays a key role in the management of digital change, should be given a significantly higher priority in the distribution of research funds.

High-Tech Strategy: institutionalise inter-departmental cooperation

To ensure effective communication, networking and cooperation between ministries, as well as a coherent external image, a Federal Committee of State Secretaries for the HTS should be made a fixture. Internal incentives for different ministries to participate in the HTS could be strengthened by a separate, additional HTS research budget.

Shape innovation policy at the European level In the coming years – also in view of Brexit – German research and innovation policy must become more engaged in the European Research Area and contribute at an early stage to shaping a successor programme for Horizon 2020.

Pay more attention to social innovations

Not only technological, but also social innovations – i.e. changes in social practices – can help resolve societal challenges. Technological and social innovations can be both substitutive and complementary – and a broad understanding of innovation is becoming ever more important for the knowledge markets of the future. Although the definition of innovation has been extended in this sense in the new High-Tech Strategy, it is now also important to treat social innovations on an equal footing with technological innovations in the implementation of funding policy. Promotion should focus on the development, research and testing of new ideas for changing social practices that seem important for dealing with major societal challenges.

Permanently integrate transparency and participation in innovation policy

When identifying major societal challenges and defining target hierarchies, intensive consideration should be given to how societal groups can be included in shaping research and innovation processes. More transparency and participation can contribute to increasing long-term support for innovation policy in society. This has been implemented within the framework of the HTS, for example, with the establishment of the High-Tech Forum. When developing their ideas on research policy, the responsible ministries could experiment more with internet-based methods such as online platforms for gathering ideas or forming opinions. Ultimately, however, public innovation policy remains a task for democratically legitimate representatives of the people in a permanent and constructive discourse with knowledge bearers in both the academic and business worlds.

Gear public procurement to innovations

State innovation policy has an important role to play on the demand side in the emergence and further development of innovation-oriented markets. In view of the fact that the volume of public procurement is approximately €450 billion per annum, the Commission of Experts calls for part of these funds to be used to promote innovation more intensively and in a more coordinated way than in the past. To achieve this, it would in particular also be necessary to adjust both the legal framework and the practical operations of public procurement to give ‘priority to the more innovative offer’. However, the Commission of Experts warns against assigning the state the key role as an investor and initiator of innovations. Such an understanding of roles would risk causing considerable misallocations by weakening market-economic innovation dynamics. Furthermore, the Commission of Experts remains sceptical about direct programmes for promoting private demand for innovative products (e.g. buyer’s premiums for electric cars).

Develop innovation policy in an evidence-based way

Evaluations form the basis for an informed political decision, and they can only accomplish this if they are carried out in a way that is free of preconceived expectations, if the medium and long-term effects of a measure are also considered, and if they meet methodological standards that make it possible to identify causal effects. The best guarantor of quality assurance is transparency, i.e. the disclosure of methods used and results, as well as competitive access to data to verify the results. The institutional integration of evaluation practices in the ministries should be continued and special attention paid to further training and methodological competence. It is also expedient to legally codify the research mandate of the statistical offices to ensure that data collected by the administration can be used for evaluation purposes. The Commission of Experts recommends incorporating evaluations based on randomised experiments into the evaluation portfolio of state R&I funding as one of its standard instruments.

Continuously improve governance of R&I policy

Good governance in public research policy includes and requires innovation in the sense of experimenting with new funding strategies. This requires sufficient freedom and strategic flexibility. At the working level in the ministries, there should also be positive incentives (e.g. integrative process teams, competitive salary, career options, research budgets) to encourage involvement in key R&I initiatives. Like innovation itself, innovation policy takes place in the context of change and uncertainty. Here, the aim should be to create framework conditions and incentives for an agile form of governance, enabling it to react flexibly and actively to any short-term need to adapt R&I policy.

A

A 6 Area for action: digital change

Digital change is an extremely rapid process. Its key technologies and business models are not among the core strengths of the German (R&I) system. For Germany in particular, digital change represents a radical innovation that calls into question competitive and specialisation advantages attained over many years.

Up to now, German R&I policy has paid too little attention to the technical and economic dynamics underlying this transformation. This is also reflected in a lack of funding for the promotion of R&D in information and communication technologies. In the next few years, Germany must develop new technical and economic strengths. This will require consistent and prompt policy measures, and these should be implemented right at the beginning of the new legislative period.

Build a future-proof infrastructure

The existing measures for developing the digital infrastructure have not been designed sustainably. Germany needs an ambitious expansion of its infrastructure that is not geared towards average OECD figures, but aims to lead the way in terms of performance and upgradability. The expansion targets must be adapted dynamically to the respective technical standards.

Give SMEs support with digital change

There is currently a risk of a 'digital divide' in the corporate sector. Not all SMEs seem to be fully aware of the importance of the imminent changes. Furthermore, a lack of financing makes it difficult for companies to tackle the necessary changes systematically. For this reason, SMEs in particular should be the main target of measures aimed at explaining digital technologies and business models and facilitating their implementation. The Commission of Experts calls for the creation of an 'SME Digital' programme, in which – as in the case of the Central Innovation Programme for the Mittelstand (ZIM) for R&D support – SMEs are eligible for state support in the planning and implementation of digitisation projects.

Expand digital education

The population in Germany has less experience than people in other countries in dealing with digital technologies and data. In this context, emphasis should be placed on a broad-based promotion of skills in the use of digital technologies and models – in all training and further-education segments.

In Germany, the PISA studies have supplied transparent information on the level of education of German school students and revealed deficits. A corresponding data pool is also needed in the field of digital education. Länder governments should not – as in the case of the PISA studies – be able to block comparative surveys or their analyses.

Digital education in particular should be strengthened in all elementary and secondary schools in Germany. The education offensive for the digital knowledge-based society proposed by the BMBF is a step in the right direction. The concept must be backed up by budgets and specific, ambitious time schedules.

Students in tertiary institutions should be offered instruction in computer science – whatever they are studying. Computer science should be understood as a new key discipline and incorporated more into the curricula of other training courses. The new possibilities offered by Article 91b of the Basic Law should be used in a joint effort on the part of the Federal and Länder governments to implement appropriate best-practice approaches in tertiary education institutions.

Introduce targeted research funding for start-ups

Start-ups contribute in a special way to managing digital change. Up to now, the concerns of start-ups have not been sufficiently taken into account in R&D funding. The Commission of Experts proposes extending the EXIST programme by adding a further research component. This should be based on the established EXIST start-up grants and give those supported an opportunity to finance staff that might be required for short-term research needs that crop up in the course of building their company. In the funding programmes of the BMBF, the BMWi and other ministries, greater efforts should also be made to extend support to young companies that are already established on the market.

Use e-government and open data as innovation drivers

Germany still has a lot of catching up to do when it comes to digital governmental and administrative processes – so-called e-government. This is reflected in a limited and not-very-user-friendly range of digitized public services. Furthermore, data in the public sector are not yet automatically made available as open government data via well-structured access systems. The Commission of Experts welcomes the fact that important legislative framework conditions have been created in the last few months for the establishment and operation of efficient central portals for e-government and public data stocks. In the new legislative period, the Federal Government should make active use of its extended regulatory powers to significantly improve the quality of services provided for the citizens by the authorities and to open up significant value-added potential.

Create a future-oriented legal framework for the digital economy

Internet and internet-based technologies require new or adapted legal frameworks, e.g. in the fields of copyright, data protection and consumer protection. The legal framework should, wherever possible, be adopted at the European level in order to strengthen the internal market. In this context, legislation must not be geared towards building protective fences around established sectors of the economy.[11] Rather, the framework must be designed in such a way that new models of the digital economy can be introduced rationally and quickly in Germany and Europe.[12] In the long term, grandfathering and perks for established business models – e.g. the introduction of new intellectual property rights – jeopardise Europe's competitiveness as a centre of the digital economy.

Provide more effective governance for digital policies

Up to now, the activities of the government departments in charge of the Digital Agenda have been fragmented and in some cases contradictory; the Commission of Experts advocates a greater concentration of these activities. Above all, the next legislative period must see the rapid implementation of further measures to strengthen the digital infrastructure, research and innovation (especially among SMEs). Possible solutions could be an innovation agency, which has already been discussed in the Bundestag, a coordination office at the Federal Chancellery, or the creation of a digital ministry with far-reaching responsibility for the infrastructure, innovation funding, e-government, and public-sector digital procurement. The Commission of Experts believes that a political decision needs to be made in favour of an effective pooling of competencies – without again creating a high level of complexity.

CORE TOPICS 2017

B

B 1 Science system

Download
data

Pact for Research and Innovation

Funding phase Pact I (2006–2010) €1.1bn

Funding phase Pact II (2011–2015)

Annual grants to science and research organizations

3 % annual increase in funding

5 % annual increase in funding

2005
Pact for Research and Innovation

2006
Restrictions on Federal Government's financing possibilities in higher education by amendment of Articles 91a and b of the Basic Law

2007
Law on Fixed-Term Employment Contracts in Science comes into force

2009
Pact for Research and Innovation II

Higher Education Pact

First programme phase (2007–2010)

Second programme phase

1st pillar: Inclusion of additional new tertiary students

€22,000 per person, €11,000 of which financed by the Federal Government, federal funds acc. to agreement between Federal and Länder governments: €565.7m

€26,000 per person, €13,000 of which financed by the Federal Government

2nd pillar: Programme allowances for research projects funded by the DFG

20 % of the direct project funds. Budget acc. to agreement between Federal and Länder governments: €703.5m financed by the Federal Government as a special grant

20 % of the direct project funds

2007
Agreement between Federal and Länder governments on the Higher Education Pact 2020 (first programme phase)

2009
Agreement between Federal and Länder governments on the Higher Education Pact 2020 (second programme phase)

2010
Agreement between Federal and Länder governments on a programme for better study conditions and improved teaching quality

Teaching Quality Pact

First funding period (2011–2015)

Programme on better study

Federal share acc. to

Funding of 188 tertiary education institutions

Excellence Initiative

First funding period (2006–2011) €1.9bn

Funding lines: 1. Graduate schools, 2.Clusters of Excellence, 3. Institutional strategies

In the two funding periods of the Excellence Initiative a total of:

- 51 graduate schools at 35 universities
- 49 clusters of excellence at 35 tertiary education institutions
- institutional strategies of 14 universities were funded

2005
Excellence Agreement by Federal Government and the Länder

2009
Excellence Agreement II by Federal Government and the Länder

2005 2006 2007 2008 2009 2010 2011 2012

Programme for the Promotion of Young Academics

up to 2032

2016
Agreement between Federal and Länder governments on a Programme for the Promotion of Young Academics

- Promotion of tenure-track professorships, follow-up positions and equipment expenditure at tertiary education institutions, payment of a strategy premium by the Federal Government

- Federal funding: up to €1bn
- Overall funding to be secured by Länder

€1.8bn

Funding phase Pact III (2016–2020) €3.9bn

3 % annual increase in funding financed by the Federal Government alone

2014
Pact for Research and Innovation III

2015
The new Article 91b, para. 1 of the Basic Law comes into force

2016
Law on Fixed-Term Employment Contracts in Science comes into force

(2011–2015)

Third programme phase (2016–2020)

Federal funds acc. to agreement between Federal and Länder governments; last amended in 2013: €5.561bn plus completion funding of the first programme phase

€26,000 per person, €13,000 of which financed by the Federal Government, federal funds acc. to agreement between Federal and Länder governments: €6.252bn plus completion funding

Budget acc. to agreement between Federal and Länder governments: financed by the Federal Government as a special grant

22 % of the direct project funds (Financing: 20 % points federal, 2 % points Länder) Budget acc. to agreement between Federal and Länder governments: €2.174bn

2013
Amendment of the agreement between Federal and Länder governments on the Higher Education Pact 2020 (second programme phase)

2014
Agreement on the Higher Education Pact 2020 (third programme phase)

Second funding period (2016–2020)

conditions and improved teaching quality (3rd pillar of the Higher Education Pact)

agreement between Federal and Länder governments: €1.915bn

Funding of 156 tertiary education institutions

Excellence Strategy

Second funding period (2012–2017): €2.7bn

Bridge financing €734m

No time limit: €533m p.a.

Funding lines: 1. Clusters of Excellence, 2. Universities of Excellence

- Clusters of excellence (including university allowance) 45 to 50 cases of funding per year
- initially 11 universities of excellence

2016
Agreement between Federal and Länder governments on the Excellence Strategy

2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020

Overall federal conditions

up to 2006: Joint task of 'university construction' is enshrined in Article 91a para. 1 of the Basic Law; possibility of collaboration between Federal Government and the Länder in funding institutions and projects of national importance and in educational planning pursuant to Article 91b of the Basic Law

2006: Amendment of Article 91a para. 1 of the Basic Law: joint task of 'university construction' abolished; Article 91b of the Basic Law amended: federal funding restricted to projects with defined content and a time limit, to research buildings in tertiary education institutions including large appliances, and to assessing the performance of the education system by international comparison

2015: Amendment of Article 91a para. 1 of the Basic Law: Federal Government and Länder can cooperate in the funding of science, research and teaching (long term institutional funding of tertiary education institutions, individual institutes or 'institute associations' by the Federal Government is again possible)

B

For references of infocharts see Chapter D2.

B 1-1 Research at tertiary education institutions

Development of federal framework conditions

With a few exceptions, tertiary education institutions (universities and colleges) in Germany are subject to the right of initiative and executive powers of the Länder (federal states). The Federal Government's options are regulated by Germany's constitution, the Basic Law, when it comes to contributing to the financing of tertiary education institutions. There have been significant changes here in the last few years (cf. Infochart B 1). The 2006 amendment to the Basic Law, which severely restricted the Federal Government's previously existing financing options in higher education, was the subject of a great deal of criticism because it restricted opportunities to further develop the German science system.[13] The Commission of Experts, too, has on several occasions advocated putting the Federal Government back into a position to take responsibility for the long-term institutional funding of tertiary education institutions.[14] In 2014, the Bundestag and Bundesrat finally decided to amend Article 91b of the Basic Law once more to make long-term institutional funding possible again.[15] This will create new opportunities for advancing the development of the German science system. In June 2016, an agreement was concluded between the Federal and Länder governments on the Excellence Strategy on the basis of the amended Article 91b of the Basic Law (cf. Chapter B 1-2).

Staffing and financial resources of tertiary education institutions

In 2015, there were 426 tertiary education institutions in Germany: 107 universities, 215 universities of applied sciences (UAS) and 104 other tertiary education institutions.[16] They employed 385,300 people as academic or artistic staff; for 239,200 of them this was their principal employment, for 146,100 their secondary employment.[17] The total number of academic and artistic staff has risen by 60 percent compared to 2005. At the same time, there have been significant changes in the personnel structure due to an above-average growth of fixed-term, third-party-funded jobs for young academics (cf. Chapter B 1-3 for more details).

Despite the increase in academic and artistic staff, there has been a slight worsening of the student/faculty ratio – i.e. the numerical ratio between students and academic/artistic staff in terms of full-time equivalents (FTEs) without externally funded staff. It rose from 15.2 to 16.6 students per FTE between 2004 and 2014.[18] In the same period, the ratio between students and full-time professors deteriorated from 51.1 to 59.0.[19]

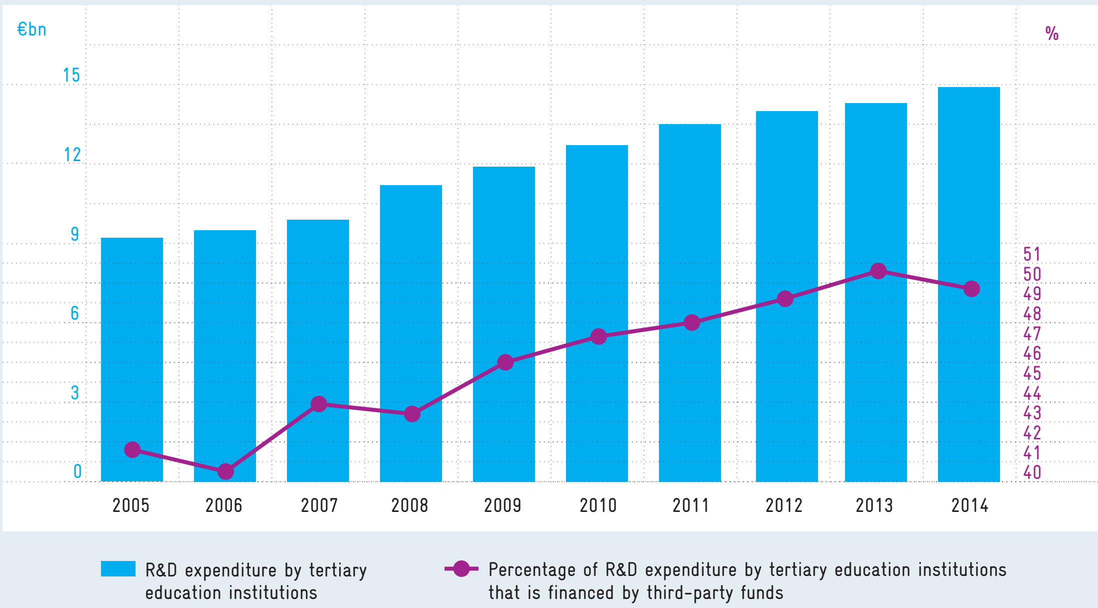
The basic funds (Grundmittel)[20] of the tertiary education institutions totalled 23.1 billion euros in 2014, having risen by 43 percent in nominal terms since 2005.[21] The Higher Education Pact contributed to this growth because funding from its first pillar is attributed to basic funds. The Higher Education Pact was initiated as a Federal and Federal-State programme (Bund-Länder-Programm) in 2007 with the aims of securing sufficient study opportunities to meet demand (first pillar) and strengthening research at tertiary education institutions by introducing overhead allowances (second pillar) (cf. Infochart B 1).

Over the last ten years, the overall importance of third-party funding has increased considerably compared to basic funds. In 2005, 23 euro cents in third-party funds was received for every euro of basic funds; by 2014 this figure had risen to 32 euro cents.[22] Third-party funds are generally used to finance research, but not teaching.[23] The costs of teaching must ultimately be covered by tertiary education institutions' basic funds, so that the financial room for manoeuvre is reduced whenever third-party funds do not adequately cover the overhead costs[24] related to third-party projects (cf. next section).

Fig. B 1-1-1

Download data

R&D expenditure by tertiary education institutions in billions of euros and percentage of externally funded R&D expenditure by tertiary education institutions between 2005 and 2014



How to read: R&D expenditure by tertiary education institutions amounted to €11.9bn in 2009; 46 percent of R&D expenditure was financed by third-party funds.
Source: Statistisches Bundesamt (Federal Statistical Office), Fachserie 11, Reihe 4.3.2; own calculations.

R&D personnel and the funding of R&D at tertiary education institutions

In 2014, the year for which the latest statistics are available, Germany's tertiary education institutions employed R&D personnel amounting to approximately 132,500 full-time equivalents.[25] This was an increase of 40 percent since 2005. The percentage of all R&D staff who were third-party-funded rose from 50 percent in 2005 to 62 percent in 2014.

The R&D expenditure of German tertiary education institutions amounted to approximately 14.9 billion euros in 2014.[26] Third-party funding accounted for 50 percent in 2014, having risen from 42 percent in 2005. The increase in third-party funds stemmed from different sources. In absolute terms, there were increases in third-party funding particularly by the German Research Foundation (Deutsche Forschungsgemeinschaft, DFG), including funding within the framework of the Excellence Initiative, and the Federal Government.[27]

On the one hand, this increase in third-party funds brought major benefits, because it allowed a marked expansion of research at tertiary education institutions.[28] In addition, it can be assumed to have contributed to an improvement in quality, since the allocation of research funds within the framework of an application and competition procedure is more geared towards specific quality criteria than the allocation of basic funding.

On the other hand, increasing third-party funding also involves risks. For example, the greater orientation towards third-party funding can restrict the freedom of researchers in terms of content and the amount of time available. Writing research applications is very time consuming, and the review and assessment of applications by other researchers also increasingly ties up valuable resources. Moreover, third-party funds sometimes have thematic restrictions, creating incentives for the researchers to gear their research to areas where funding is available. On the one hand, this is the intention of providers of the third-party funds. On the other hand, promising research programmes and important topics with a comparatively low chance of third-party funding might be neglected. The increase in third-party funding thus also involves the risk that university research might lose breadth and diversity. These problems should be taken seriously by political decision-makers – research and teaching at tertiary education institutions must therefore be sustainably and substantially financed by basic funding.

Another problem with rising third-party funding is overhead costs, some of which have to be covered by resources from basic funding. At present, the DFG provides a programme allowance amounting to 22 percent of the direct costs (cf. Infochart B 1), and the Federal Ministry for Education and Research (BMBF) pays a project allowance of 20 percent for research projects conducted by tertiary education institutions and university hospitals, in order to cover overhead costs. However, these allowances cannot fully cover the overhead costs that are actually incurred. Thus, with growing volumes of third-party funding, tertiary education institutions are forced to use more and more basic funds to cover the overhead costs of third-party projects.[29] The Commission of Experts is therefore in favour of bringing the overhead allowances more into line with the overhead costs actually incurred. Discipline-specific differences must be taken into account to avoid distortions in the allocation and use of funds.

Excellence Initiative and Excellence Strategy

B 1–2

Objectives and structure of the Excellence Initiative

The aim of the Excellence Initiative is to make top performers in the university and science field more visible and to improve the overall quality level of German academia and research.[30] The Federal-Länder agreement on the first funding period of the Excellence Initiative was concluded in 2005 for the period from 2006 to 2011 and includes a budget of 1.9 billion euros.[31] The second Excellence agreement was signed in 2009 for the period from 2011 to 2017.[32] The agreement provided for a budget of 2.7 billion euros. Support is granted on the basis of three funding lines: graduate schools, clusters of excellence, and institutional strategies:

– The graduate schools support young scientists and academics and aim to create optimum conditions for doctoral research within a broad scientific field.[33] At the same time, they are supposed to help develop leading, internationally competitive, and excellent scientific locations in Germany and to raise their profile.
– The aim of clusters of excellence is to establish internationally visible and competitive research and educational institutions at German university locations and to promote scientific networking and cooperation.[34] The aim is to sharpen the profile of the universities and create excellent research and career conditions for young scientists.
– Institutional strategies aim to expand top-level university research in a project-based manner in Germany and to make it more internationally competitive.[35] The funding aims to strengthen universities in their entirety as institutions and establish them in the top group of international competition. The prerequisite for funding an institutional strategy was the simultaneous funding of at least one cluster of excellence or DFG research center and at least one graduate school.[36]

The DFG and the German Council of Science and Humanities (Wissenschaftsrat) were charged with the implementation of the science-driven selection and evaluation procedure.

Impacts of the Excellence Initiative

As shown by the current ‘University Barometer’ of the Donors’ Association for German Science (Stifterverband für die Deutsche Wissenschaft), most university managements give the Excellence Initiative a positive assessment.[37] Approval is 100 percent among the managements of supported universities, and 82 percent among those universities that are not supported. Almost two thirds of managements at universities of applied sciences share this positive assessment.

According to a bibliometric study published by the Berlin Brandenburg Academy of Sciences (Berlin-Brandenburgische Akademie der Wissenschaften), 25.9 percent of the Cluster of Excellence publications from 2008 to 2011 belonged to the group of publications in the top decile of the citation distribution[38] – the percentage for universities as a whole was 14.3 percent.[39] Both the authors of this study and the International Commission of Experts on the Excellence Initiative (IEKE), which was set up to evaluate the Excellence Initiative, point out that on the basis of the data, it is impossible to say whether the new university research priorities have evolved or whether existing research capacity has only been made visible by bundling.[40] The IEKE sums up as follows: “Although it cannot be proved that the German university system has become more differentiated as a result of the Excellence Initiative, at least the ‘all-are-equal’ illusion has been buried in the course of the public discussion."[41] Moreover, the IEKE comes to the conclusion that the Excellence Initiative has driven the internationalization of German research forward.[42]

Excellence Strategy

Already in December 2014, the Federal and Länder Governments passed a fundamental decision to adopt a follow-up program to the Excellence Initiative, which expires in 2017.[43] After the IEKE submitted its evaluation of the Excellence Initiative in January 2016, the Joint Science Conference (Gemeinsame Wissenschaftskonferenz, GWK) drafted an agreement between the Federal and Länder Governments for an 'Excellence Strategy' in April 2016, which was adopted in a modified form by the Federal and Länder Governments in June 2016.[44] The Federal and Länder Governments intend to "maintain and build on the new dynamism within the German science system generated by the Excellence Initiative, and to provide longer-term prospects for successful Excellence Initiative projects. A further aim is to strengthen the universities by supporting the enhancement of their subject-specific and strategic profiles, which can relate to all performance areas."[45] 533 million euros per year will be made available for this purpose.[46]

The current Excellence Initiative has been extended by two years, i.e., the ongoing projects will receive transitional funding for a maximum of 24 months. A total of approximately 734 million euros will be made available for the period from 2017 to 2019.[47]

As recommended by the IEKE,[48] graduate schools will no longer be continued as a separate funding line in the Excellence Strategy. The other two funding lines are to be further developed:[49]

– The Cluster of Excellence funding line is designed to support project-based funding in internationally competitive research fields at universities or university consortia. The funding lasts for twice seven years. To strengthen governance and strategic orientation, universities with a Cluster of Excellence can apply for a university allowance.[50]
– The second funding line – the Universities of Excellence – aims to strengthen universities or university consortia as institutions in the long term and to further develop their leading international role in research on the basis of successful Clusters of Excellence. Funding is subject to the approval of two Clusters of Excellence at a university, or three in the case of a university consortium. Eleven universities of excellence and university consortia will be funded in the first call for proposals. They will be evaluated after seven years. New calls will be issued to fill any position that becomes vacant; four new universities will definitely be included.

The procedure for the Cluster of Excellence funding line is conducted by the DFG, for the Universities of Excellence by the German Council of Science and Humanities.

The Commission of Experts welcomes the decision in favor of a follow-up program for the Excellence Initiative with no time limit. The possibilities opened up by the new Article 91b of the Basic Law have been put to good use. The Commission of Experts agrees with the goal of both funding lines – institutional funding for the best-performing universities and support for outstanding research structures.

In its 2016 Report, the Commission of Experts suggested that the term 'excellence' should be defined more precisely in future. In its view, a University of Excellence must not only conduct outstanding research, but also make a successful contribution to knowledge and technology transfer.[51] This recommendation has been partly met in the Excellence Strategy. Measures relating to the transfer of ideas and knowledge, and measures in the field of research-based teaching and research infrastructures, can be funded in both funding lines of the Excellence Strategy if they support the objective of top-level research.[52]

The Commission of Experts fully agrees with the idea of selecting the institutions to be funded in a science-driven competition procedure, and with reducing the workload associated with the application in relation to the duration of funding.

Young academics at tertiary education institutions

B 1–3

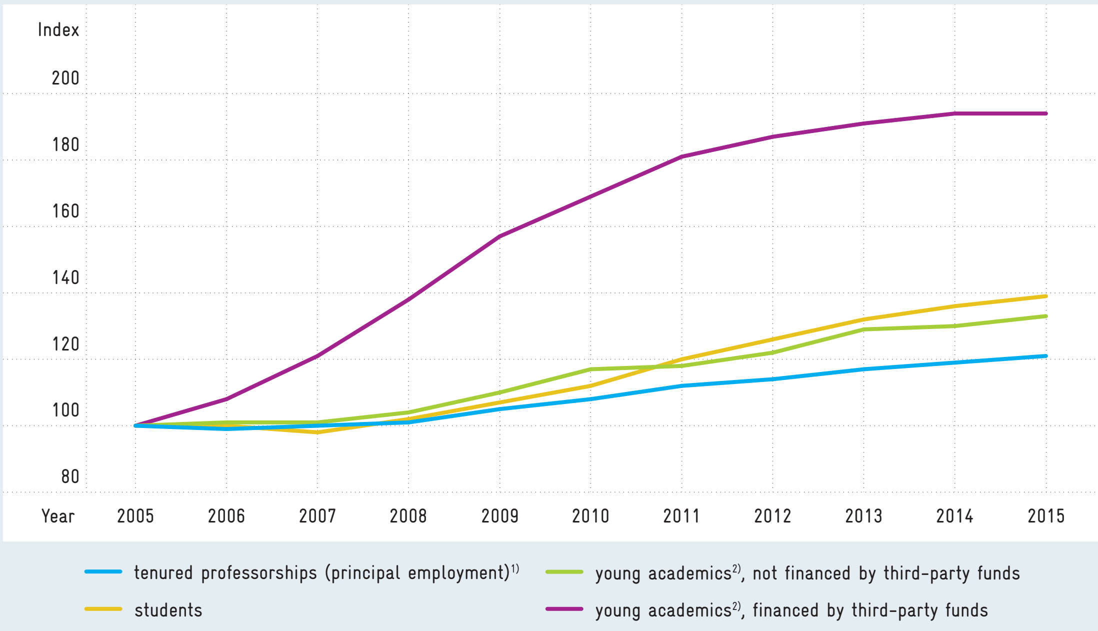
Development of the structure of personnel at tertiary education institutions

The structure of personnel at German tertiary education institutions has changed considerably over the last decade – among other things as a result of the Higher Education Pact, the Excellence Initiative and the increase in third-party funding (cf. Chapters B1-1 and B 1-2; Figure B 1-5-1).[53] The number of full-time tenured professors[54] grew comparatively slowly from 2005 to 2015 (plus 21 percent to 43,700), and was unable to keep pace with the growth in the number of students (plus 39 percent to 2.76 million). The number of young academics[55] not financed by third-party funds (114,400) grew slightly faster (at a rate of 33 percent) than the number of professors. The number of young academics financed by third-party funds grew by far the most (plus 94 percent to 71,300). The

Fig. B 1-3-1

Download data

Development of the number of professorships, the number of scientific and artistic staff who can be classified as young scientists, and the number of students at German tertiary education institutions, 2005 to 2015



Index: 2005 = 100

1) Tenured (principal employment) professorships do not include temporary professorships paid according to the C2 scale (or equivalent remuneration grades) or junior professorships.

2) Young academics include the following personnel categories: temporary professorships paid according to the C2 scale (or equivalent remuneration grades), junior professorships, lecturers, assistants, academic and artistic staff.

Source: own calculations based on Statistisches Bundesamt (Federal Statistical Office), Fachserie 11, Reihe 4.4 and 4.1.

Box B 1-3-2

Programme for the Promotion of Young Scientists

The aim of the Programme for the Promotion of Young Scientists is to create 1,000 additional tenure-track professorships, and retain them permanently within the overall number of professorships at universities. After the programme expires, the number of permanent professorships at universities should have increased by the same amount.[56]

The Federal Government is making funds of up to one billion euros available to finance the programme over the period from 2017 to 2032. Decisions on the funding of tertiary education institutions are taken by a selection committee in a competitive procedure.

The funding can be used for the following:
- personnel expenditure for tenure-track professorships,
- personnel expenditure for follow-up positions (W2 or W3 equivalent) for up to two years,
- equipment costs,
- 15 percent strategy premium on personnel expenditure and equipment costs.

The Länder where the institutions are located[57] are responsible for securing the total funding of the programme.[58]

growth rate here was thus more than four times higher than the rate for professors over the past decade.[59]

On the one hand, the sharp increase in the number of young academics is desirable, because it is the result of the above-mentioned programmes and the intended increase in third-party funding. On the other hand, this also causes a considerable imbalance in the personnel structures – specifically in the ratio between junior staff and tenured full professors. Such a development adversely affects long-term employment opportunities for young academics in the higher education sector. The problem is further aggravated by the fact that a large proportion of the newly established positions for young academics explicitly aims to train junior staff for an academic career. However, the number of tenured professorships as potential 'landing' places for the trained junior staff is falling further and further behind. The professorships vacated by retirement cannot rectify the resulting imbalance.[60] The enormous growth in the number of young academics is greatly aggravating the 'bottleneck' problem. The insufficient number of tenured full professorships will aggravate this 'bottleneck' in the coming years.

Structural changes in the system are urgently required to counteract this growing imbalance in the personnel structure and to prevent investment in training and employment opportunities from drifting further apart. On the one hand, additional tenured full professorships need to be created – not just to generate new employment opportunities, but also to sustainably improve the quality of research and teaching. On the other hand, the training of young academics should focus more on career prospects outside the higher education sector.[61] The issue here is that it is necessary not only to create new employment opportunities, but also to intensify the transfer of knowledge and technology that is so important for innovation. When junior staff move from tertiary education institutions to the business sector, the knowledge generated in research is transferred directly to established companies or spin-offs. Both steps – the creation of additional tenured full professorships and extending qualification targets to also cover the labour market outside academia – can sustainably strengthen the tertiary education and innovation system in Germany.

In this context, the Commission of Experts considers it necessary to also adapt the student/faculty ratios[62] by creating additional tenured professorships, so that the quality of training can be improved, the time available for research can be increased, and the teaching loads can be made more internationally competitive. Without an adjustment of the student/faculty ratios, any increase in the number of tenured professorships will result in the need for tertiary education institutions to increase the number of students. This could lead to a lowering of both entry thresholds and training standards.

Law on Fixed-Term Employment Contracts for young academics

Most young academics at tertiary education institutions have fixed-term contracts. Such contracts are subject to the Law on Fixed-Term Employment Contracts in Science (WissZeitVG), which came into force in 2007 and was modified in 2016.[63] This amendment eliminated several shortcomings in the previous version. However, the Commission of Experts is doubtful whether the revised version of the law will lead to a general and sustainable improvement in the situation of young academics. Furthermore, tertiary education institutions are heavily burdened with additional bureaucracy and their flexibility restricted. At the same time, the key issue – the small number of tenured full professorships – is not being addressed.

Programme for the Promotion of Young Academics

In June 2016, the Federal and Länder governments agreed a Programme for the Promotion of Young Academics (cf. Box B 1-3-2) pursuant to Article 91b paragraph 1 of the Basic Law.[64]

Although in Germany it was in principle also possible to offer tenure-track careers to promote young academics even before the establishment of the Programme for the Promotion of Young Academics, tertiary education institutions made only very limited use of this option. From the point of view of junior researchers, this may have reduced the attractiveness of German tertiary education institutions compared to international competitors (cf. Chapter B 1-5).[65] In its 2012 Report, the Commission of Experts already recommended that tenure-track careers should also be established at German tertiary education institutions, and that the number of tenured full professorships be simultaneously increased.[66]

Of course, it is too early to see any effects of the new Programme for the Promotion of Young Academics adopted in June 2016. However, the Commission of Experts doubts that all the Länder will be able or willing to guarantee the overall financing of the programme. The Commission of Experts is concerned that the tenure-track positions funded by the Federal Government will in many cases simply be used to bring regular appointment decisions forward. The Alliance of Science Organisations also sees this risk, should the Länder fail to meet their financing commitments.[67] The 'bottleneck' problem would not be resolved, but at best postponed for a while, and could even worsen.

B 1-4 Non-university research organisations

B

Pact for Research and Innovation

Germany has a highly developed system of research with several independent research organisations, each with a very distinctive mission.

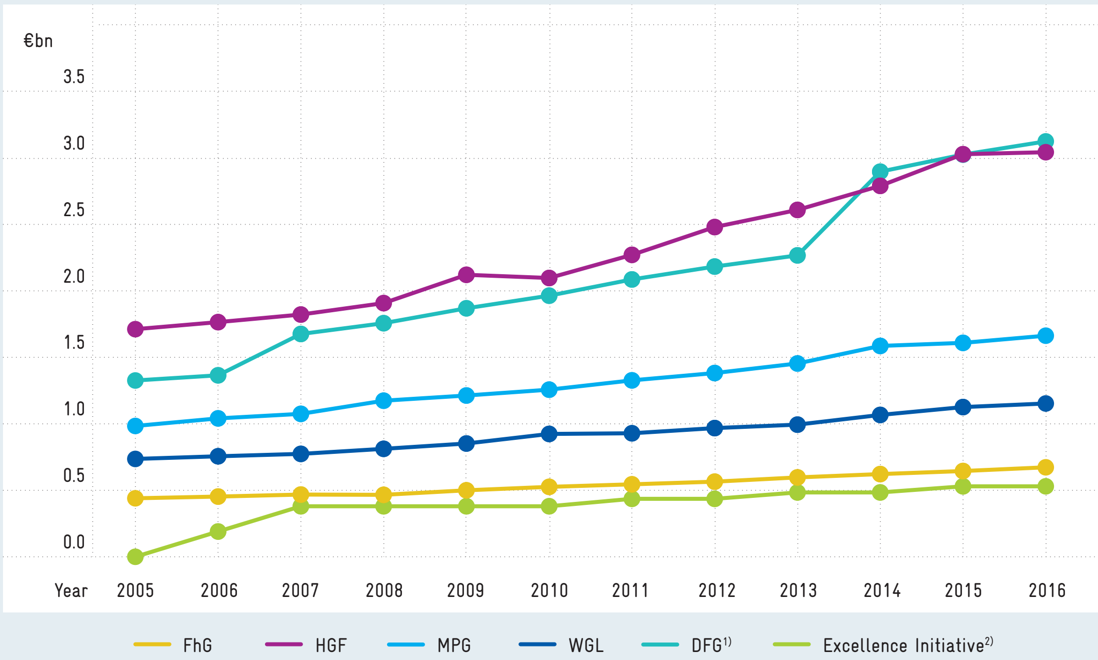
In order to boost the international competitiveness of this system, in 2005 the Federal and Länder governments concluded the Pact for Research and Innovation (Pakt für Forschung und Innovation, PFI) with the four main organisations of non-university research – the Fraunhofer Society (FhG), the Helmholtz Association (HGF), the Max Planck Society (MPG) and the Leibniz Association (WGL) – as well as the German Research Foundation (Deutsche Forschungsgemeinschaft, DFG); it was extended most recently

Fig. B 1-4-1

Download data

Grants from the Federal Government and the Länder for non-university research organisations and the German Research Foundation (DFG), 2005 to 2016

Institutional grants to FhG, HGF, MPG, WGL and DFG, as well as grants to the DFG for the implementation of the Excellence Initiative in billions of euros.



1) Including Federal Government grants for programme allowances under the Higher Education Pact as well as Federal Government grants and complementary grants by the Länder for large appliances at tertiary education institutions according to implementation agreements, research buildings and large appliances.

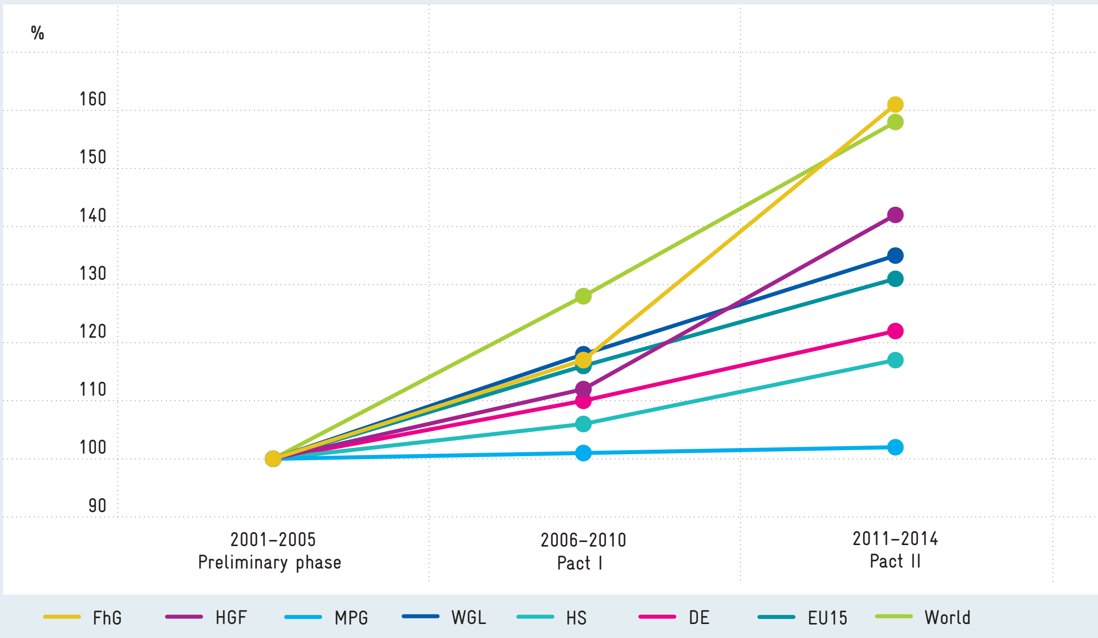
2) Plus pro-rata administrative costs of the German Council of Science and Humanities (Wissenschaftsrat).

Source: GWK (2016c: 96).

Fig. B 1-4-2

Download data

Development of publications of non-university research organisations, tertiary education institutions, Germany, EU-15 and the world, 2001 to 2014 (as percentages)



Index: 2001–2005 = 100
Fractional counting based on the number of institutions stated.
Source: ThomsonReuters – Web of Science in Frietsch et al. (2016).

in December 2014 to cover the years 2016 to 2020.[68] The Pact lays down the research-policy objectives to be implemented by the non-university research organisations. These aims include networking within the science system, intensified international and European cooperation, more exchanges between science on the one hand and the private sector and society on the other, and winning the best researchers for German science. In return, the science organisations received (and are still receiving) financial planning security through an annual budget increase of 3 percent between 2006 to 2010, 5 percent between 2011 and 2015, and 3 percent for the 2016 to 2020 period.[69] It has not yet been decided whether and how the PFI is to be continued after 2020.

Figure B 1-4-1 provides an overview of the growth in the funds allocated by the Federal and Länder governments to the non-university research organisations and the DFG, including the Excellence Initiative, in the period from 2005 to 2016.

Publication activities of research organisations and tertiary education institutions

An analysis of the publication activities of non-university research organisations and tertiary education institutions has been conducted to compare the results from the first (2006–2010) and second (2011–2015) periods of the PFI with the initial figures before the pacts came into force (2001–2005).

In order to categorise the development of publication activities at German non-university research organisations and tertiary education institutions, they are compared with world-wide publication activities and with activities in the EU-15 countries. Worldwide, the number of scientific publications has risen considerably since the beginning of the new millennium. This increase was primarily caused by the increase in publications from Asia, especially China, India and South Korea.[70]

Figure B 1-4-2 shows that the number of publications from all non-university research organisations and tertiary education institutions rose during the study period. The MPG shows the lowest growth, the FhG has the highest. The increase in the number of publications can be mainly explained by the increase in scientific staff at these establishments during the study period.[71] By contrast, the scientists' publication intensity has fallen slightly. For example, the annual average number of journal articles per scientist[72] fell at MPG from 0.83 (2001-2005) to 0.62 (2011-2014), at HGF from 0.28 (2001-2005) to 0.25 (2011-2014) and at tertiary education institutions from 0.38 (2001-2005) to 0.33 (2011-2014).[73] One explanation for this decline is the trend towards co-publications. With research projects becoming ever larger and more complex, the average number of researchers involved is growing and with it the number of authors participating in a publication.[74] When calculating the level of publication intensity, the publications are attributed to the respective researchers pro-rata, which, when the number of co-authors is rising, tends to lead to a decrease in publication intensity, because the number of publications does not rise linearly with the number of co-authors when research projects become more complex.

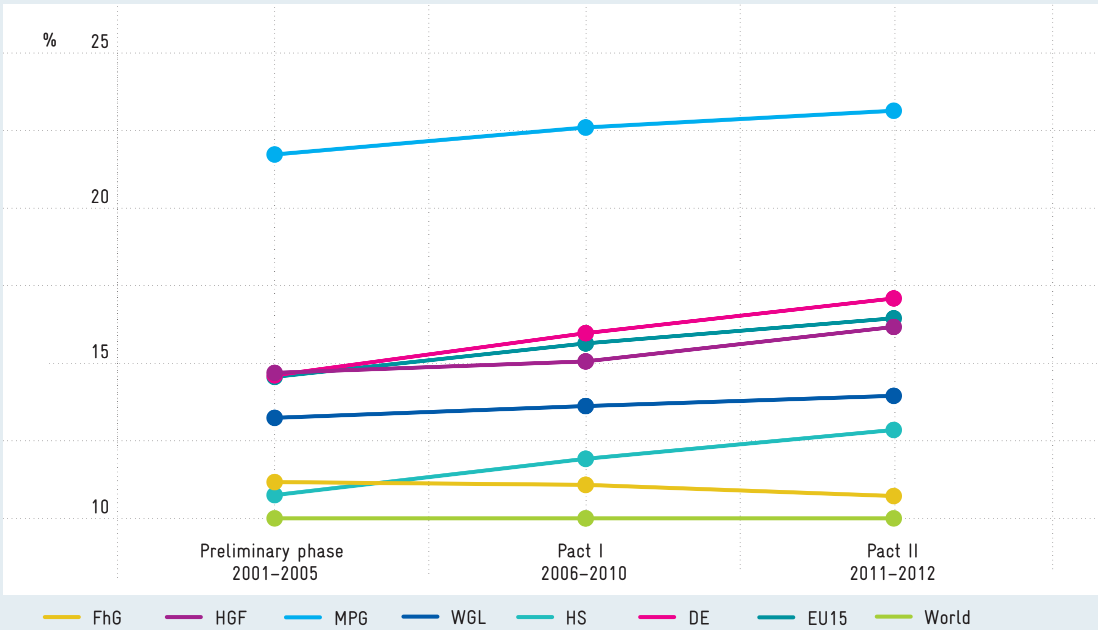
However, the number of publications has not increased at the expense of quality. If we look at the development of excellence rates of publications by non-university research organisations and tertiary education institutions (cf. Figure B 1-4-3), we see a marked increase in the excellence rate of over 2 percentage points for the tertiary education institutions. Their excellence rate rose from 10.8 (2001-2005) to 12.9 percent (2011-2012). The non-university research organisations also showed a rising excellence rate for the study period. The only exception is the FhG, which is devoted primarily to applied research and technology transfer. This is reflected in a lower intensity of publishing activities compared to the other organisations surveyed. The FhG recorded a slight decline in the excellence rate during the study period from 11.2 (2001-2005) to 10.7 percent (2011-2012). However, the Commission of Experts does not regard this decline as a cause for concern. In order to

B

Fig. B 1-4-3

Download data

Development of the excellence rate* of publications by non-university research organisations, tertiary education institutions, Germany, EU-15 and the world (as percentages)



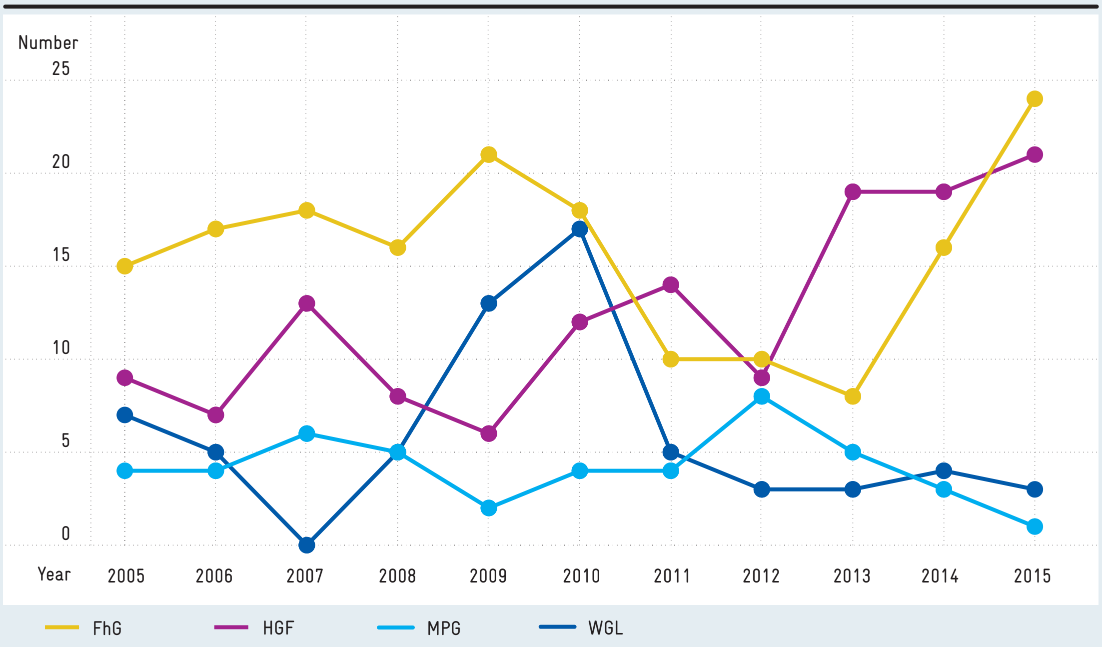
* Excellence rate: share of publications belonging to the top 10 percent of the most cited publications worldwide in the respective field. The excellence rate is calculated on the basis of citations. Since the chart is based on a citation period of three years (including the year of publication), it can only include publications with a corresponding time interval from the present.
Source: ThomsonReuters – Web of Science in Frietsch et al. (2016).

Fig. B 1-4-4

Download data

Spin-offs from non-university research organisations, 2005 to 2015

Number of spin-offs founded in a calendar year to exploit the organisation's intellectual property rights or know-how under a formal agreement.



Source: GWK (2016c: 117), own diagram.

keep the FhG's focus on applied research and technology transfer, its work should in the future also not be evaluated primarily on the basis of the publication indices that are otherwise customary in science.

By contrast, the excellence rate is particularly high at the MPG; it rose from 21.7 (2001-2005) to 23.1 percent (2011-2012). The institutes of the Max Planck Society are primarily geared towards excellent basic research.

Spin-offs from research organisations and tertiary education institutions

In addition to their scientific work, one of the tasks of non-university research organisations is to transfer research findings to market applications. One instrument used in this context is spin-offs, which are supported by all four non-university research organisations via their own funding programmes and service institutions.[75]

An analysis of the spin-offs between 2006 and 2015 shows that there was no systematic increase in start-up activities at non-university research organisations during this period (Figure B 1-4-4). The Commission of Experts believes that non-university research organisations still have potential to increase their start-up activity.

Compared to non-university research organisations, there are significantly more spin-offs at tertiary education institutions.[76] These differences can be explained by examining the heterogeneity of the spin-offs. For example, spin-offs in the field of social media, which are not very capital-intensive, take place primarily at universities and not at non-university research organisations.

An analysis of technically sophisticated start-ups financed by the High-Tech Gründerfonds (HTGF)[77] reveals that there is no difference concerning the likelihood of financial funding between spin-offs from tertiary education institutions and from non-university research organisations (cf. Table B 1-4-5).

Tab. B 1-4-5

Download data

Spin-offs from tertiary education institutions and research institutions that are financed by the High-Tech Gründerfonds (HTGF), 2005 to 2015[78]

Year of the query	Queries on spin-offs	of which tertiary education institutions	of which research institutions	HTGF-financed	of which tertiary education institutions	of which research institutions
2005	41	33	8	20	16	4
2006	75	59	16	20	18	2
2007	89	72	17	19	14	5
2008	86	70	17	14	12	2
2009	105	74	31	16	14	2
2010	88	72	16	16	12	4
2011	136	113	24	24	19	5
2012	124	101	25	13	11	3
2013	134	112	23	18	15	3
2014	115	92	23	11	9	2
2015	92	76	22	7	5	2

Research institutions: research institutions of the four major non-university research organisations, federal department research institutions and other research institutions.
Source: High-Tech Gründerfonds Management GmbH.

B

The mobility of researchers

B 1–5

When researchers are internationally mobile,[79] knowledge is disseminated and new combinations of knowledge can be made – favouring the emergence of innovations.[80] On average, mobile researchers are more productive than those who remain in their home country. For this reason, they are of particular relevance for an R&I policy that is oriented towards research excellence.[81]

Net migration balances among publishing researchers

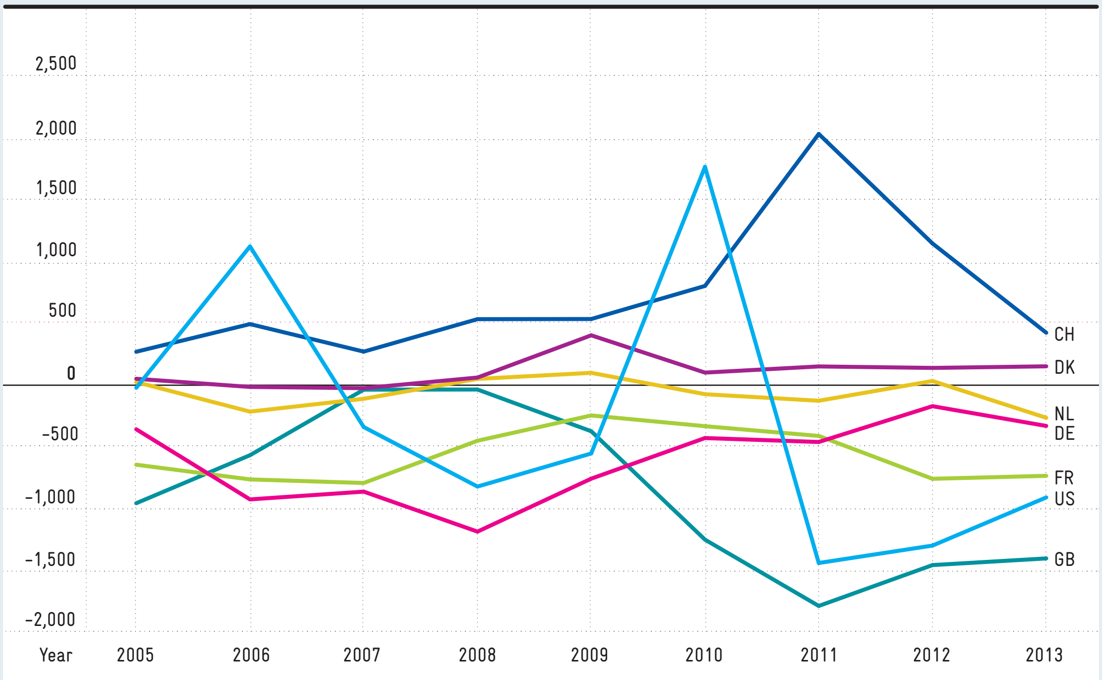
OECD statistics evaluating the migration movements of all publishing researchers give a first impression of the development of net researcher migration and Germany's international position (cf. Figure B 1-5-1).[82] According to these figures, there has been

B

Fig. B 1-5-1

Download data

Net migration of publishing researchers in selected countries between 2005 and 2013

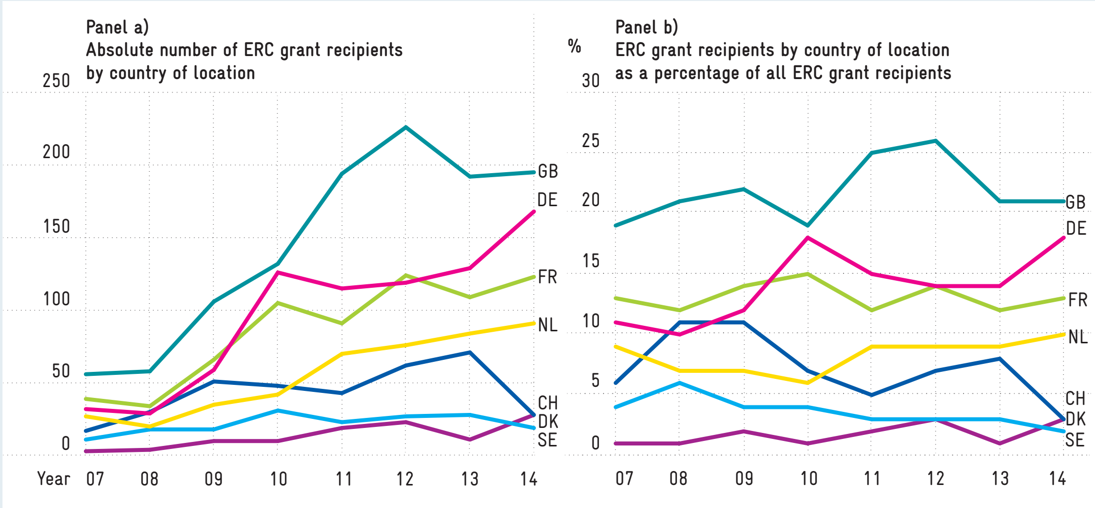


Source: OECD (2015a: 68). The bibliometric calculations carried out therein are based on Scopus Custom Data, Elsevier.
Legend: Germany had a negative net migration balance of approximately 335 researchers in 2013. Net migration is calculated from the difference between the number of publishing researchers who immigrate to Germany minus the number of publishing researchers who emigrate from Germany in the same year.

Fig. B 1-5-2

Download data

Grants of the European Research Council (ERC) according to the country of location of the funded scientists' research institution, 2007 to 2014



Notes: ERC grants include 'Starting Grants', 'Advanced Grants' and 'Consolidator Grants'. Under the different funding lines, top scientists receive funds amounting to between €1.5m and €2.5m for a period of five years.
Source: own diagram based on EFI (2011, 2014) and calculations using the EU ECORDA database.
Legend for Panel a): In 2014 there were 168 ERC grant recipients at research institutions in Germany.
Legend for Panel b): In 2014, 18 percent of all ERC grant recipients were at research institutions in Germany.

an upward trend since 2008, although the migration balance was again negative in 2013, i.e. the number of researchers emigrating was higher than the number of those immigrating. On balance, therefore, Germany loses several hundred researchers to foreign research institutions every year.[83]

A comparison (based on OECD statistics for 2013) between the publication performance of mobile researchers with that of non-mobile researchers residing in Germany reveals[84] that an above-average number of researchers who publish prolifically have returned to Germany.[85] The publication performance of newcomers from abroad is also slightly above-average. However, in the case of returning researchers, the figures for the science systems in neighbouring countries like Switzerland, France and the Netherlands are still slightly better than in Germany. Moreover, when it comes to newcomers, research locations such as Switzerland, the USA, Denmark and Sweden are also more successful than Germany. Thus, there is room for improvement for the German science system which should be better exploited.[86]

ERC grants in an international comparison

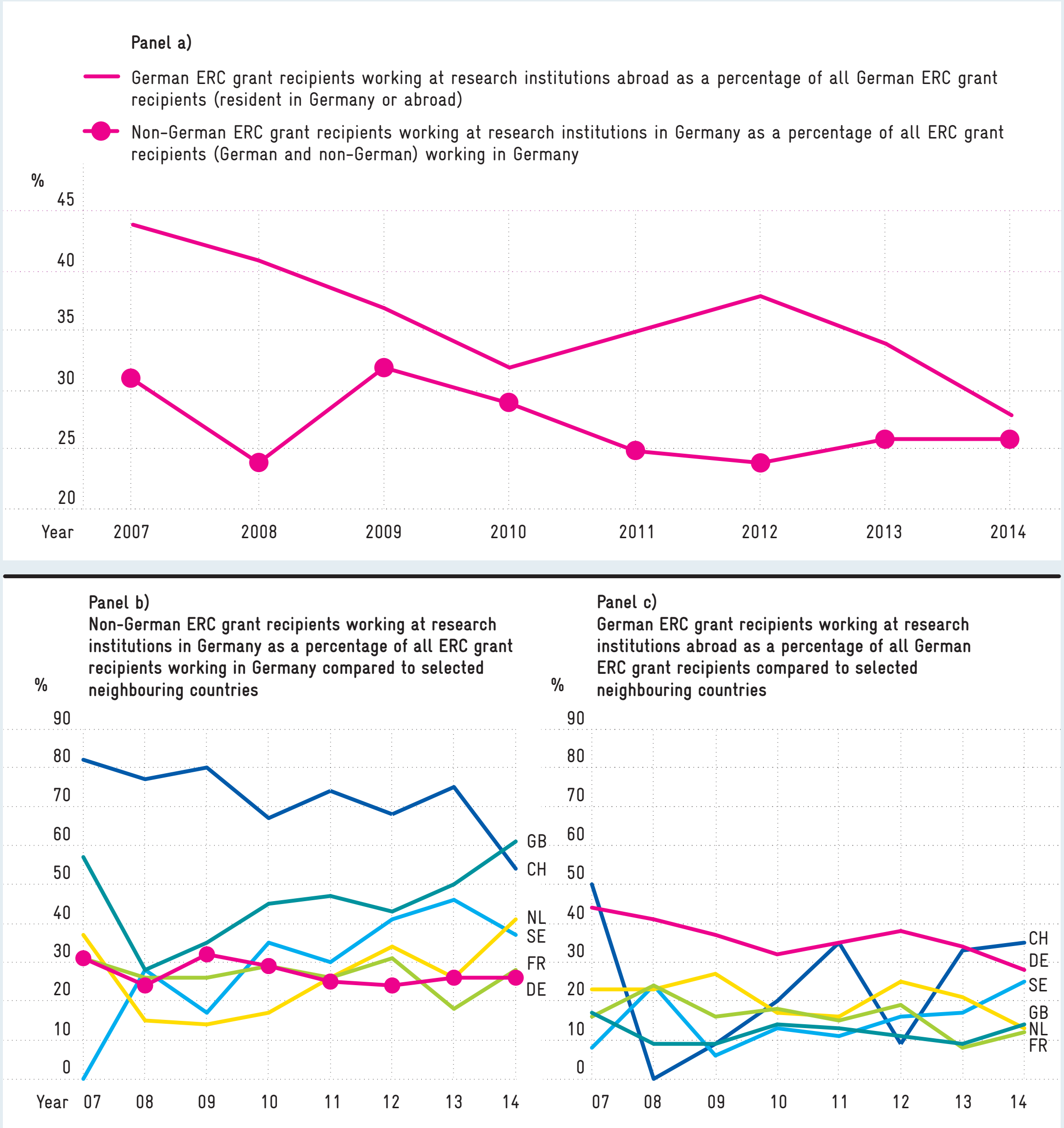
If the impact of mobility on a country's top-level science is measured by the number of attracted ERC grants (cf. Figure B 1-5-2), the picture for Germany is again mixed.[87] Since 2007 there has been an almost continuously rising trend in the absolute number of ERC grants for German locations (from 32 to 168 grants, cf. Figure B 1-5-2, panel a). However, the number of ERC grants has risen across all countries in this period, so that Germany's relative share rose to almost 20 percent up until 2010, but has not risen any further since (cf. Figure B 1-5-2, panel b).

But how does the international mobility of researchers influence the country-specific location of ERC grants, and what conclusions can be drawn from this about the attractiveness of Germany as a science location? To answer this question, the nationality of the ERC grant winners can be compared with the country in which they won their ERC grant (cf. Figure B 1-5-3, panel a). This reveals that of all the Germans who have won an ERC grant, a considerable proportion are

Fig. B 1-5-3

Download data

Grants of the European Research Council (ERC) according to the country of location of the funded scientists' research organisation and according to the scientists' nationality, 2007 to 2014



Source: own diagram based on EFI (2011, 2014) and calculations using the EU ECORDA database.
Notes: ERC grants include 'Starting Grants', 'Advanced Grants' and 'Consolidator Grants'. Under the different funding lines, top scientists receive funds amounting to between €1.5m and €2.5m for a period of five years.
Legend for Panel b): In 2014, foreign researchers won 26 % of all ERC grants in German research institutions; in the United Kingdom, foreign researchers won 61 percent of all local ERC grants.
Legend for Panel c): In 2014, 28 percent of all German ERC grant recipients won their grants at research institutions abroad, while 12 % of all French ERC grant recipients won their grants at research institutions abroad.

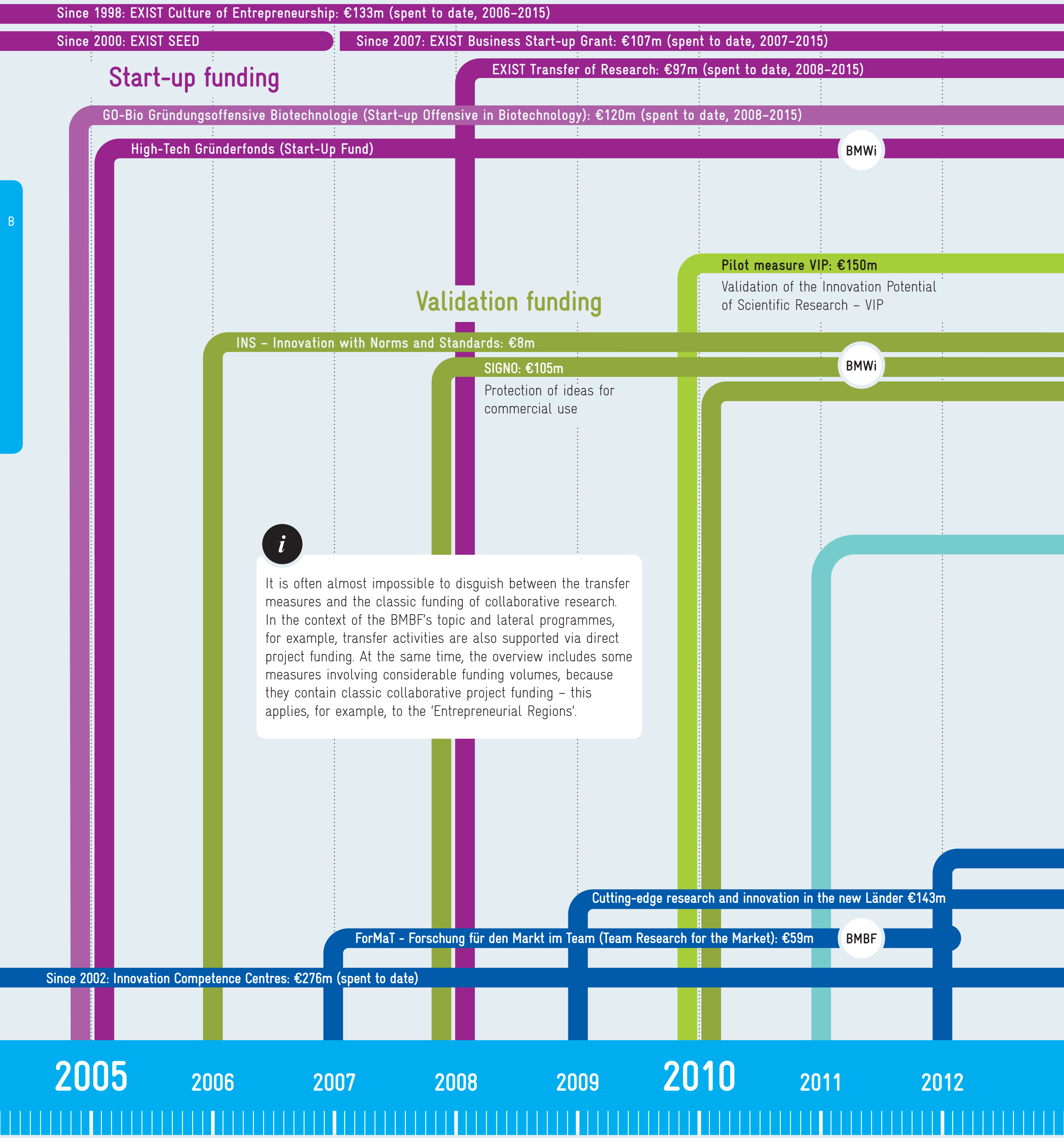
not residing in Germany but abroad (about 28 percent in 2014). However, the trend is declining noticeably. At the same time, the percentage of foreign researchers who won an ERC grant while residing in Germany has remained more or less stable over the years. Most recently, it has been approximately 25 percent. Germany thus positions itself in the middle of the table compared to neighbouring European countries, while Switzerland and the United Kingdom respectively record much higher immigration (cf. Figure B 1-5-3, panel b) and simultaneously lower emigration of their own top researchers (cf. Figure B 1-5-3, panel c).

Further information on the attractiveness of a science location can be obtained from surveys of researchers on their reasons for migrating.[88] The reasons most commonly given in these interviews are the scientific excellence of the host institution, collaboration with outstanding research teams, better career prospects in the host country, and a powerful research infrastructure.[89] In this context, it can be supposed that the positive trends in the international mobility of researchers in Germany in recent years have, among other things,[90] been promoted by the Excellence Initiative.[91]

B 2 Transfer

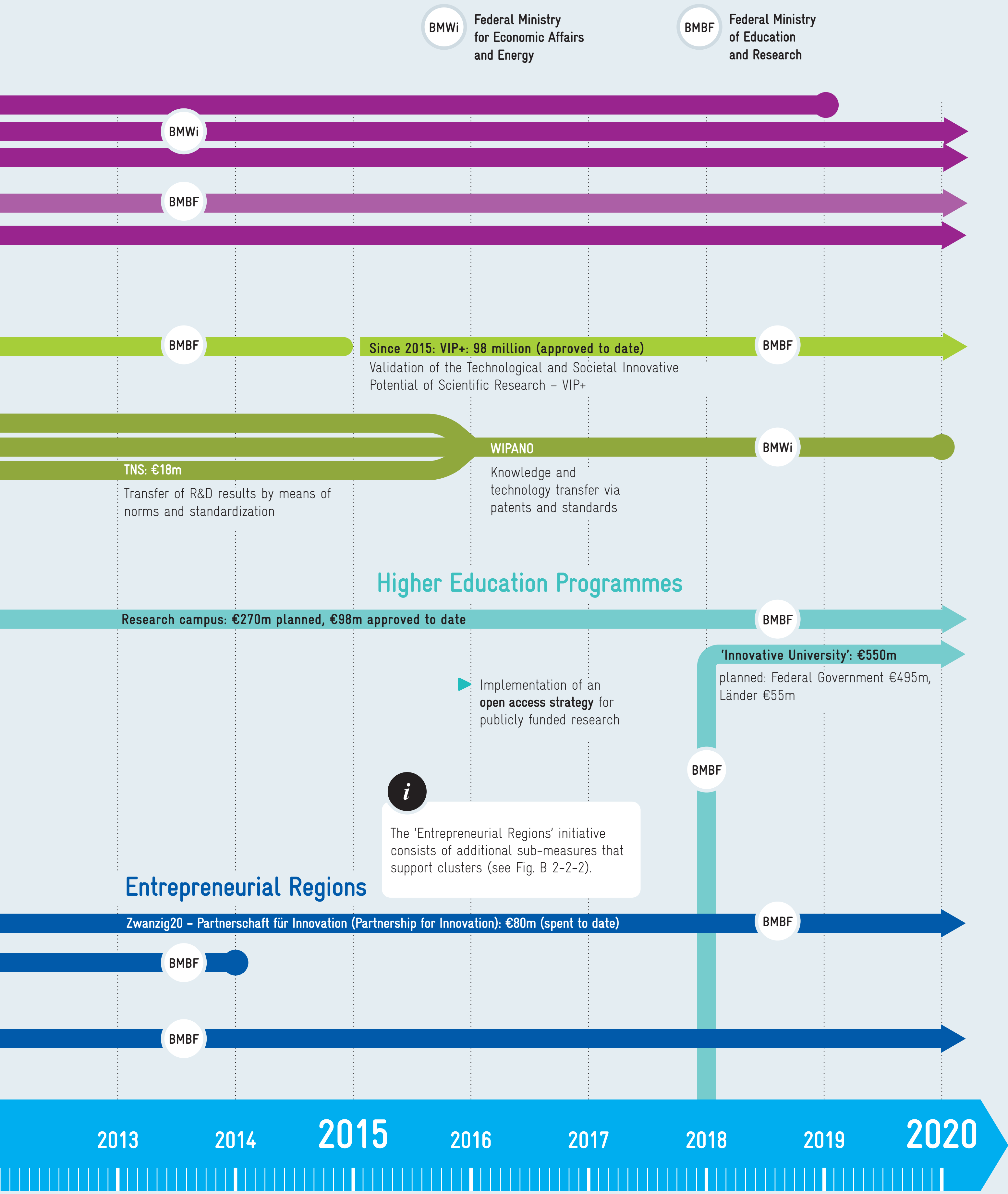
Download data

Transfer of knowledge and technology



i

It is often almost impossible to disguish between the transfer measures and the classic funding of collaborative research. In the context of the BMBF's topic and lateral programmes, for example, transfer activities are also supported via direct project funding. At the same time, the overview includes some measures involving considerable funding volumes, because they contain classic collaborative project funding – this applies, for example, to the 'Entrepreneurial Regions'.


BMWi Federal Ministry for Economic Affairs and Energy
BMBF Federal Ministry of Education and Research
BMWi
BMBF
BMBF
Since 2015: VIP+: 98 million (approved to date)
Validation of the Technological and Societal Innovative Potential of Scientific Research – VIP+
BMBF
WIPANO
Knowledge and technology transfer via patents and standards
BMWi
TNS: €18m
Transfer of R&D results by means of norms and standardization
Higher Education Programmes
Research campus: €270m planned, €98m approved to date
BMBF
'Innovative University': €550m
planned: Federal Government €495m, Länder €55m
Implementation of an open access strategy for publicly funded research
BMBF
The 'Entrepreneurial Regions' initiative consists of additional sub-measures that support clusters (see Fig. B 2-2-2).
Entrepreneurial Regions
Zwanzig20 – Partnerschaft für Innovation (Partnership for Innovation): €80m (spent to date)
BMBF
BMBF
BMBF
2013
2014
2015
2016
2017
2018
2019
2020

B

B 2-1 Transfer of knowledge and technology

Transfer goals and problems

Knowledge and new technologies generated by the science sector are an essential source of job-creating innovations, economic growth, as well as societal and cultural developments.[92] If transfers are to succeed, findings need to be transmitted from research to a wide range of applications and then utilised economically or socio-culturally. The mechanisms of knowledge and technology transfer vary considerably in this context (cf. Box B 2-1-1).

However, different types of market failure are inherent in knowledge and technology transfer that justify state support for transfer and utilisation processes (cf. also Box B 2-1-1). Furthermore, the transfer is hampered by the fact that incentive systems and cultures differ between research institutions and knowledge users. While in science success is measured primarily according to whether a finding is really new and publishable, society's interest lies in using this knowledge for the benefit of the general public. The criteria that are decisive for knowledge users are often not so much novelty, but, for example, practical applicability, reliability and the cost of use.

Particularly serious problems occur when knowledge is transferred to the economy. Companies involved in transfer aim to generate economic returns by applying the knowledge. In the science system, by contrast, there are often still reservations against the economic exploitation of research results. The 'culture of commercialising knowledge' at universities and non-university research organisations is often poorly developed, or else existing structures – for example transfer offices or patent utilisation agencies – have not yet been correspondingly professionalised. This requires setting up corresponding framework conditions and taking targeted measures (such as start-up funding) to intervene.

Measures and general framework

Various measures have been introduced to overcome market failures and support cultural change in the academic field, combined with a professionalisation of commercialisation processes.[93] In this context, different phases and mechanisms are used in the transfer and commercialisation process, and different actors in science and business are targeted (cf. Infochart at the beginning of the chapter on selected measures and initiatives over the last decade). The BMBF (Federal Ministry for Education and Research) focuses in particular on transfer processes involving tertiary education institutions, universities of applied sciences and non-university research organisations; the BMWi (Federal Ministry for Economic Affairs and Energy) concentrates on transfers to SMEs, commercialisation management and start-up activities in science.

The innovation and commercialisation efforts of universities and universities of applied sciences are comprehensively supported by the BMBF programmes 'Innovative University'[94] and 'Research at Universities of Applied Sciences'. In addition to these measures by the Federal Government, institutional promotion of non-university research organisations by Federal and Länder funds encourages the transfer of knowledge and technologies, inter alia by appropriate structures to promote commercialisation and spin-offs.[95] Furthermore, the agreements between the Federal Government and the science and research organisations in the context of the continuation of the Pact for Research and Innovation allow for a stronger role for knowledge transfer by 2020.[96]

The BMWi programme called 'EXIST – University-Based Business Start-Ups' offers comprehensive support for start-up activities at research institutions

Box B 2-1-1

Mechanisms and problems of knowledge and technology transfer

The transfer of knowledge and new technologies from science to economic and socio-cultural applications takes place via various mechanisms. These can involve considerable uncertainty and market failures, making the transfer difficult or even preventing it.[97]

Start-ups:
Start-ups are a direct way of transferring findings from research to commercial application. However, there is great uncertainty as to whether a finding is practically applicable, whether it is marketable at all, and ultimately whether there is market demand. This uncertainty leads to substantial financial risks for the founders, as well as for the venture-capital investors that finance such type of start-up.

Exploitation of property rights:
New knowledge and technologies can be protected by patents. These rights can be commercialized in different ways; however, to do so involves search and transaction costs as well as considerable uncertainty with respect to usability due to information asymmetries between the parties involved in commercializing the patent.

Research collaborations:
Research collaborations enable research institutions and companies to work together on a research topic and to benefit from knowledge externalities. Ideally, the findings and the economic exploitation are shared. Information asymmetries can lead to coordination problems with respect to the identification and selection of suitable partners and to jointly exploiting research results.

Contract research:
Contract research enables companies to use the expertise and infrastructure of research institutions to obtain research results for specific problems.

Scientific exchange:
A direct transfer of knowledge takes place via scientific publications, congresses and informal contacts. Transfer problems occur when the corresponding recipients are unable to understand and process the knowledge.

Education and training:
Tertiary education institutions and non-university research organisations are important training centres for scientific, technical and creative staff that transfers new research and methodological knowledge into companies or finds employment there.

and is attempting to establish a start-up culture.[98] The BMBF’s measure entitled ‘Validation of the Technological and Societal Innovative Potential of Scientific Research – VIP+’, which provides funds for the transition from the orientation phase to the utilisation phase, is meant to reduce uncertainty regarding the potential commercialisation of scientific findings. To support the reduction of information asymmetries, a variety of measures have been introduced, for example the BMBF’s funding initiative called ‘Research Campus – Public-Private Partnership for Innovation’. Science and business cooperate here ‘under a shared roof’ and ‘on an equal footing’ in research, development and innovation, and jointly develop utilisation strategies. The BMWi has bundled several measures under the title ‘Transfer of Knowledge and Technology through Patents and Standards (WIPANO)’ with the aim of encouraging and facilitating the codification and commercialisation of research results.[99]

The legal framework plays an important role in the success of a transfer. It is especially important for an accelerated exchange of knowledge when it comes to initiating or further strengthening the targeted cultural change among all participants. A legal paradigm shift to this effect took place in 2002 with the abolition of the ‘university lecturers’ privilege’ in the course of the amendment to section 42 of the Employee Inventions Act (Arbeitnehmererfindungsgesetz, ArbErfG). As a result, the rights to commercialise inventions passed from the professors to the tertiary education institutions.

A further improvement in the framework conditions governing the transfer of knowledge could be achieved by introducing a grace period[100] in patent law. Such a regulation could make it easier for scientists to mitigate conflicting goals relating, on the one hand, to the reputation-based publication of new knowledge and, on the other, to the commercialisation of these findings. International experience with a grace period indicates that such a scheme has a predominantly positive effect on scientists' freedom of action. At the same time, the intellectual property rights of established actors in the business sector can be adequately protected.[101]

In 2016, the BMBF presented an open-access strategy. This provides for an open-access clause for all projects funded by the BMBF. As a result, research findings are to be published in a way that is freely accessible.[102] Furthermore, in the past the Commission of Experts has called for the introduction of a general exemption from copyright for scientific and education purposes.[103] Such a measure was included in the coalition agreement for the current legislative period. Both measures can lead to an improved circulation of knowledge and current research findings both inside and outside the science system.

Impact and effectiveness of policy measures

The list of measures in the field of knowledge and technology transfer has been further developed and expanded over the past ten to fifteen years (cf. Infochart at the beginning of this chapter), and evaluation studies are available for some of these measures.[104] Up to now, not all the measures carried out in the field of knowledge and technology transfer have been evaluated in a way that is in line with scientific standards, e.g. with the aid of control groups. Reliable statements on their effectiveness and efficiency are therefore only possible to a limited extent.

Conclusions can be drawn, for example, from the evaluations on the introduction of the 'Research Campus' and the abolition of the university lecturers' privilege. The evaluation of the 'Research Campus' confirms that having companies and research institutions operating under one roof has positive regional economic effects, establishes and strengthens research collaborations, and benefits young scientists.[105] However, long-term effects cannot yet be assessed.

Various studies show that the abolition of the university lecturers' privilege in 2002 led to a significant decrease in the patenting activities of scientists at German tertiary education institutions.[106] The new regulation has not yet had the desired success.

In view of the wide range of funding measures in the field of knowledge and technology transfer, the term 'subsidy jungle' has come up – at least from the point of view of the target groups.[107] However, closer inspection shows that there is very little redundancy in funding.[108] Only in a few cases has the funding portfolio been adjusted and consolidated. Overall, a closer examination of the different mechanisms and phases of knowledge and technology transfer reveals a consistent mix of instruments.

Yet there is still little involvement in the funding programmes on the part of the sciences that are not patent-relevant. At present, it is still too early to conclude whether the current measures, e.g. 'VIP+', which also attribute a greater role to knowledge transfer, will lead to a corresponding interest and increased participation from the humanities and social sciences.[109]

Cluster policy

B 2-2

Clusters and cluster policy

A cluster is defined as "a geographic concentration of interconnected companies and institutions in a particular field."[110] Its effect on individual cluster actors is based on the fact that their inventive, innovative and – building on this – economic performance not only depends on their own efforts, but is also influenced by tangible and intangible resources outside their own organisation that are geographically concentrated within a cluster.[111]

The extent and accessibility of these resources are decisive for the success of cluster actors and the cluster as a whole. Through interaction, networking and exchange via local factor markets, as well as via value chains, the actors provide each other with tangible and intangible resources such as research infrastructure, special services or specialised staff. Geographical proximity makes it easier for them to find out about each other, make contact and interact. This leads in particular to knowledge and information spillovers, enabling them to learn from each other and to use synergies that raise innovative performance and productivity.[112]

A cluster thus constitutes a system of actors who are connected with each other in many different ways and in this way jointly promote innovation activities. Via these interactions, a cluster constantly develops in a self-enhancing way. However, this process often proves to be error-prone and distorted, leading to low levels of R&D and R&I expenditure, to under- or unused cooperation potential, and to technological lock-in constellations (cf. Box B 2-2-3). To address these market and system failures, various measures which can be subsumed under cluster policy have been introduced.

Cluster policy in Germany

Numerous cluster initiatives have been launched over the past 20 years in Germany at both the Federal and Länder levels.[113] According to a current survey on behalf of the Commission of Experts, in the recent past more than 430 clusters have received funding in Germany (including European cluster measures, see Figure B 2-2-1). Currently ongoing measures at the federal level alone include the 'Leading-Edge Cluster Competition', 'go-cluster', the 'Internationalisation of Leading-Edge Clusters, Future-oriented Projects and Comparable Networks', as well as several funding programmes from the 'Innovation Initiative for the New German Länder – Entrepreneurial Regions' (cf. Figure B 2-2-2).[114]

The BMBF supports innovation clusters in cutting-edge technologies with the non-thematic 'Leading-Edge Cluster Competition', launched in 2007 within the framework of the High-Tech Strategy. In three rounds, 15 cluster initiatives were selected and subsidised with up to 40 million euros[115] in funding to support them on their way into the top international group of their respective technology field, or to consolidate a top position already achieved. The measure was aimed at mobilising regional innovative potential and, as a consequence, increasing economic growth, creating new jobs, and making Germany more attractive as a location for innovation and business.[116]

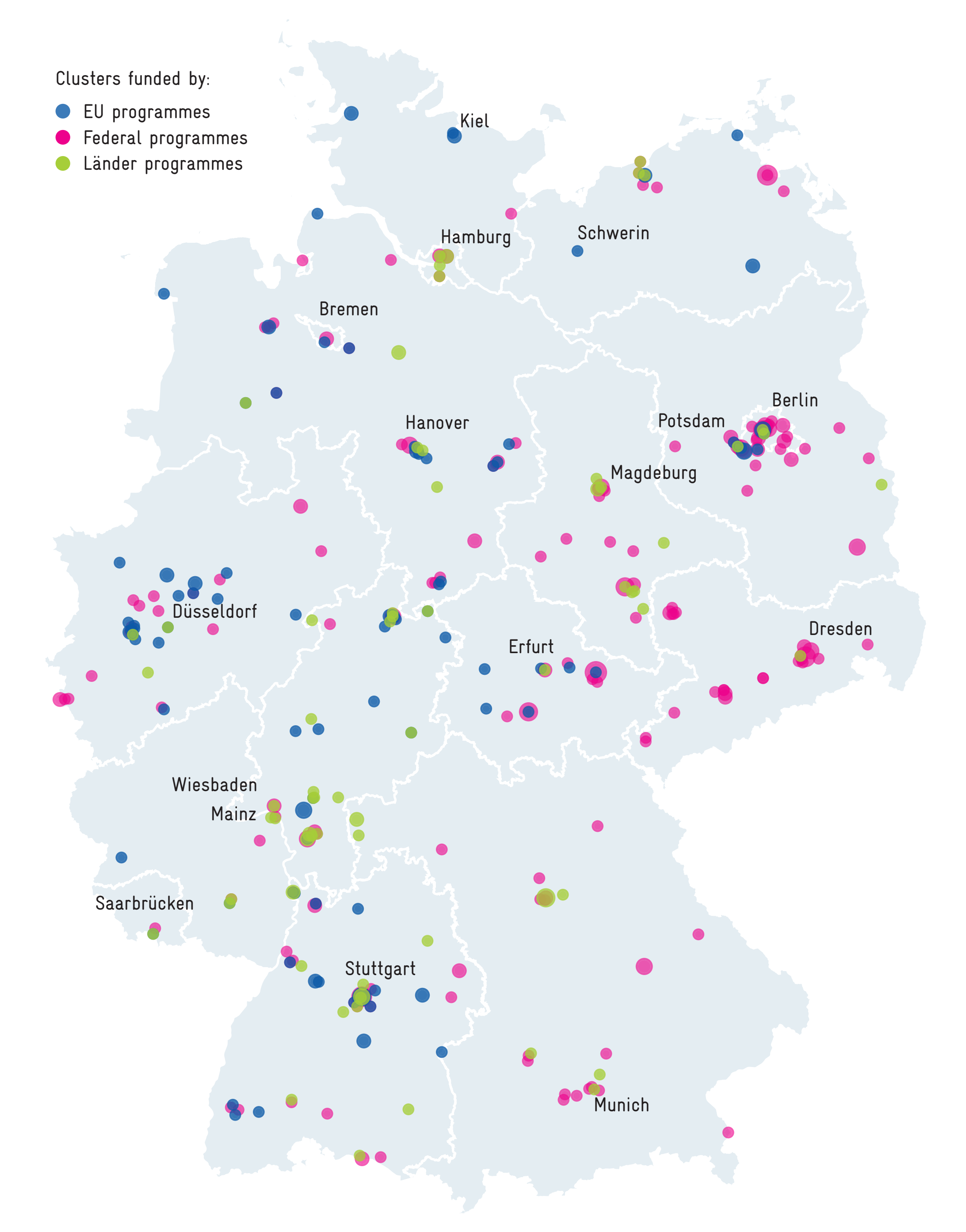
The BMWi has also been offering a cluster-policy measure since July 2012: the 'go-cluster' programme.[117] It is aimed at the promotion of cluster management and the development of novel cluster services.[118] A total of 3.3 million euros was spent during the first funding period up until the middle of 2015.[119] According to the BMWi, approximately the same amount of funding has been earmarked for the current programme period (mid-2015 to mid-2018).

Fig. B 2-2-1

Download data

Clusters currently funded by the EU, the Federal Government and the Länder

The diagram shows all publicly funded cluster initiatives (the dots mark the locations of the respective cluster management) that were still funded at the time of the survey in December 2016, or whose funding expired in 2015 at the earliest.
Where two (three, ...) cluster initiatives are funded in one postcode area, the size of the respective dot is doubled (trebled, ...).



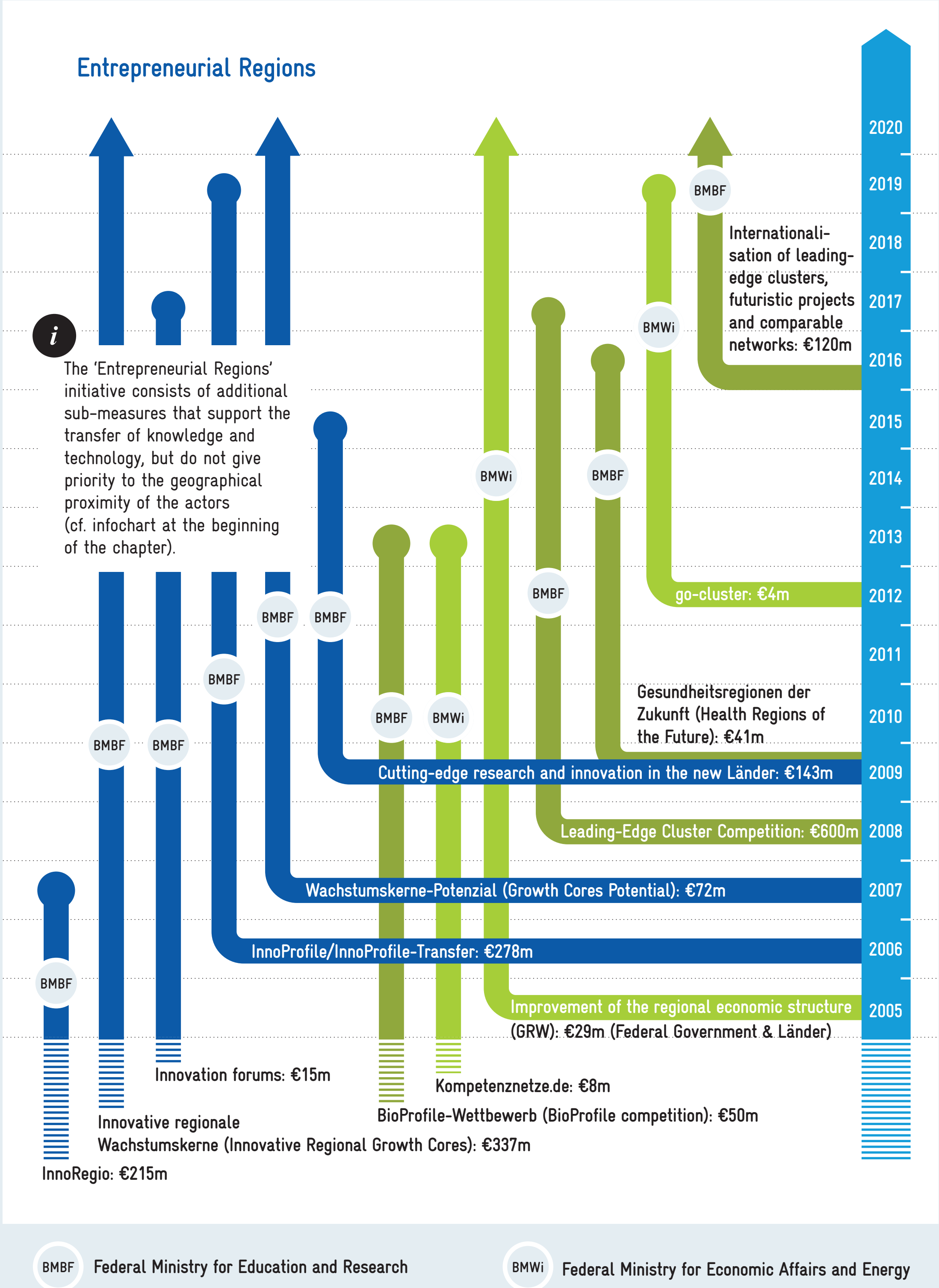
Source: own diagram on the basis of written information provided by the Institute for Social Research.

B

Fig. B 2-2-2

Download data

Overview of the Federal Government's cluster-policy measures



All the figures correspond to approved funds. Last revised January 2017.
Source: written information provided by BMBF and BMWi.

Box B 2-2-3

Economic justification of cluster policy

The aim of cluster policy is either to correct (at reasonable costs) market and system failures[120] which may hinder the emergence of a cluster and its early growth[121], or to support an existing cluster in its development towards the top international group of its respective technology field.

The reasons for market failure in clusters can be that positive external effects are not taken into account, or industry-specific public goods such as basic research are lacking. Furthermore, in the case of increasing economies of scale, the problem can arise that the tipping point from which on the agglomeration process reinforces itself cannot be reached without state support.

A system failure with respect to intended knowledge and information spillovers may occur, when, e.g., the degree of interconnectedness and interaction between the cluster actors is too low and thus the knowledge and information flows are too small. Reasons here can, for example, include high start-up costs for building networks or a lack of trust between potential partners.[122]

Another manifestation of system failure can be a technological lock-in of a cluster. In such case, cluster actors have focused too narrowly on a technology that is no longer future-proof, and it is hardly (or no longer) possible for the cluster to change by its own efforts.[123]

B

Since the end of 2014, the BMBF has been specifically funding the 'Internationalisation of Leading-Edge Clusters, Future-oriented Projects and Similar Networks'.[124] This funding scheme, which will run at least until the end of 2018 (with the option of an extension until 2024), aims to encourage the selected clusters and networks to intensify their existing contacts with international innovation regions. The funding totals up to four million euros respectively (totalling a maximum of 120 million euros by 2024). As a result of the first of a total of three competition rounds, the conceptual phases of eleven projects are initially funded over two years; in order to implement the strategies this will be followed by the promotion of international research, development and innovation projects for periods of up to three years.

The BMBF's 'Innovation Initiative for the New German Länder – Entrepreneurial Regions'[125] implemented since 1999 combines several funding initiatives and instruments which have been focusing on different phases of the innovation process, while simultaneously taking into account the special features of east Germany's innovation structures. Since 2016, the programme has been developed further into a Germany-wide innovation-funding concept to support regions facing special challenges of structural change.[126] The total volume of the cluster measures is difficult to assess, but it is likely to be more than 40 million euros per year.[127]

Impact and effectiveness of cluster policies

Cluster policy is used in different sectors of the economy, during different industrial life-cycle phases, and in different socio-economic contexts.[128] This – and the broad diversity of cluster-policy measures in terms of objectives, design and implementation – makes it difficult to compare and evaluate the effectiveness and efficiency of the various initiatives.

An evaluation of the 'Leading-Edge Cluster Competition' conducted in 2014 revealed positive activation effects, e.g. in terms of the provision of resources, the quantity and quality of the supply of human capital, the density of connections among the actors, and the emergence of new training facilities.[129] At the same time, the competition led to a documented mobilisation effect, even in the applicant groups that were not selected. A point of criticism was that in some cases the measure led to an excessive focus on the respective local network. It was also shown that the evidence on activation effects created by the 'Leading-Edge Cluster Competition' on R&D was not uniform and that these effects were not higher compared to companies funded by other schemes.

The BMWi has conducted a study to determine the satisfaction level of participants in the 'go-cluster' funding programme.[130] The respondents referred mainly to marked professionalisation and learning effects, as well as reputation gains.[131] On the basis of the evaluation methods used, it has not been possible to determine whether the programme led to an increase in innovative activity.

The measure entitled 'Internationalisation of Leading-Edge Clusters, Future-oriented Projects and Similar Networks' will be evaluated by an accompanying research project called InterSpiN, which aims to assess the impacts of internationalisation efforts.[132] The idea is to use the evaluation results for designing future measures of cluster promotion and also for the strategic orientation of clusters that are not funded.[133] At present, it is not yet clear what methods will be used and whether they will provide a basis for robust conclusions.

Evaluations based on comparative group analyses of the medium- to long-term effects of the different programmes of the 'Innovation Initiative for the New German Länder – Entrepreneurial Regions' are not yet available.[134]

Overall, the instruments of cluster policy in Germany over the past ten years have been comprehensively applied in a geographically broad manner as well as in many areas of high-value and cutting-edge technologies. Activation effects were detected in individual programmes. The observation periods are as yet too short – or else there is a lack of relevant evaluations – to document sustainable effects of specific funding schemes.

B 3 Innovation in established companies

Download data

B

Internationalisation of R&D

German companies (defined by corporate headquarters) invested almost €70bn in R&D in 2013: approx. €52bn at German locations and approx. €17bn abroad. Foreign companies invested almost €15bn in R&D in Germany in 2013 – slightly less than in 2011.

The contribution of SMEs to research and innovation in Germany

The innovation intensity of SMEs – i.e. innovation expenditure as a percentage of total turnover – has declined over the last ten years, but rose again in 2015. R&D intensity has remained relatively constant during the same time period.

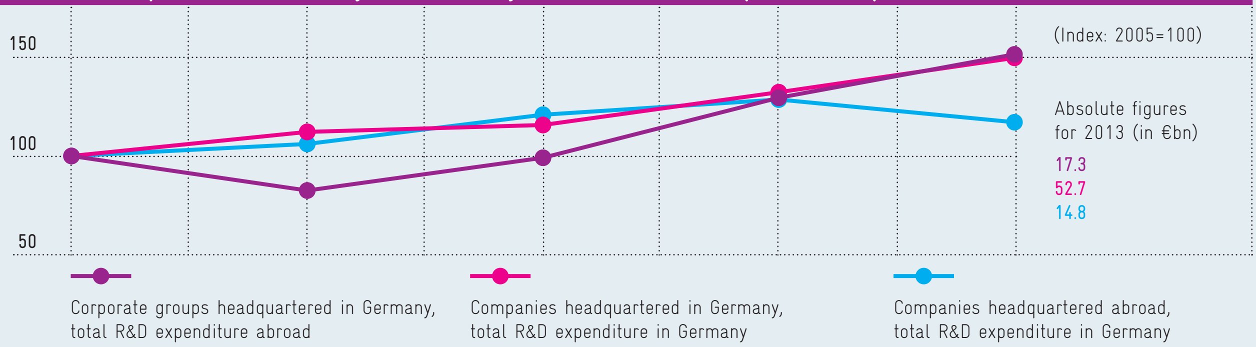
State financing of innovation activities in companies

The structure of state R&D funding of companies by the Federal Government changed during the period from 2005 to 2014: thematic funding and the award of civilian R&D contracts increased in importance. The same applies to funding that is open to all technologies By contrast, the award of R&D contracts by BMVg declined sharply.

Demography and skilled personnel

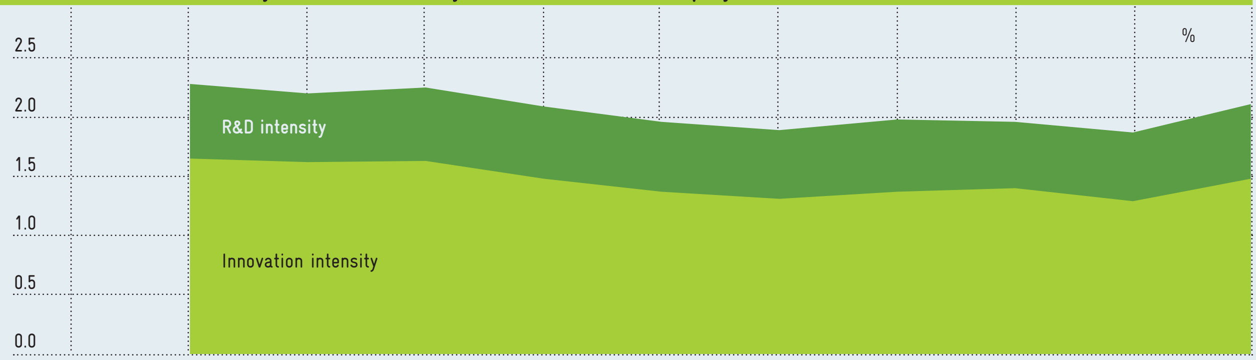
The relationship between vocational and tertiary education has shifted greatly in the last ten years. In 2005, 59 percent of all students began an apprenticeship and 41 percent a course of study; by 2011 the same number began a course of study (50.1 percent) as dual vocational training (49.9 percent). This ratio has stabilised: in 2014, 51 percent of beginners were studying, compared to 49 percent in dual vocational training.

R&D expenditure in Germany and abroad by R&D location and corporate headquarters 2005–2013



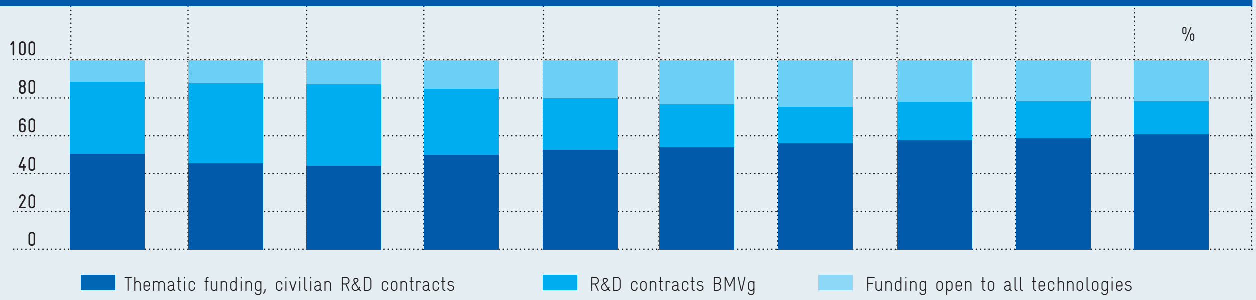
Source: SV Wissenschaftsstatistik, own calculations.

Innovation intensity and R&D intensity of SMEs (5 to 249 employees), 2006 until 2015



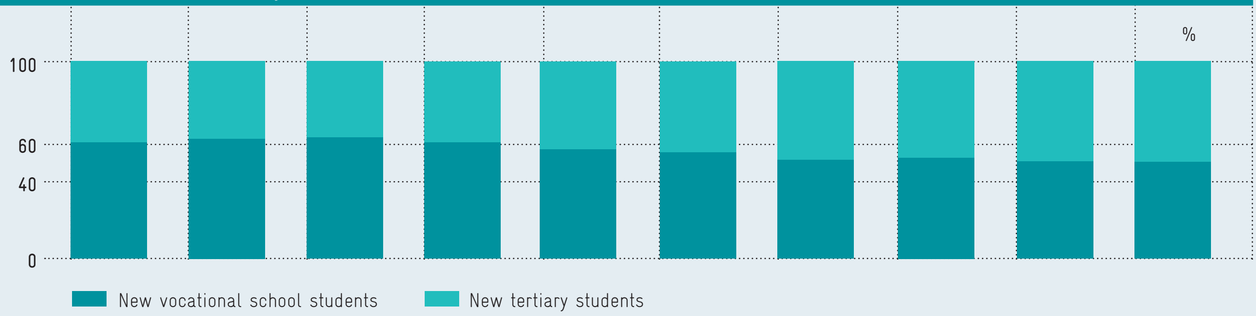
Source: Mannheim Innovation Panel. Own diagram based on written information provided by the ZEW.

Distribution of state R&D funding of companies by the Federal Government by funding types 2005 to 2014



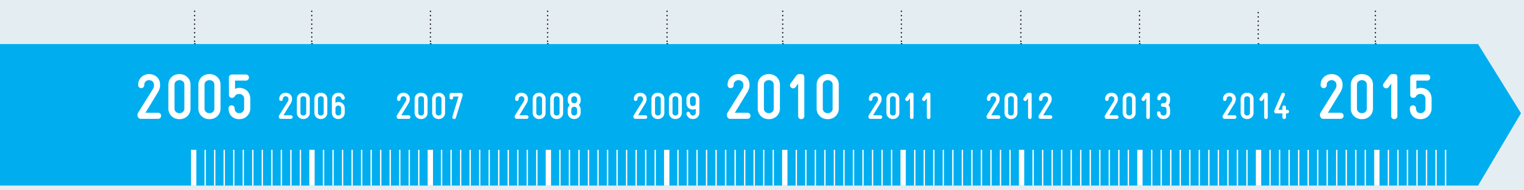
Source: BMBF data portal. Calculations by Rammer and Schmitz (2017).

Ratio of new tertiary students to new vocational school students 2005 to 2014



New vocational school students: students in the 1st year at vocational schools in the dual system

Source: Own diagram. Calculations by SOFI in Gehrke et al. (2017a).



For references of infocharts see Chapter D2.

B 3-1 Demography and skilled labour

B

The German innovation model is based on a specific combination of highly qualified graduates from the higher-education system and highly skilled workers trained in the dual vocational education system. This combination avoids a narrow focus on academic knowledge, and instead promotes the use of more varied, high-quality sources of knowledge.[135]

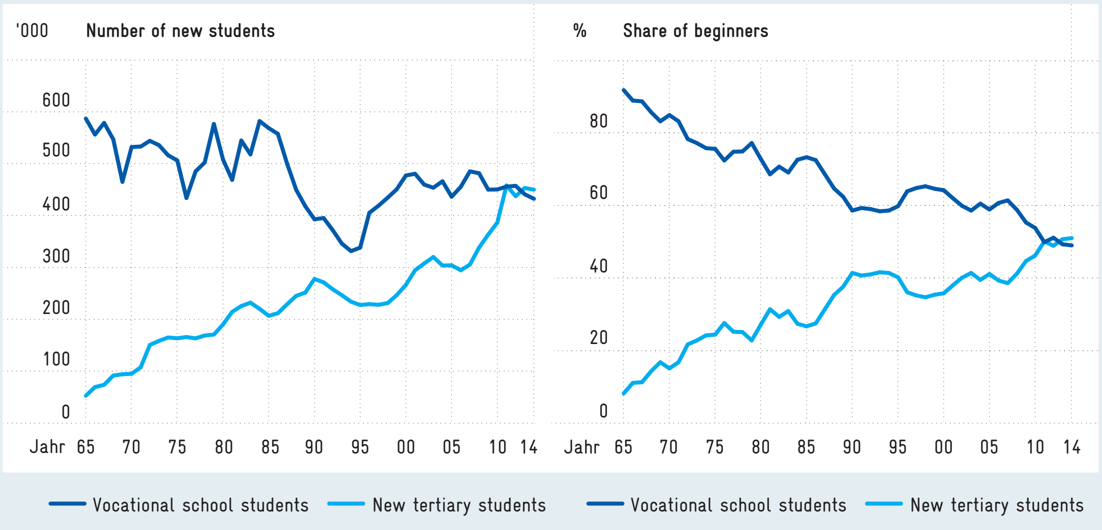
Demographic developments and shortage of skilled labour

The structure of the skilled workforce available in Germany will change markedly over the coming decades. First, demographic change will permanently transform the available potential of (qualified) skilled workers.[136] The number of people entering the labour market for the first time is falling relative to the number of older workers, leading to an ageing process in companies. It will no longer be possible to meet new qualification requirements by hiring new, young labour-market entrants; instead, these requirements will have to be met with the existing workforce.[137] Second, this shortage of skilled labour will be aggravated by the fact that the baby-boomer cohorts will be reaching retirement age in the next few decades, with many well qualified workers leaving their companies.[138]

Fig. B 3-1-1

Download data

Beginners at tertiary education institutions and in their first year of the dual system of vocational schools in the former territory of the Federal Republic,* 1965 to 2014



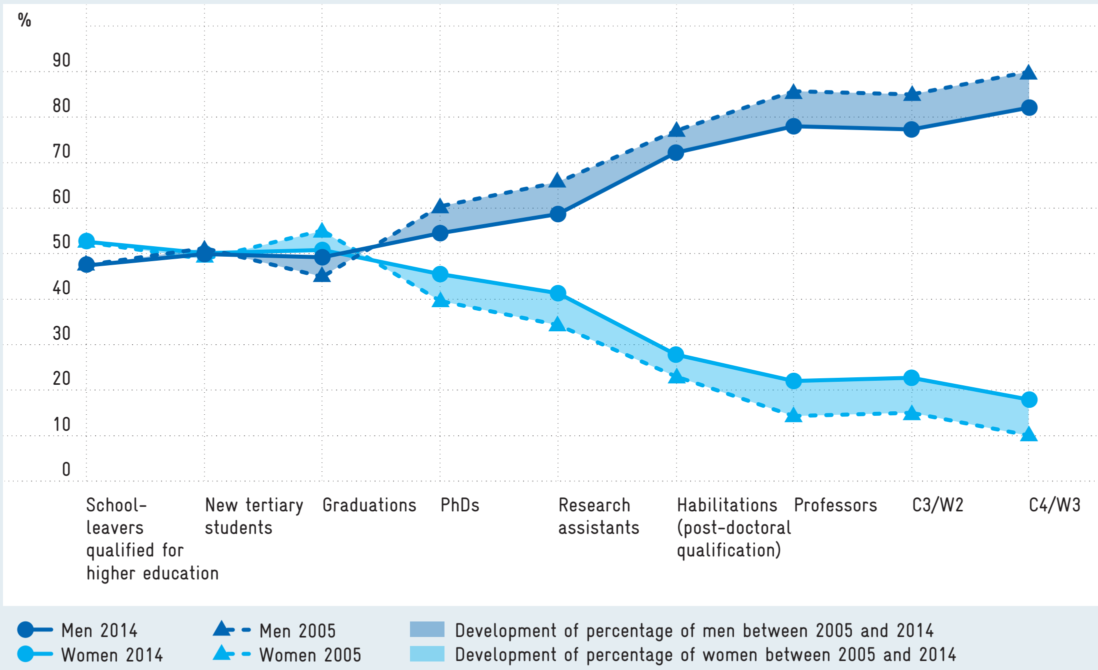
* Vocational schools including people with no training contract, including East Berlin 1991–2004 and from 2012. New tertiary students including East Berlin from 2002.

Source: Calculations by SOFI in: Gehrke et al. (2017a).

Fig. B 3-1-2

Download data

Percentages of men and women in academic careers, 2005 and 2014

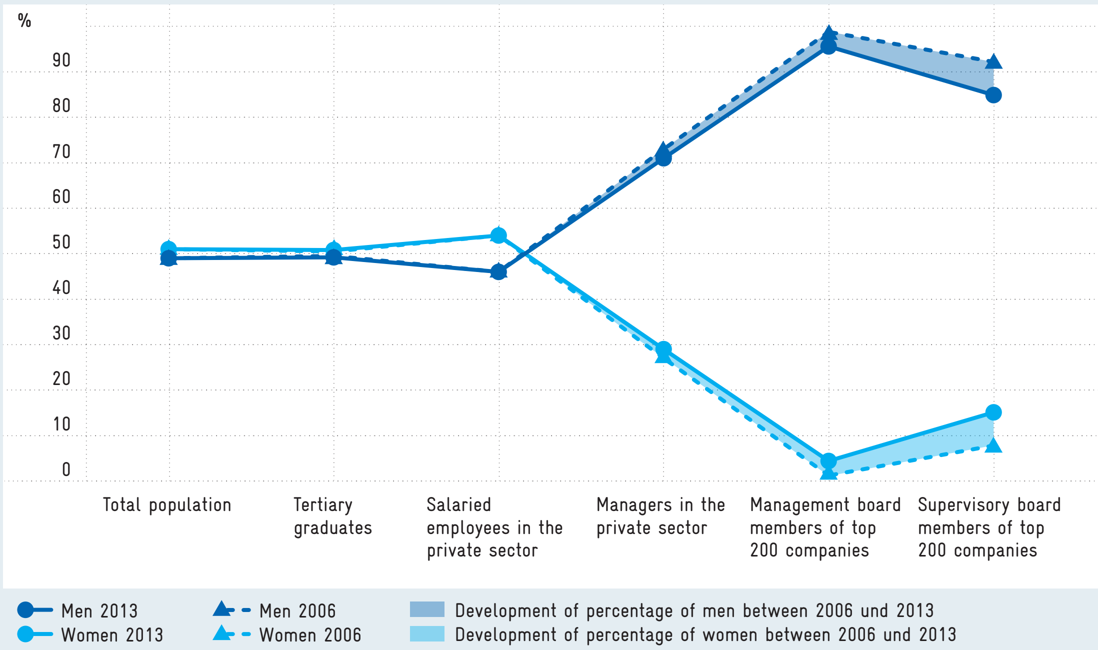


Source: GWK (2011, 2016a).

Fig. B 3-1-3

Download data

Percentages of men and women in the private sector in 2006 and 2013



Source: DEW-Führungskräftemonitor 2015, Statistisches Bundesamt (Federal Statistical Office), Fachserie 11, Reihe 4.2, Statistisches Jahrbuch 2016.

Change in the qualification mix as a result of trends in the education system

The problem of a shortage of skilled labour is also influenced by shifts in the qualification mix. The ratio between apprenticeship training and higher education has shifted dramatically in favour of higher education (cf. Figure B 3-1-1). During the mid-1960s, 92 percent of all compulsory school leavers began apprenticeship training, and only 8 percent began a course of study at a higher education institution; by 2011, for the first time in the history of the Federal Republic of Germany, there were more beginners at higher education institutions (50.1 percent) than in apprenticeship training (49.9 percent).[139] This ratio has stabilised since then: in 2014, 51 percent of all beginners were studying, compared to 49 percent in apprenticeship training.

Unused potential of skilled workers

In order to prevent a shortage of skilled labour and to avoid bottlenecks for the innovativeness and competitiveness of Germany as an industrial location, it will be increasingly important in future to make the most of a hitherto insufficiently used skilled workforce – the so-called hidden reserves of skilled workers who are currently not participating in the labour market.

At present, Germany has a large hidden reserve (in 2015, there were more than 200,000 people in the hidden reserves in the narrower sense[140], approximately two-thirds of them women[141]). For example, whereas the participation of women in the education system has increased enormously in recent decades, the percentage of women in employment has remained comparatively low.[142] Despite slight improvements, women are still greatly underrepresented in management positions – even more so the higher the career level. Examples in Figure B 3-1-2 and B 3-1-3 show the development of the proportion of women across the academic career ladder and across leadership positions in the private sector.[143]

Germany is thus wasting the potential from its expensive and valuable investments in the human capital of women – which it would urgently need in the light of demographic developments, global challenges and growing international innovation competition.[144] Furthermore, a better gender mix in teams and a greater participation of women in management positions would be especially valuable for the competitiveness of innovative companies.[145]

The experience and knowledge of older workers also has great potential that could be put to better use by keeping them in employment longer. Empirical studies show that, contrary to many prejudices, the performance of older workers is not generally lower than that of younger workers. It is rather the case that even up to very old age there is a great variation in productivity, as well as in the ability to learn and the willingness to participate in further training.[146] Moreover, a company's productivity is not an individual matter; it is always the result of the interaction between workers with different skills and experience. Age-heterogeneous workforces can actually promote innovation in this context; attention should thus be paid to a suitable combination of older and younger workers.[147] Against this background, Germany should aim to keep older workers in the employment system for longer. Different proposals for pension-system reforms are currently being discussed.[148] Any further decoupling of life expectancy from the retirement age should be avoided, since this is the only way of reducing the foreseeable problem of a shortage of skilled workers and securing the financing of the statutory pension system.

Furthermore, in the view of the Commission of Experts a targeted immigration and integration policy is required in order to close the remaining gap in the number of skilled workers in the long term. Over the last few years, a number of improvements have been made to immigration regulations for well-qualified foreign workers, entrepreneurs and foreign graduates of German tertiary education institutions at both the national and European level.[149] In addition, strengthening national diversity through migration can also contribute to more innovation.[150]

Flexibility and permeability in the education system

In the light of demographic change and the growing shortage of skilled labour, an increase in the flexibility in the education system and in longer-term labour-market mobility can make an important contribution to solving the problem of the shortage of skilled labour.

There are essentially two approaches available in the education system. First, existing educational programmes could generate graduates who can be deployed more flexibly. Second, a maximum degree of vertical and horizontal permeability could be guaranteed by further developing the education system.[151]

In this context, it is important to maintain a clear profile of each of the two pillars of the German education system – vocational education and training on the one hand, and higher education on the otherhand – and to ensure a high level of permeability between these two pillars.[152] Life-long learning is also important in this context. Long-term flexibility is easier to achieve if the system provides good options for individual educational paths ('kein Abschluss ohne Anschluss' – 'no dead ends in education')[153] and if skills acquired in one job can be formally recognised after a change of job and transferred relatively easily to a new qualification.[154] Particularly important target groups for further-training measures are hitherto under-represented groups of workers – women, migrants and older workers.[155] In this context, digital forms of learning such as MOOCs can support life-long learning, since they can also reach people who are already in work or have major time constraints, as well as other sections of the population who, until now, have not found access to further education.[156]

In addition, developments in the education system can be supported by appropriate changes in incentives on the labour market. In order to boost the strengths of Germany's education system with its two pillars, employers can make an important contribution by investing in the attractiveness of vocational education and training. Aspects that can help here include in particular clear career prospects for talented and ambitious graduates of apprenticeship training programmes, highlighting opportunities for personnel development, and clearly communicating the permeability of the system.[157]

B 3-2 State financing of innovation activities in companies

Structure of the R&I funding by the Federal Government

The public sector finances R&D in companies primarily by promoting specific R&D projects on the basis of application and approval procedures, and by public authorities issuing R&D commissions to companies.[158] Unlike most other OECD countries, Germany has no R&D funding through tax credits (cf. Chapter B 7). The latest figures for Germany show that 3.4 percent of all corporate R&D expenditure is financed by the state; this figure is low compared to important European competitor countries.[159]

The promotion of civilian projects as part of thematic programmes and promotion measures, and the award of civil R&D contracts have gained in importance in the last few years (cf. Infochart B 3).[160] Their share of total corporate R&D financing by the Federal Government rose from 50.5 to 60.8 percent between 2005 and 2014. The percentage of total corporate R&D financing provided by the Federal Government that is open to all technologies also increased – from 11.4 percent in 2005 to 21.8 percent in 2014.[161] The Central Innovation Programme for SMEs (Zentrales Innovationsprogramm Mittelstand, ZIM) and its predecessor programmes, as well as Industrial Joint Research (Industrielle Gemeinschaftsforschung, IGF) are important funding tools that are open to all technologies. The number of R&D orders awarded by the Federal Ministry of Defence (BMVg) fell sharply during the same period. The BMVg's share of total corporate R&D funding by the Federal Government fell from 38.1 percent to 17.4 percent.

The thematic orientation of Federal Government funding has also changed over time. Table B 3-2-1 shows the development of the thematic orientation of the funding disbursed by the BMBF to the private sector (including other institutions) in the relevant areas of promotion for the period from 2009 to 2015.[162] The evaluation includes funding for education, science and R&D. According to the table, BMBF funds increased by 8.4 percent – from 546 to 592 million euros – between 2009 and 2015. Funding for the science system rose by 32.3 percent in the same period. The volume of funding provided by the BMBF declined significantly in the field of information and communication technologies (ICT). The Commission of Experts regards this development as a cause for concern, because this area is of great relevance for managing digital change (cf. Chapter B 5-1).

Table B 3-2-2 contains information categorised by fields of technology on the development of approved funds in the BMWi's Central Innovation Programme for SMEs (ZIM) for the period from 2010 to 2016. ZIM funding is not geared to any specific fields of research, but is open to all technologies. It reflects the projects applied for by companies and selected for funding. The Commission of Experts has no information on whether the approval rates differ between the respective research fields. The distribution of funds approved by the ZIM to the various fields of technology has remained surprisingly stable over time. Just under a quarter (24.3 percent) of the funds approved since the programme was launched were allocated to projects in the field of production technologies.[163] ICT technologies only received 10.6 percent of the funds. In the face of the challenges posed by digitisation, a considerable increase in the demand for and approval of funding would be desirable in this area.

Organisation of Federal and Länder funding measures

The Federal and Länder governments offer a wide range of measures that help support corporate research and innovation projects by providing grants and low-interest loans for R&D and innovation projects, and by making venture capital available for innova-

Tab. B 3-2-1

Download data

Percentages of funding disbursed by the BMBF[1)] to the private sector by funding areas, 2009 to 2015

Funding areas[2)]	2009	2010	2011	2012	2013	2014	2015	% change 2009–2015
A Health research and health industry	4.9	5.1	5.0	4.8	3.3	3.8	2.9	-35.8
B Bioeconomy	5.9	5.2	4.2	5.1	5.1	4.4	4.5	-17.7
C Civil security research	2.6	3.1	3.3	3.2	2.5	2.4	2.1	-15.1
E Energy research and energy technologies	1.2	0.7	0.7	0.8	0.9	1.9	1.3	22.3
F Climate, environment, sustainability	7.6	7.2	7.2	7.6	8.6	6.7	10.5	50.3
G Information and communication technologies	26.7	22.5	17.8	14.5	13.4	14.4	13.1	-47.0
J Research and development to improve working conditions and in the service sector	2.5	2.6	2.4	1.7	0.9	1.3	1.2	-47.5
K Nanotechnologies and materials technologies	7.8	7.4	6.9	5.9	4.7	4.6	3.8	-47.7
L Optical technologies	9.0	8.9	8.1	8.5	8.5	6.9	8.5	1.8
M Production technologies	6.9	6.8	5.8	4.5	4.0	4.7	4.1	-35.6
O Innovations in education	12.5	14.3	20.0	22.6	27.2	30.2	28.1	143.3
P Humanities; economics and social sciences	1.1	1.0	0.8	1.0	0.9	0.9	1.1	1.9
R Innovation-relevant underlying conditions and other cross-cutting activities	11.3	15.2	17.9	19.7	20.1	17.9	19.0	82.2
Total as %	100.0	100.0	100.0	100.0	100.0	100.0	100.0	
Total in billions of euros	546	593	625	618	638	566	592	8.4

1) The 'Profi Database' distinguishes the following recipient groups: tertiary education institutions, public research institutions, private sector and other. The recipient group 'private sector' presented here also includes 'other'.
2) Funding areas according to categories of the Federal Government's R&D-planning system (Leistungsplansystematik) excluding N (Regional planning and urban development; construction research), T (Funding organisations, restructuring of the research field in acceding areas; construction of universities and primarily university-specific special programmes), U (Large-scale equipment for basic research), Y (Non-R&D-relevant education expenditures) and Z (Ministry incl. supplies).

Source: Federal Government's 'Profi Database', evaluation by BMBF, calculations by ZEW in Rammer and Schmitz (2017) and own calculations.

tive corporate start-ups. The current funding structure is complex and often considered confusing.[164] Especially in the field of thematic funding there are a large number of programmes, measures and initiatives for which a wide range of Federal and Länder government ministries are responsible; there is no uniform, clearly structured external profile. The risk here is that funding measures might become too fragmented and require excessive effort on the part of the innovative companies to obtain information about funding opportunities. The Commission of Experts suggests making it a priority in the next legislative period to analyse any overlap between Federal funding programmes within the successor organisation of the Science and Industry Research Union (Forschungsunion) and the High-Tech Forum, and to reduce this overlap as far as possible.

Tab. B 3-2-2

Download data

Percentages of funding granted under the ZIM to different fields of technology

	2010	2011	2012	2013	2014	2015	2016	Average 2010–2016
Optical technologies	2.5	3.1	2.7	2.7	2.2	2.7	3.2	2.7
Materials technologies	11.9	9.4	11.0	9.2	12.0	10.2	10.4	10.7
Environmental technologies	4.8	4.0	4.4	5.0	3.8	4.7	4.5	4.5
Textiles research	2.9	3.1	3.2	2.8	3.2	2.8	2.6	2.9
Production technologies	23.4	24.5	24.1	23.8	23.4	25.2	26.2	24.3
Information and communication technologies	10.5	10.8	10.2	11.3	11.2	10.3	10.2	10.6
Health research and medical technology	6.3	7.6	8.0	8,.4	8.0	8.7	8.1	7.8
Vehicle and traffic technologies	4.9	4.4	2.8	3.4	2.1	2.4	2.1	3.3
Energy technologies	5.0	4.6	5.5	5.7	4.5	4.6	4.4	4.9
Electrical engineering, measurement technology, sensor technology	12.4	10.3	12.6	11.5	11.7	13.1	12.7	12.1
Biotechnologies	5.5	6.0	4.4	5.0	4.8	5.4	3.9	5.0
Construction technologies	4.2	6.6	5.0	5.9	6.6	5.5	5.8	5.6
Others	5,.8	5.5	6.1	5.2	6.5	4.5	5.9	5.6
Total as percentage	100.0	100.0	100.0	100.0	100.0	100.0	100.0	
Total in billions of euros	769	535	562	557	564	630	440	

ZIM was topped up for the years 2009 to 2011 in the context of the Economic Stimulus Package II.
Source: Information from the Federal Ministry for Economic Affairs and Energy, own calculations.

The organisation of R&D and innovation funding in Germany also contributes to the impression of a complex funding landscape.[165] As a rule, the measures are administered by so-called project management organisations. The ministries responsible give the project management organisations the task of implementing the programme on the basis of the respective funding policy. In some cases, individual programmes are managed by several project management organisations, and individual project management organisations take care of different programmes or programme elements. The Commission of Experts has no information on how the service quality of the project management organisations compares to that of the institutions responsible for R&I funding in other countries. The Commission of Experts notes a need to take action here – comparisons are also important for project management organisations in charge of implementation to enable them to continuously review and, if necessary, improve their own service quality.

There is no uniform data pool – broken down by sectors and simultaneously by recipient groups – that would allow a differentiated analysis of all funding offered by the Federal Government. The BMBF uses the Federal Government's 'Profi Database'. A number of other federal ministries also use the Profi Database – but only for selected items. The BMWi's ZIM funding is not yet covered by this database. The Profi Database is currently primarily a tool for the administration of the projects; the possibilities for evaluations on the development of the R&I policy and access for external researchers are currently limited. The database should be further developed to do more to reach the High-Tech Strategy's objective of greater transparency. The Commission of Experts considers it necessary for the Federal Government to implement a powerful database that fully covers data on the extent, thematic orientation and recipients of all R&I funding measures run by all Federal authorities and ministries.[166]

B

B 3-3 The contribution of SMEs to research and innovation in Germany

Innovation activities of SMEs

In all industrialised countries, the majority of employees work in companies with fewer than 250 employees – so-called small and medium-sized enterprises (SMEs). In Germany these represent about 61 percent of employees working in the private sector.[167] German SMEs are often regarded as highly innovative without further differentiation. In fact, they are heterogeneous with regard to their innovation activities. Between 2013 and 2015, only 42.6 percent of SMEs were involved in innovation activities – i.e. activities aimed at the development and introduction of product or process innovations.

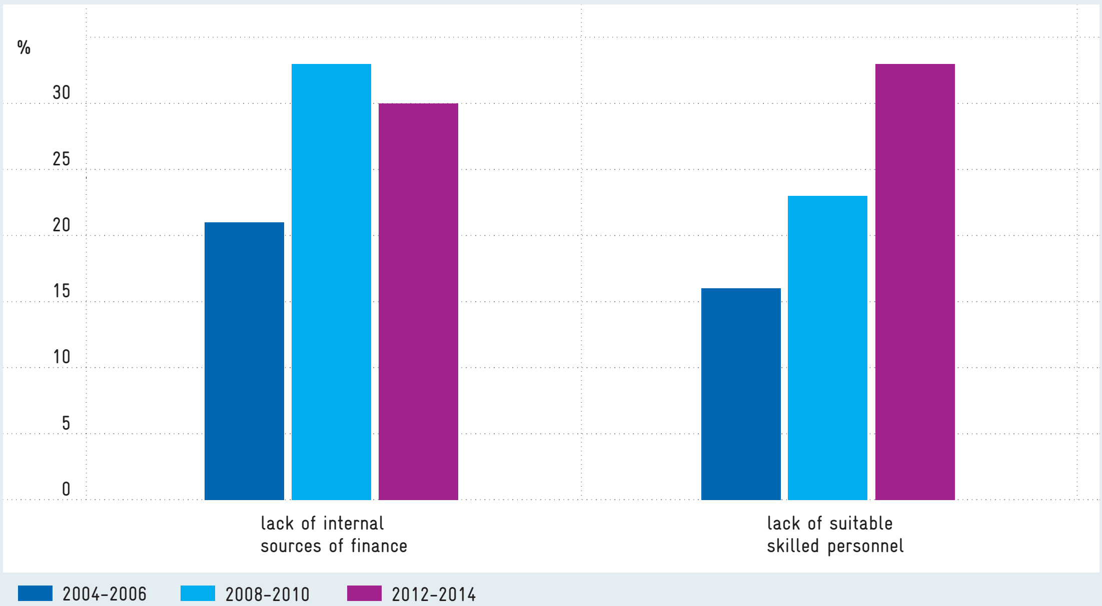
International comparisons lead to varying results, depending on the indicator used.[168] When it comes to the frequency of product or process innovations, German SMEs are leaders compared to important European competitor countries.[169] In terms of patent-intensity and the share of turnover generated with new products, on the other hand, German SMEs only rank around mid-table.[170]

The innovation intensity of SMEs – i.e. innovation expenditure as a percentage of total turnover – has declined over the last ten years. This is a cause for concern, especially as it means that Germany is not in a leading position compared to important Euro-

Fig. B 3-3-1

Download data

Percentage of innovation-active SMEs (5 to 249 employees) with a lack of internal sources of finance and a lack of suitable skilled personnel in Germany, 2004 to 2014



Source: Mannheim Innovation Panel. Calculations by ZEW in Rammer et al. (2016).

pean reference countries.[171] The innovation intensity of SMEs fell from 1.7 percent in 2006 to 1.3 percent in 2014. The increase to 1.5 percent in 2015 is good news. However, it is currently too early to conclude that there has been a sustainable trend reversal. R&D intensity, i.e. R&D expenditure in relation to total turnover, remained constant during the same period at 0.6 percent. This means that the changes in innovation intensity are the result of a change in innovation expenditure that is not allocated to R&D expenditure (cf. Box 3-3-2 and Infochart B 3).

There are several factors that influence the level of SMEs' reported expenditure on innovation and R&D.[172]

- The group of SMEs changes as a result of start-ups and firm closures, as well as movements of companies above and below the threshold values. In the period under review, this led to an overall reduction in both innovation and R&D spending by SMEs. The decisive factor for the negative balance is the transition from SMEs that are active in innovation and R&D to the group of large companies. The question is why this is not offset by the innovation and R&D expenditure of young companies. There are two reasons for this. On the one hand, innovation expenditure per young SME has fallen significantly, while R&D expenditure has remained stable. On the other hand, the number of young companies has decreased overall against the background of declining start-up activity in Germany.
- The innovation expenditures of SMEs with continuous R&D and SMEs with no internal R&D have recovered following a decline during the crisis year of 2009. However, the number of companies occasionally engaging in R&D is still declining. On balance, therefore, there has been a fall in the innovation expenditure of SMEs.

Innovation barriers for SMEs

Corporate innovation activities can be delayed, cancelled or prevented when obstacles to innovation crop up.[173] Three quarters of the innovation-active SMEs in Germany reported that their innovation activities were hindered by one or several obstacles in the period from 2012 to 2014. The most widespread obstacles to innovation in this period were excessive innovation costs and a high economic risk (40% respectively). These factors were followed by a lack of suitably skilled personnel (33 percent) and a lack of internal sources of finance (30 percent).

When it comes to removing obstacles to innovation for SMEs, education, research and innovation policy can have a direct effect above all on the fields of skilled personnel and innovation finance.[177]

- Whereas a lack of suitably skilled personnel only constituted a barrier to innovation for 16 percent of the innovation-active SMEs between 2004 and 2006, the figure had risen to 23 percent between 2008 and 2010 and to as much as 33 percent in the period from 2012 to 2014 (cf. Figure B 3-3-1).
- From 2004 to 2006, the lack of internal financing sources impeded the innovation activities of 21 percent of the innovation-active SMEs. The figure rose to 33 percent during the financial and economic crisis (from 2008 to 2010). Thereafter, it fell again, but at 30 percent still remained well above the pre-crisis level in the period from 2012 to 2014 (cf. Figure B 3-3-1).

Box B 3-3-2

R&D expenditure versus innovation expenditure

The OECD's Frascati Manual[174] defines R&D expenditure as expenditure on systematic, creative work aimed at expanding knowledge – also with the objective of developing new applications. The definition of innovation expenditure in the OECD's Oslo Manual[175] is broader. Apart from R&D expenditure, it includes the acquisition of machines, equipment, software and external knowledge (e.g. patents or licences), expenditure on construction, design, product development, conceptual design, training and further education, market launches and other preparations for the production and distribution of innovations.[176]

B

B 3-4 Internationalisation of R&D

B

Determinants of the internationalisation of R&D

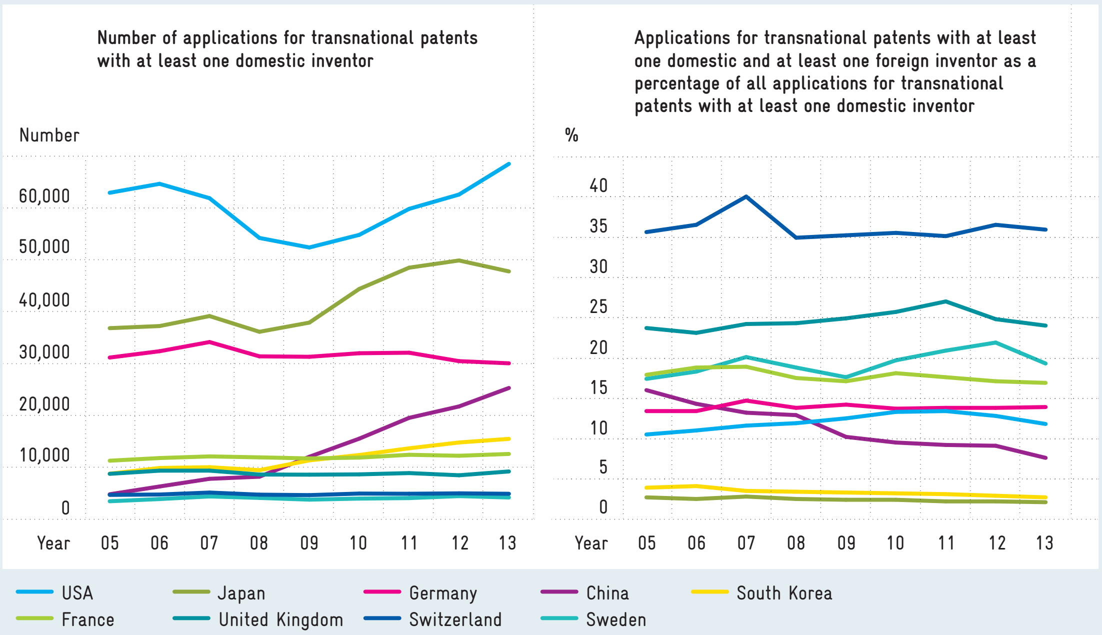
Just like production and sales, research and development (R&D) are becoming increasingly involved in global value chains. Cross-national R&D activities facilitate access to knowledge and to sales markets in other locations.[178] Important factors determining the choice of R&D location include local public goods, the availability of access infrastructure such as airports, a highly efficient digital infrastructure, and the quality of local university research.[179] Further factors that make a location attractive for the R&D activities of multinational enterprises (MNEs) are a research-friendly state regulation of the product and labour markets, comprehensive protection of property rights, a low corporate tax burden, or the public promotion of international R&D cooperation with the participation of local companies.[180]

However, state intervention can also distort international competition for R&D locations.[181] For example, in recent years several BRIC states have gone over to demanding that MNEs get involved in local R&D as a condition for allowing them access to their markets.[182] The Commission of Experts also regards so-called Patent Boxes as a distorting element in international competition for locations.[183]

Fig. B 3-4-1

Download data

Transnational patents for selected countries, 2005 to 2013

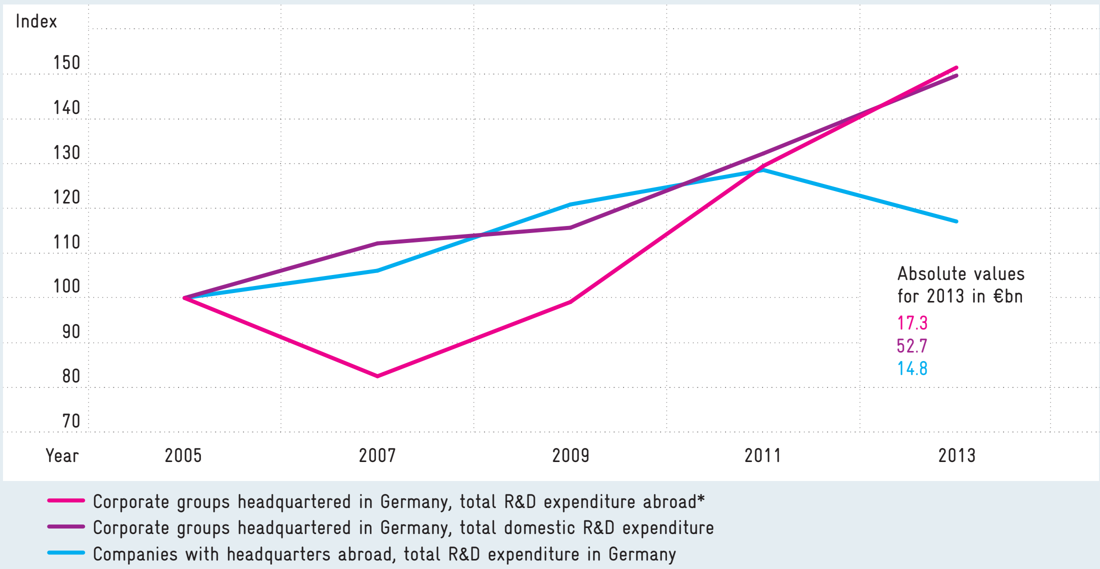


Source: own diagram based on data from Fraunhofer ISI.

Fig. B 3-4-2

Download data

R&D expenditure within and outside Germany classified by location of company headquarters, 2005 to 2013



Index 2005 = 100
* By the approximately 100 German corporate groups with the strongest research divisions according to the European R&D Scoreboard.
Note: the sharp fall in R&D expenditure abroad by corporate groups headquartered in Germany between 2005 and 2007 can be attributed to the separation of Daimler and Chrysler.
Data for 2015 were not available by the editorial deadline.
Source: Own calculations and diagram based on data from SV Wissenschaftsstatistik.

In the early 2000s, there was a marked increase in international R&D expenditure in the Asian region, especially in the agglomerations of Beijing, Bangalore, Shanghai and Singapore.[184] However, this development has slowed down considerably in the meantime, and, most recently, established locations such as the USA, the United Kingdom and Germany have become attractive again for MNEs' R&D investment.[185] This strengthening of the 'classical' global research locations can also be explained by the fact that India and China no longer act only as target countries, but also increasingly as countries of origin for international R&D.[186]

R&D internationalisation trends worldwide

Cooperation between domestic inventors and those from other countries is seen as an indicator of the globalisation of knowledge formation.[187] Figure B 3-4-1 (right panel) looks at the frequency of such international co-inventions regarding transnational patent applications with at least one domestic inventor.[188] The number of transnational patent applications with at least one domestic inventor remained almost constant in Germany between 2005 and 2013 (left panel). A comparison with the other countries reveals above all the striking five-fold increase in application figures from China. At the same time, the number of transnational patent applications with at least one domestic and at least one foreign inventor as a share of the total number of all transnational patent applications with at least one domestic inventor fell considerably there in the period under review. This development can be explained by the country's strengthening innovative capacity combined with the availability of qualified human capital.

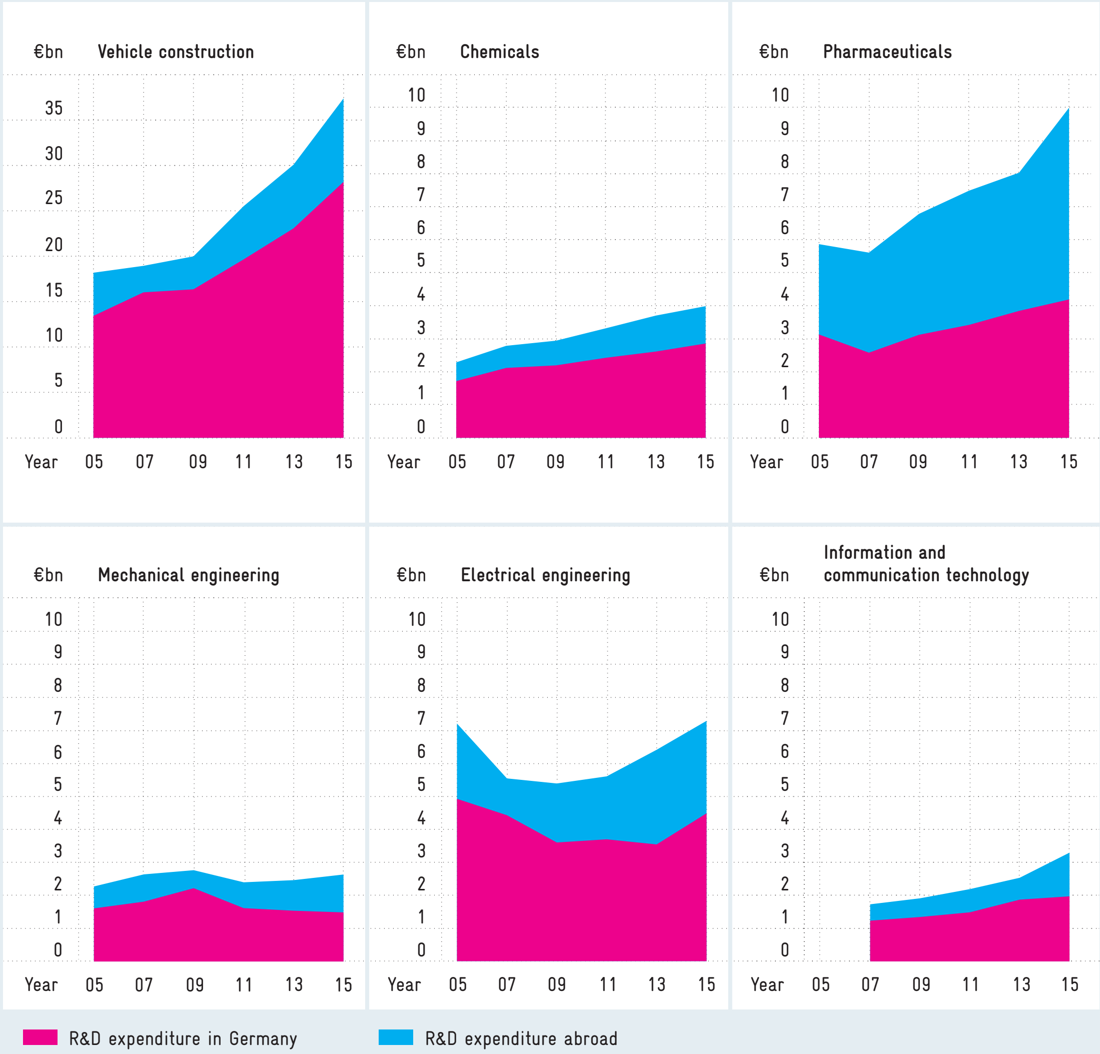
R&D internationalisation trends in Germany: R&D expenditure

From Germany's perspective, the inward and outward internationalisation of R&D has developed as follows (cf. Figure B 3-4-2): between 2005 and 2013, the degree of involvement of foreign companies in R&D in Germany showed little dynamics; between 2011 and 2013 there was even a slight decrease. It

Fig. B 3-4-3

Download data

Dynamics of total worldwide R&D expenditure by the 100 German corporate groups* with the strongest research divisions in selected industries, 2005 to 2015



* Identification is carried out according to the respective European R&D Scoreboard; the exact number of corporate groups varies slightly between observations.
Figures in billions of euros, stacked areas. Figures for 2015 are provisional.
Source: own diagram based on data from SV Wissenschaftsstatistik.

remains to be seen whether this negative development continues over the next few years.[189] On the other hand, companies domiciled in Germany have systematically expanded their R&D expenditure both domestically and abroad during the period under review. R&D expenditure abroad by corporate groups headquartered in Germany have even increased disproportionately since 2007. The sharp fall between 2005 and 2007 can be attributed to the separation of Daimler and Chrysler.[190]

R&D internationalisation trends in Germany: industries

German companies' R&D activities abroad are dominated by MNEs in the manufacturing sector (cf. Figure B 3-4-3).[191] An analysis of the approximately 100 German corporate groups with the strongest research budgets[192] for 2015 shows that in pharmaceuticals 58.1 percent of R&D expenditure flowed abroad (52.1 percent in 2013). In vehicle construction, by contrast, the foreign share was only 24.6 percent in 2015 (23.3 percent in 2013).[193]

The internal R&D expenditure invested by foreign companies in Germany[194] – totalling 11.9 billion euros in 2013 – also went mainly to those industries that can be considered as Germany's innovation system's strengths. For example, vehicle construction alone accounted for 33.9 percent, pharmaceuticals for only 10.0 percent.[195]

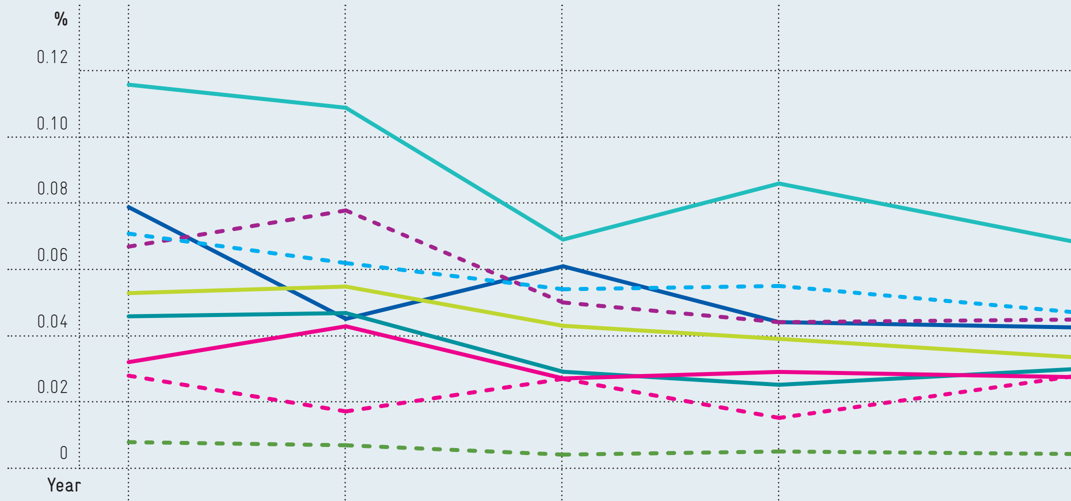
High concentration of domestic and foreign R&D in vehicle construction

Over the past decade, R&D spending by German companies has increased in almost all branches of industry, both in Germany and abroad. The sharp increase in private R&D spending by German companies over the last ten years is a remarkable development.

At the same time, the fact that the R&D activities are highly concentrated in a few core industries is a cause for concern. Vehicle construction alone accounted for more than a third of Germany's internal R&D expenditure in 2015.[196] The R&D activities of foreign companies in Germany reinforce this concentration. This is also reflected in the international mobility of skilled personnel and patent-active inventors.[197]

B 4 Entrepreneurship

Download
data



since 1998: 'EXIST – Start-ups from Science' funds start-ups and aims to improve the funding environment at

since 2004: KfW as anchor investor for venture-capital funds

since 2004: ERP/EIF Fund of Funds

2008
Corporate tax reform

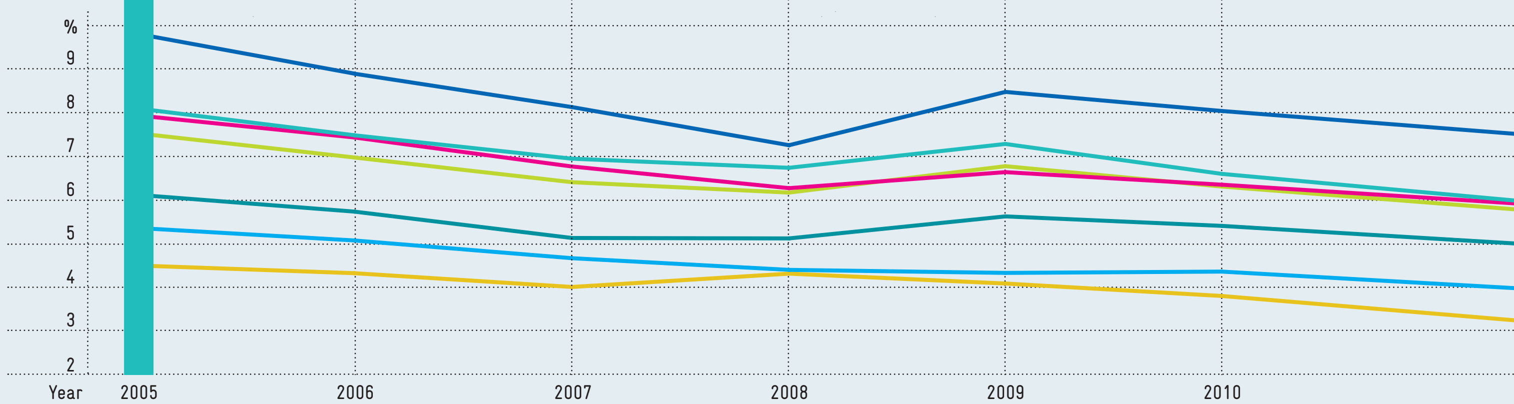
2008
Law on the Modernisation of the Framework Conditions for Venture Capital and Equity Investments (MoRaKG)

GO-Bio: funding programme for researcher teams wishing to start businesses in the life sciences

High-Tech Gründerfonds (Start-up Fund) (HTGF I)

The High-Tech Gründerfonds is set up to invest risk capital in newly established German technology companies

Start-up rates
in Germany's knowledge economy,
2005 to 2015 (as percentage)



2005 2006 2007 2008 2009 2010

2013
Coalition agreement between CDU/CSU and SPD:
"We will turn Germany into an internationally attractive investment location for venture capital (…)"

2016
Deutsche Börse announces introduction of a new market segment for young growth companies and SMEs

2016
Bundestag passes Law on the Further Development of Tax Loss Carryforwards for Corporations

Development of venture-capital investment as a percentage of national gross domestic product, 2007 to 2015

Source: EVCA, Eurostat. Own calculations.

BMWi, EIF and KfW establish two new instruments for financing venture capital

ERP/EIF Growth Facility

Coparion Fund

tertiary education institutions and other research organisations

KfW returns to the market as fund investor

INVEST Subsidy for Venture Capital

German Accelerator Tech (Silicon Valley)

First accelerator for German start-ups is set up in the USA

German Accelerator Tech (New York)

2014
INVEST Subsidy for Venture Capital is exempted from tax

German Accelerator Life Science (Cambridge)

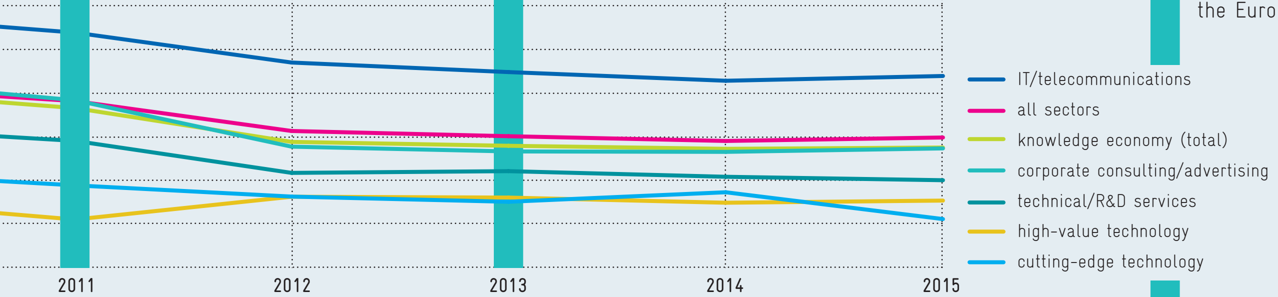
2016
INVEST Subsidy is further developed

HTGF II

HTGF III

2016
Federal Government announces Tech Growth Fund

2016
BMWi and EIF increase the funds for the ERP/EIF fund of funds to €2.7bn; €270m of this is used for the European Angels Fund



Source: Mannheim Enterprise Panel (ZEW). Calculations by ZEW in Müller et al. (2017a)

2011 2012 2013 2014 **2015** 2016 2017

For references of infocharts see Chapter D2.

B 4-1 Start-ups

B

Importance of start-ups

Business start-ups contribute significantly to raising productivity and to economic growth. The Commission of Experts has repeatedly pointed out that innovative products, processes and business models are often developed and implemented especially in new companies. In this way, start-ups secure the creation of jobs in Germany by generating local value added. As new competitors, they also force established companies to further develop their products, services and processes. Designing a founder-friendly framework must therefore be a key objective of political decision-makers.[198]

The start-up rate, i.e. the number of start-up businesses as a percentage of the total number of companies in Germany, is low by international comparison (cf. Figure B 4-1-1). Moreover, the start-up rates in the knowledge economy have been declining for years (cf. Infochart B 4).[199] In the same period, the death rates in the knowledge economy have remained constant.[200]

Promotion of innovative start-ups

There are several funding programmes at the federal level to support start-ups: EXIST, High-Tech Gründerfonds, GO-Bio, and the ERP Start-up Fund (cf. p. 84f.).

The funding programme ‘EXIST – Existenzgründungen aus der Wissenschaft’ (Start-ups from Science), which was launched as early as 1998, aims “to improve the funding environment in universities and non-university research facilities. In addition, the number of technology-oriented and knowledge-based business start-ups is to be increased.”[201] EXIST has been extended by a number of funding programmes since its introduction. Most recently, the funding for entrepreneurial teams from tertiary education institutions was increased in 2014.[202]

The HTGF – ‘High-Tech Gründerfonds’ (High-Tech Start-up Fund) is a fund created as a public-private partnership by the BMWi, the KfW and several major German companies. The HTGF has been investing in technology-oriented start-ups without any restrictions to specific industries since 2005. In 2017, the third HTGF (HTGF III) will be launched with a volume of 300 million euros. According to the BMWi, the participation of private companies in HTGF III is to be significantly expanded compared to the previous two funds.[203]

The ‘GO-Bio Gründungsoffensive Biotechnologie’ (Start-up Offensive in Biotechnology) was launched in 2005 as a funding programme specifically for teams of researchers prepared to start businesses in the field of life sciences. It takes into account the long development periods and considerable financial requirements that are typical of biotechnological research projects. It aims to offer extensive support to prepare research teams for the activities involved in founding a company.[204]

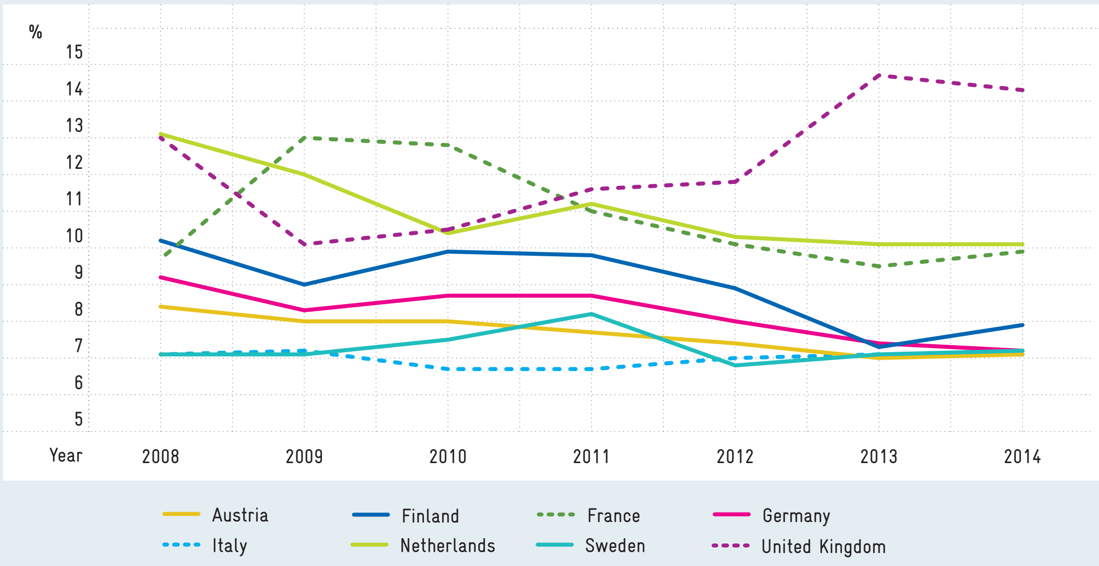
The Commission of Experts rates the above-mentioned funding programmes as important support instruments for young companies. It considers the EXIST funding programme and GO-Bio important measures for creating a start-up-friendly environment in tertiary education institutions and non-university research organisations. In the last few years, the HTGF has continuously contributed to the financing of young companies in their early stages.

However, the Commission of Experts simultaneously repeats its criticism of the decision, taken in 2011, to convert the Federal Employment Agency’s instrument of the start-up subsidy from a mandatory into a discretionary measure. This change has been critically commented on by labour-market researchers.[205] In addition, the Commission of Experts points out that this change in the law could have a negative impact on the start-up culture in Germany and reduce the motivation of the unemployed to show initiative.[206]

Fig. B 4-1-1

Download data

Development of percentage start-up rates in selected European countries from 2008 to 2014



Source: Business Development Statistics (Eurostat). Calculations by ZEW (Centre for European Economic Research).

Indeed, the number of start-up subsidies granted fell from 134,000 in 2011 to just over 20,000 in 2012 and rose only slightly to 31,000 in the following two years.[207]

Framework conditions and start-up culture in Germany

The likelihood and propensity of a person to launch a start-up is influenced by institutional framework conditions. In the view of start-up experts in business, science and politics, Germany has a number of advantages to offer, e.g. the physical infrastructure, effective public funding programmes, and well-developed institutions for the protection of intellectual property. The availability of technically competent consulting firms and suppliers also makes the country attractive as a business location. Furthermore, German consumers and companies are considered inherently open to innovative new products and services.[208]

Disadvantages are seen especially in start-up training in school and to some extent in out-of-school education.[209] Despite an increasing number of programmes to promote entrepreneurial thinking in schools,[210] school-based start-up training is regarded as one of Germany's greatest weaknesses as a start-up location.[211]

Activities in the field of start-up training have been intensified at many German tertiary education institutions since the 1990s, although awareness of the issue is being raised mainly in study courses relating to economics. In the Commission of Experts' assessment, awareness of the topic of founding a new company is still relatively low, and there is little teaching with start-up-relevant content, in the natural sciences and engineering.

Yet both tertiary education institutions and non-university research organisations are considered to have significant start-up potential which would be economically worthwhile developing.[212] The Commission of Experts does not see any inherent contradictions between the first two tasks of scientific institutions (teaching and research) and the third task (transfer of knowledge and technology). Rather, these tasks are complementary.

The Federal Government launched the above-mentioned EXIST programme back in 1998 to support the third task.[213] An up-to-date evaluation report on the funding programme attests significant progress at the tertiary education institutions examined, and recommends the continuation of the funding programme. However, the report also criticises the fact that there is still considerable room for improvement in structures and staffing levels devoted to carrying out the third task at many tertiary education institutions.[214] However, EXIST funding and other promotional activities have led to a gradual change in awareness at tertiary education institutions.[215]

The Commission of Experts welcomes evidence indicating that start-up failures are becoming less stigmatised in society than they used to be. In fact, many companies regard experience with a failed start-up as valuable know-how.[216]

Administrative barriers

There have repeatedly been complaints about the high administrative hurdles for start-ups in Germany.[217] The red tape involved in starting a business in Germany is indeed greater than in all other industrialised countries. In a global comparison of the administrative costs of a start-up, the World Bank ranks Germany 114th among the 190 countries covered.[218] By contrast, the administrative costs of running an existing company are comparatively moderate. In this case, Germany is placed 17th in the World Bank's Doing Business Ranking.[219]

The impression of high administrative costs is confirmed by statements made by business founders in Germany. When asked about their expectations from political decision-makers, the participants in the German Startup Monitor give top priority to the reduction of bureaucratic and regulatory hurdles (20.3 percent). Expectations relating to tax relief and assistance with capital procurement follow a long way behind (13.5 percent).[220]

In order to offer companies and founders simplified access to administrative information and procedures and thus cut red tape, since 2009 the EU member states have been obliged to set up a so-called Point of Single Contact,[221] where companies can take care of all the necessary procedures and formalities. However, in an inner-European comparison, Germany comes last in the implementation of the Point of Single Contact.[222] In December 2015, therefore, the Meeting of German State Economic Ministers decided on the strategic realignment of the Point of Single Contact on the basis of common organisational principles.[223] The aim is to implement the Point of Single Contact 2.0 project by the end of 2017 under the leadership of the Federal Government and the state of Hesse.[224]

The administrative practice of some state funding programmes represents a special problem. Although public funding programmes in Germany are regarded as effective in principle (cf. p. 81), there is criticism from young companies financed by venture capital. For example, companies must prove their credit rating for the duration of a project in order to qualify for funding. This credit check is necessary as the companies usually do not receive full financing, but must raise a certain proportion of the project costs themselves. In practice, it has been shown that the formal requirements for the credit check are often interpreted restrictively. This restrictive practice becomes a problem for companies financed by venture capital, because they can usually only prove their credit rating for the limited period of a financing phase. Due to this uncertainty, the project administration frequently decides against funding innovative, venture-backed companies.[225]

In addition, companies taking part in a funding programme must prove that they run the state-funded project activities separately from their actual businesses. This separation between project and business activity is difficult to guarantee, especially for small and micro businesses.[226]

Lack of a Europe-wide legal form

In the Commission of Experts' assessment, the absence of a legal form for small businesses that is valid Europe-wide is another obstacle to growth for companies. While the legal form of the European public limited company (Societas Europaea) is used by many large companies, no agreement has yet been reached on a European corporate form for the private limited company. As a result, a company that wants to expand its business activities across Europe has to form a separate company in each country. This process involves considerable organisational and financial effort.[227]

B 4-2 Venture capital

B

Importance of venture capital for innovation

Venture capital is an important source of financing for young innovative enterprises, without which they are unable to create and market their innovative products or business models.[228]

Financing represents a major challenge for many companies – not only in the early start-up stage, but also during the growth phase. Particularly in the case of highly growth-oriented businesses, the financing requirements can quickly rise to several million euros[229]; this is why external financing is often essential at the beginning of business operations. The typical form of financing is to borrow external equity capital from business angels or venture capitalists. As a rule, debt financing is not an option, since young companies are usually unable to provide the collateral required by banks.[230]

Despite some improvements over the past few years, only a limited amount of venture capital is available in Germany. Many venture capital funds are too small, especially for the particularly capital-intensive financing rounds during the growth phase. Nor is this gap closed by foreign funds. The lack of capital means that many promising start-ups in Germany only grow slowly compared to start-ups in other countries. Furthermore, no stock-market segment is currently available to allow a transition to a share-based form of financing. As a result, IPO exits by German start-ups are rare; German start-ups with excellent chances of success are often taken over by foreign firms.[231]

An international comparison shows that the venture capital market in Germany is much less developed than in the USA or in other European countries. In 2015, about 0.027 percent of GDP was invested in young growth companies in Germany; approximately 0.333 percent of GDP was available in the USA.[232] Even by European comparison, Germany only ranks about mid-table. The frontrunners in Europe – Finland, Switzerland and Sweden – have figures of 0.051 percent, 0.043 percent and 0.036 percent respectively.[233] In the United Kingdom, venture capital amounting to 0.034 percent of GDP is available to young companies.

In Europe, the largest number of former venture-backed companies whose current value exceeds a billion US dollars are based in the UK and Sweden; Germany follows in third place. The cumulative value of these so-called unicorns amounts to 39.6 billion US dollars in the United Kingdom, 31.1 billion in Sweden, and 20.8 billion in Germany.[234]

Framework conditions for venture capital financing

In order to overcome the weakness of the German venture capital market and turn Germany into an internationally competitive investment location, the Federal Government has initiated a whole series of improvements for venture capital investment over the last few years.[235] In 2013, for example, the programme ‘INVEST – Zuschuss für Wagniskapital’ (Subsidy for Venture Capital) was launched to mobilise more capital from private investors in Germany.[236] The programme was extended to INVEST 2.0 with effect from January 2017. Investors receive a subsidy of up to 100,000 euros per year for investments in young innovative companies. In addition, the tax on capital gains is refunded.[237] EXIST funding for start-up teams from tertiary education institutions was increased, and the regulations – in particular the prospectus requirements – for crowdfunding with a volume of up to 2.5 million euros were relaxed.[238]

Many venture capital funds have been newly launched or topped up. KfW returned to the market as an investor for venture capital funds in 2015 with a budget of 400 million euros.[239]

In addition, the BMWi, the European Investment Fund (EIF) and the KfW set up the 'ERP/EIF-Wachstumsfaszilität' (Growth Facility) and the Coparion fund in March 2016, two new instruments for financing venture capital with volumes of 500 and 225 million euros respectively.[240] Coparion succeeds the ERP-Startfonds (Start Fund), which had – as part of KfW – previously invested in small, innovative technology companies.[241]

In July 2016, an extra billion euros in funding was made available to the ERP/EIF-Dachfonds (Fund of Funds), established in 2004, topping it up to 2.7 billion euros.[242] The purpose of these measures is to close the gap in supplying follow-up financing for young businesses in the growth phase.[243] The ERP/EIF-Dachfonds provides 270 million euros for the European Angels Fund, which was launched in 2012.[244]

Furthermore, in July 2016, the Federal Government announced the launch of a new fund with a volume of 10 billion euros. This so-called Tech-Growth-Fund is to grant founders one additional euro of credit on favourable terms for every euro of venture capital.[245]

In addition to the measures for improving the financing situation, the Federal Government set up accelerators for young companies in the field of information and communication technology (ICT) and life sciences between 2012 and 2016. The BMWi-supported German Accelerator in Silicon Valley, New York and Cambridge (Boston) makes it possible for founders of start-ups to spend several months accompanied by mentors in the environment of the USA's great ICT and life-sciences cluster.[246] The aim is to encourage business development in the USA, which is still the largest international market for innovative products and services.

Law for the improvement of loss carryforward regulation

In order to overcome a further obstacle for venture capital investment, the Federal Government submitted a draft Act on the Further Development of Tax Loss Carryforwards for Corporations (Gesetz zur Weiterentwicklung der steuerlichen Verlustverrechnung bei Körperschaften) in September 2016; it was passed by the Bundestag and adopted by the Bundesrat in December 2016.[247] The restrictive tax regulations on the treatment of loss carryforwards[248] (section 8c of the Corporation Tax Act [Körperschaftsteuergesetz, KStG]) had repeatedly been named in the past as the reason for the weak venture capital market in Germany by international comparison.[249]

At present, carried-over losses cannot be deducted from tax if an investor acquires shares in a company above a certain level. Yet innovative companies in particular spend large sums on research and development (R&D) in the first few years, which can then be posted as carried-over losses. If these loss carryforwards for R&D expenditure can no longer be deducted from tax after a takeover, the companies are less attractive for potential investors.[250]

The new regulations launched by the Federal Government (new section 8d of the KStG) aim to ensure that unexploited losses (loss carryforwards) can still be used despite a change in shareholders. The precondition is that the entity's business operations are maintained after the change of shareholders and any other use of the losses is excluded.[251] The Commission of Experts warns that this condition must be interpreted flexibly enough, since start-ups often change their business model, customer target group or technology.

B

Taxation of capital gains and the remuneration of fund initiators

In 2014, within the framework of a Bundesrat initiative, the Länder called on the government to introduce a general taxation on capital gains realised on the sales of free-floating shares in corporations. The Federal Government has not taken up this initiative.[252] The Commission of Experts welcomes this decision because it would have made small-scale investments by venture capitalists and business angels less attractive and thus reduced incentives to invest in young, innovative enterprises.[253]

Similarly, the Federal Government has not agreed to calls by the Länder for an increase in the taxation of fund-initiator remuneration – known as carried interests.[254] However, it is not clear whether the discussion might be resumed at a later date. This ongoing uncertainty reduces long-term planning security for the initiators of venture capital funds.[255]

Another locational disadvantage is that – unlike in many other European countries – the administrative services of fund managers in Germany are subject to turnover tax.[256] Building up and administering venture capital funds in Germany is therefore relatively unattractive.[257]

Restrictions for anchor investors

Not only changes to overall tax conditions are necessary in order to revive the venture capital market. Major institutional investors, e.g. pension funds, are also important. In countries with funded pension schemes, such funds often act as anchor investors that send important signals to foreign investors on investment opportunities on the domestic market. Since the pension system in Germany is largely financed according to the pay-as-you-go principle, these anchor investors are missing here. This makes it all the more important that other institutional investors – e.g. insurance companies – can become active in this field. However, institutional investors are often hesitant to invest in venture capital funds because of stringent regulatory requirements. The Commission of Experts regards it as a positive initial signal that the KfW returned to the market as a fund investor in 2015 (cf. p. 85) and can thus contribute to winning over further domestic and foreign institutional investors.[258]

Importance of liquid secondary markets

In the long run, liquid secondary markets are also needed to improve incentives for investors. The availability of flexible exit options increases the incentive for investors to invest in venture capital funds.[259]

Since it has not been possible to create a separate stock-market segment for young companies in the past, due to the small number of exits, in December 2014 the BMWi opened a dialogue process aimed at reviving the stock market as a source of financing for young growth companies and as an important exit channel for investors.[260]

In June 2015, the first result of the dialogue became visible with the founding of the Deutsche Börse Venture Network.[261] This network acts as a pre-trade matching platform to bring institutional and private investors together with young, growth-oriented companies, and to give support in setting up rounds of financing.[262] As a further step in November 2016, Deutsche Börse (the German stock exchange) announced the introduction of a new stock-market segment for young growth companies and SMEs.[263] The new segment is to be launched in March 2017.[264]

Encouraging final spurt

The Commission of Experts expressly welcomes the improvement in the framework for start-ups and venture capital financing initiated at the end of the current legislative period. The reorganisation of loss carryforwards and the creation of a stock-market segment for young growth companies represent important milestones on the road to making Germany competitive in the field of venture capital funding. The continuation of the High-Tech Gründerfonds and the INVEST programme will provide important support in this context.

B 5 Governance

Download
data

Development of research and innovation policy

Classic mission orientation

Key civilian technologies

Systemic approach

New mission orientation

Classic mission orientation
Definition of goals and the technical developments with which they are to be achieved (priorities in the field of large-scale technologies such as nuclear power and aerospace)
Goal: Production of public goods

Key civilian technologies
Funding of key technologies with great application potential (e.g. information technology and biotechnology)
Goal: To realise economies of scale and first-mover advantages, as well as the use of knowledge spillover and other positive external effects

Systemic approach
Funding of cooperation, innovation activities of SMEs and knowledge-intensive start-ups, as well as the creation of innovation-friendly framework conditions (inter alia the design of tax policy and product-specific regulations)
Goal: To avoid policy failure and undesirable path dependencies

New mission orientation
Funding is not primarily related to the production of specific technologies, but to contributions to solving problems and meeting societal challenges
Goal: To trigger transformative processes to meet societal challenges (e.g. climate change, demographic change)

High-Tech Strategy

High-Tech Strategy for Germany (2006–2009)
Focus primarily on key technologies and lead markets

Evidence-based innovation policy

Data of the Federal Employment Agency opened for science
Researchers given access to microdata in the field of social insurance, as well as labour-market and occupational research

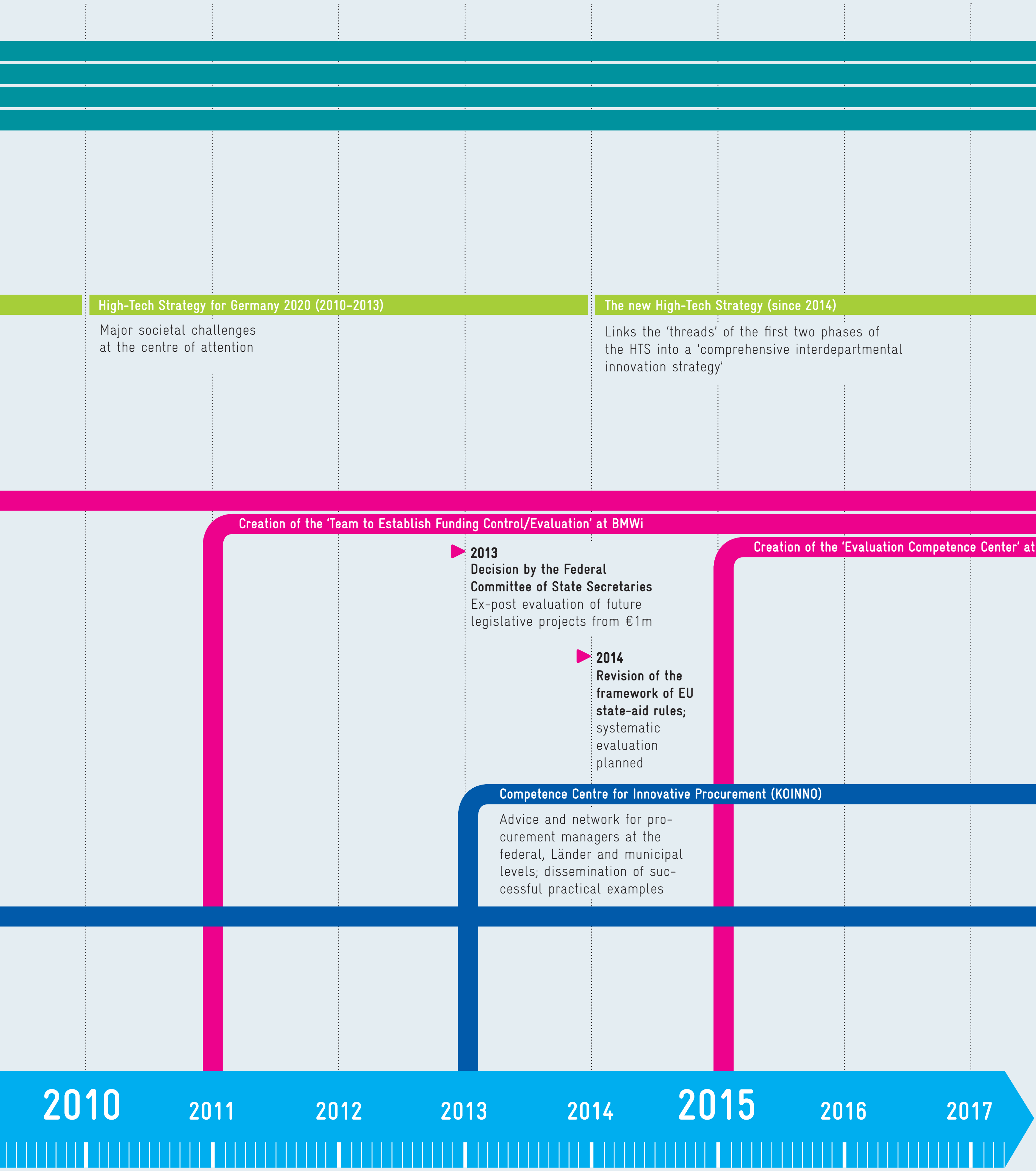
2009
Reform of Public Procurement Law: Permission of innovation-promoting aspects as procurement criterion

Innovation-oriented public procurement

'Leadership Through Innovation'
Prize for the procurement of innovations and the design of innovative procurement processes

2006
Decision to strengthen innovation orientation of public procurement at six federal ministries

1950 1990 2004 2005 2006 2007 2008 2009


High-Tech Strategy for Germany 2020 (2010–2013)
Major societal challenges at the centre of attention
The new High-Tech Strategy (since 2014)
Links the 'threads' of the first two phases of the HTS into a 'comprehensive interdepartmental innovation strategy'
Creation of the 'Team to Establish Funding Control/Evaluation' at BMWi
2013
Decision by the Federal Committee of State Secretaries
Ex-post evaluation of future legislative projects from €1m
Creation of the 'Evaluation Competence Center' at BMBF
2014
Revision of the framework of EU state-aid rules;
systematic evaluation planned
Competence Centre for Innovative Procurement (KOINNO)
Advice and network for procurement managers at the federal, Länder and municipal levels; dissemination of successful practical examples
2010
2011
2012
2013
2014
2015
2016
2017

B 5-1 The High-Tech Strategy

The High-Tech Strategy as a coordination instrument

Policies on research, technology and innovation have become increasingly complex in recent decades in highly developed industrialised countries like the Federal Republic of Germany.[265] This complexity is reflected in the coexistence of different state funding concepts for research and innovation (R&I), each of which have been initiated with different motivations and objectives (cf. Infochart B 5). There has been a significant increase over time in the number of instruments used and actor groups addressed, as well as in the number of allocation modalities and funding institutions. In addition, the societal challenges that have become the focus of R&I policy in the context of the new mission orientation also impact on different areas and levels of policy. This makes the coordination of R&I policy a key challenge.

Partially as a response to the increased need for coordination in state R&I policy, in 2006 the Federal Government initiated the so-called High-Tech Strategy (HTS), which entered its third phase in September 2014. In the first phase of the HTS from 2006 to 2009, the focus was mainly on key technologies and lead markets,[266] although attention was also already drawn to the need to use innovations to help overcome major societal challenges. The second HTS phase from 2010 to 2013 (High-Tech Strategy 2020 for Germany – Ideas, Innovations, Growth) brought these societal challenges even more into the centre of attention as a justification for an overarching state R&I policy.[267] The current, third phase of the HTS since 2014 (The New High-Tech Strategy – Innovations for Germany) aims to link together the 'threads' of the first two phases[268] and to further develop the HTS[269] into a "comprehensive interdepartmental innovation strategy."[270]

The Commission of Experts welcomes the fact that the establishment of the HTS has successfully strengthened inter-departmental cooperation in the shaping of R&I policy.[271] However, it still sees room for improvement – above all, the inter-departmental coordination of R&I policy should be significantly speeded up during the next legislative period.

The New High-Tech Strategy

The New HTS[272] includes a number of different approaches of R&I policy: the promotion of key technologies, promotion based on systemic approaches, and the new mission orientation (cf. Infochart B 5).

In the view of the Federal Government, key technologies are "of particular importance due to their economic leverage effect".[273] Unlike the second phase of the HTS, the use of key technologies in the third HTS phase was no longer geared primarily towards solving specific problems in the field of societal challenges.[274] In its 2015 Report, the Commission of Experts welcomed this as well as the open funding concept. However, the delayed implementation of the third phase of the HTS makes it almost impossible to draw conclusions on the effectiveness or success of the new approach.

Many of the new HTS's funding measures are based on systemic approaches. For example, the HTS promotes networking and transfer, as well as the innovation activities of SMEs and the creation of start-ups.[275] Furthermore, the Federal Government regards it as an important task to create innovation-friendly framework conditions – including, for example, better innovation financing and the creation of an education- and research-friendly copyright law.[276]

The New HTS contains policy requirements that are characteristic of the new mission orientation.[277] Six societal challenges were named in the HTS as "priority challenges": digital economy and society, sustainable development and energy, innovative work

Tab. B 5-1-1

Download data

Percentages of expenditure by the Federal Government on research and development by funding areas, 2009 to 2016

	2009	2010	2011	2012	2013	2014	2015	2016	% change 2009–2016
Funding area[1),2)]	Actual	Actual	Actual	Actual	Actual	Actual	Target[3)]	Target[3)]	
A Health research and health industry	12.8	12.8	12.8	13.5	13.0	13.8	13.9	14.1	45.2
B Bioeconomy	1.9	1.8	1.7	2.0	1.9	1.9	1.9	1.8	27.0
C Civil security research	0.7	0.7	0.7	0.7	0.7	0.6	0.7	0.7	25.3
D Nutrition, agriculture and consumer protection	4.5	4.5	4.3	4.7	4.4	4.5	4.8	5.0	46.4
E Energy research and energy technologies	6.5	6.2	6.5	7.6	8.0	8.3	8.4	8.3	67.9
F Climate, environment, sustainability	8.1	7.7	7.6	8.0	8.0	8.1	8.4	8.4	36.8
G Information and communication technologies	6.2	5.8	5.5	5.5	5.4	5.1	5.2	5.7	21.8
H Vehicle and traffic technologies including maritime technologies	1.9	3.1	3.9	1.6	2.0	2.0	2.3	2.5	75.8
I Aerospace	10.4	9.9	10.0	9.8	9.7	9.9	9.9	10.5	33.1
J Research and development to improve working conditions and in the service sector	0.7	0.7	0.7	0.6	0.5	0.5	0.6	0.6	12.6
K Nanotechnologies and materials technologies	3.6	3.4	3.5	3.6	3.7	3.6	3.6	3.5	28.0
L Optical technologies	1.4	1.3	1.3	1.3	1.3	1.2	1.2	1.2	15.2
M Production technologies	1.7	1.7	1.6	1.5	1.5	1.6	1.5	1.5	11.5
N Regional planning and urban development; construction research	0.6	0.6	0.6	0.6	0.6	0.6	0.7	0.7	43.8
O Innovations in education	3.0	3.1	3.1	3.2	3.2	3.4	4.0	3.0	31.2
P Humanities; economics and social sciences	6.3	6.2	6.2	6.5	6.4	6.5	6.7	6.9	45.5
Q Innovation funding for small and medium-sized SMEs	6.7	8.4	9.4	7.4	7.5	7.1	7.5	7.2	40.3
R Innovation-relevant underlying conditions and other cross-cutting activities	2.3	2.7	2.5	2.7	2.8	2.8	3.1	2.7	56.0
T Funding organisations, restructuring of the research field in acceding areas; construction of universities and primarily university-specific special programmes[4)]	4.6	3.8	4.1	4.7	4.6	4.8	4.7	4.6	32.1
U Large-scale equipment for basic research	7.0	6.6	7.1	7.6	7.3	7.3	8.1	8.1	51.8
Z Global reduced expenditure; budget reserve[5)]	0.0	0.0	0.0	0.0	0.0	0.0	-2.7	-1.6	
Civilian funding areas combined	90.8	91.1	92.8	93.2	92.4	93.8	94.4	95.1	38.2
S Military scientific research	9.2	8.9	7.2	6.8	7.6	6.2	5.6	4.9	-29.3
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	
Total expenditure in billions of euros	12.0	12.8	13.3	13.4	14.3	14.2	14.9	15.8	32.0

1) According to the categories of the Federal Government's 2009 R&D-planning system (Leistungsplansystematik). Expenditure was converted to the final planning system in 2009. Expenditure by the non-university research organisations is distributed across individual funding areas and funding priorities.
2) 2009 to 2011 including Investment and Amortisation Fund without Länder allocations (Economic Stimulus Package II), from 2011 including the Energy and Climate Fund. Research funding in the field of electromobility has been financed by the Energy and Climate Fund since 2012. From 2016 including investments in the future.
3) Some of the distribution to funding areas and funding priorities was estimated or extrapolated.
4) Including the Bundeswehr universities and Federal University of Applied Administrative Sciences.
5) The distribution of the global reduction in the BMBF's spending across funding areas and funding priorities can only be given in the actual figures.

Source: BMBF data portal, cf. http://www.datenportal.bmbf.de/portal/de/Tabelle-1.1.5.html (accessed on 19 December 2016); own calculations.

B

environment, healthy living, intelligent mobility, and civil security.[278]

In its 2015 Report, the Commission of Experts called for clear target hierarchies to be also formulated within these priority challenges.[279] As a positive example it singled out the fact that the new HTS places more emphasis on participatory processes to ensure that citizens and groups of actors in civil society are involved in deciding on the priorities for funding.[280] For example, the 3rd Framework Programme of Research for Sustainable Development (FONA³)[281] launched in 2015 was developed as part of an agenda process involving science, business, politics and civil society.[282]

In addition to the development of clear target hierarchies, the Commission of Experts recommends paying more attention to important cross-references that are relevant for several priority challenges. Examples of these include digital business models or the use of robotics. In the view of the Commission of Experts, such cross-references have been neglected as a result of the focus on the production sector (Industry 4.0), particularly in the ICT sector.

Extension of the concept of innovation in the New High-Tech Strategy

The concept of innovation has been extended in the New HTS and now also includes social innovations.[283] However, the concept of social innovation is not uniformly defined. The Commission of Experts understands it as the change in social practices, e.g. changes in the use of technologies, changes in lifestyles, business and financial models, working practices and forms of organisation.[284] In its view, there is no need for a fundamental paradigm shift in R&I policy in order to take social innovations more into account.[285] In other words, no special funding criteria are required to distinguish between social and technological innovations.[286] In principle, funding is always required when there is a market failure.[287] According to this premise, the development, research and testing of new ideas for changing social practices are also eligible for funding.

The Commission of Experts welcomes the explicit consideration of social innovations by the new HTS and the first steps towards concrete implementation in the form of funding measures.[288]

The Federal Government's priorities in R&D funding

The Federal Government supports R&D in tertiary education institutions, non-university research organisations and private companies in many different ways – for example via the DFG's thematically unspecified funding, the institutional promotion of non-university research organisations, the promotion of civilian projects within the framework of thematic programmes and funding measures, as well as the award of civil R&D contracts, funding that is open to all technologies, and the award of R&D contracts by the BMVg (cf. Chapter B 3-2).

In recent years, the Federal Government's overall expenditure on R&D has increased significantly – from 12.0 billion euros (actual figure) in 2009 to 15.8 billion euros (target figure) in 2016. At the same time, the distribution of resources to the individual areas of funding has largely remained constant (cf. Table B 5-1-1). While welcoming the considerable growth in funds made available for R&D, the Commission of Experts calls for a critical examination of the distribution of resources. For example, there is no indication that more resources were directed to the field of information and communication technologies – which are so important for managing digital change – in the period from 2009 to 2015. Only the target value for 2016 points towards a slightly higher prioritisation of this funding area. The Federal Government published a new framework programme in the field of microelectronics in February 2016.[289] Overall, the redirection of funding to benefit research in information and communication technologies has taken a relatively long time.

Innovation-oriented public procurement

B 5-2

Promoting innovation through demand-side policy

Demand-side innovation policy has gained in importance in many countries over the last few decades.[290] Measures of demand-side innovation policy include regulation (e.g. laying down minimum technical standards for products), the promotion of private demand for innovative goods (e.g. buyers' premiums), and the public procurement of innovative goods and services. Here, this last measure is called innovation-oriented procurement.[291]

One important area of application for innovation-oriented procurement can be the development of a comprehensive and user-friendly system of e-government (cf. Chapter B 6-2). Building an efficient e-government structure can, in turn, help conduct innovation-oriented procurement in a transparent and efficient manner.

Objectives of innovation-oriented procurement

Innovation-oriented procurement can be used by state actors to correct market failures and as an instrument of strategic R&I policy. Furthermore, state actors must ensure that their services are rendered in a manner that is qualitatively appropriate and cost-effective. In order to meet this standard, the public sector must itself use enough innovative preliminary products and services.[292] The Commission of Experts believes that this is not sufficiently the case in Germany. Public procurement too often resorts to established or not-very-innovative solutions, thus leaving potential for developing innovative products and services untapped.[293]

High volume of procurement by the public sector

The potential of innovation-oriented public procurement stems from the considerable size of public-sector demand. In Germany, the total volume of public procurement accounts for around 15 percent of GDP (cf. Figure 5-2-1); the figure for 2015 was approximately 456 billion euros.[294]

The potential procurement volume for innovative products and services is estimated to be at least ten percent of public procurement.[295]

While there are uniformly collected and internationally comparable data on the volume of total public procurement in the OECD member states, innovation-oriented procurement is difficult to quantify. No data on this are systematically collected either in Germany or at the international level.[296] Data collection in Germany is made more difficult by the fact that procurement is highly fragmented with an estimated 30,000 contracting authorities.[297]

Innovation-oriented procurement in practice

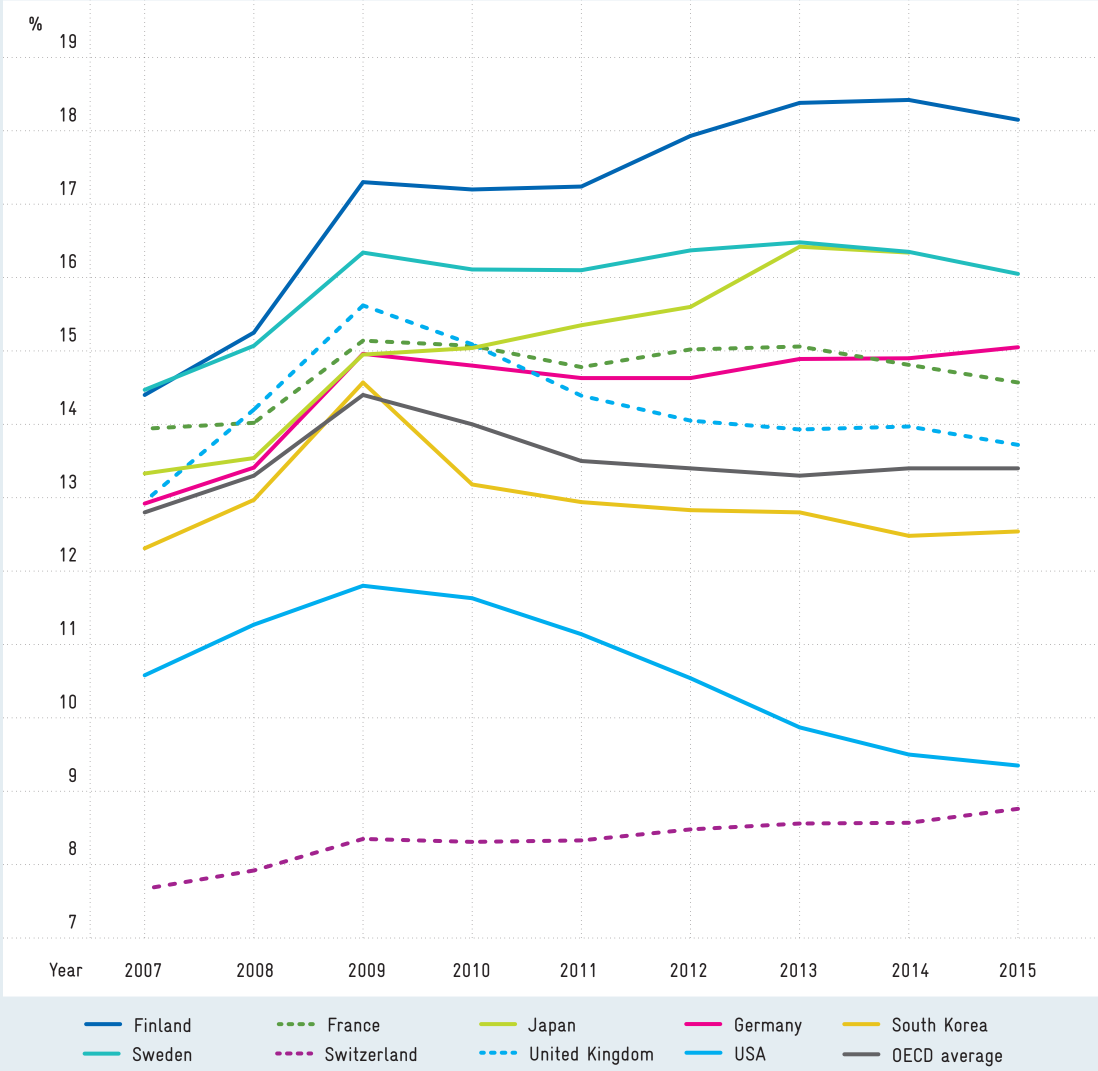
Making the public sector more aware of the potential of innovative procurement is an explicit political goal both at the EU level and in Germany. In the last few years, the European Commission has developed rules that expressly support and encourage putting emphasis on the innovation aspect in public procurement.[298]

This involves the gradual reorientation of procurement law. For example, in 2009, Germany's Act on the Modernisation of Public Procurement Law (Gesetz

Fig. B 5-2-1

Download data

Public procurement as a percentage of GDP, 2007 to 2015



Quelle: OECD National Accounts Statistics (database).

zur Modernisierung des Vergaberechts) permitted strategic procurement targets like environmental, social-policy and innovation-promoting aspects as procurement criteria for the first time.[299] With the so-called negotiation procedures and competitive dialogue, procedures for procurement processes that offer more flexibility and room for manoeuvre in public procurement were introduced. Furthermore, two instruments were created that specifically allow greater focus on innovative procurement: pre-commercial procurement (PCP) and public procurement of innovation (PPI).[300]

In order to create incentives to encourage a stronger orientation towards innovation among procurement managers, the BMWi, in cooperation with the German Association for Supply Chain Management, Procurement and Logistics (Bundesverband Materialwirtschaft, Einkauf und Logistik, BME), has since 2006 been awarding a prize called ‘Leadership Through Innovation’ (‘Innovation schafft Vorsprung’) for top performances by contracting authorities in the procurement of innovations and in innovative procurement processes.[301]

The Competence Centre for Innovative Procurement (Kompetenzzentrum innovative Beschaffung, KOINNO) was set up in Germany in March 2013 as a central political initiative. The purpose of this centre is to advise and network procurement managers at federal, Länder and municipal level. In addition, KOINNO helps disseminate successful practical examples[302] and, against this background, also supervises the award of the prize 'Leadership through Innovation' for the BMWi.[303]

However, apart from setting up the Competence Centre for Innovative Procurement, the Federal Government has not launched any major initiatives to promote innovation-oriented procurement, with the result that innovation-oriented procurement is a little-used instrument of innovation policy. In the Commission of Experts' view, this is an omission.

The US government, for example, already began state promotion of procuring innovative goods three decades ago. The Small Business Innovation Research (SBIR) programme, set up in 1982, supports small and medium-sized enterprises (SMEs) via innovation-oriented public procurement. According to the SBIR programme, all federal agencies with an R&D budget of at least 100 million US dollars must pay out a certain percentage of this budget to innovative SMEs via a competition-based procedure. To this purpose, the federal agencies identify societal innovation requirements, e.g. in the fields of health, safety, the environment and energy. SMEs are then invited to compile feasibility studies for innovative projects in these areas of need, which are then financed by the SBIR programme.[304] In a second step, the R&D activities to implement a project proposal can then be promoted, e.g. in the form of a prototype.[305] However, the market launch of the new product developed in this way takes place outside the SBIR programme.[306]

Several countries, including Japan, the United Kingdom and the Netherlands, have set up similar support programmes.[307] The Commission of Experts recommends carefully assessing the costs and benefits of the US SBIR programme and similar programmes in the above-mentioned countries from the point of view of their innovation effects.

B 5-3 Evidence-based innovation policy

B

Aims, potential and limits of impact research

Impact analyses on funding measures of R&I policy make it possible to assess whether the funds provided and measures taken have the desired effect and thus achieve the intended objectives. The findings of evaluations are therefore an important factual basis for the continuous adjustment and improvement of existing measures. They help ensure that the funds spent have maximum effect in reaching the previously clearly defined objectives with a minimum of effort and resources. Thus, the purpose of such evaluations is to encourage learning processes and to provide more knowledge for decision-makers. In turn, funds made available by effective and cost-efficient use can be diverted to further strengthen particularly effective measures, to reach objectives more quickly, and to further develop the instruments of R&I policy. Especially in the context of entirely new measures and instruments of R&I policy, it is important to systematically evaluate such courageous experiments conducted by political decision-makers from the outset and, in addition, to develop a strategic knowledge advantage in international competition between funding policies.

Evaluations in this sense must be in line with the latest scientific standards and ultimately help policy-makers and ministries to make informed decisions. Today, randomised experiments are among the particularly promising evaluation methods, because they are especially good at identifying causal effects.[308] Causal effects represent a direct connection between the cause (funding) and effect (impact) of measures, e.g. improved innovation performance in the companies receiving funding (treatment group) compared to companies that have received no funding (control group). They help ensure that the allocation of funds is focused on areas where they have a particularly strong effect, and that funding is quickly abandoned where it is shown to be ineffective.

However, such randomised experiments also have their limits.[309] Even when they provide information on the effectiveness of a measure in the observed context, a careful analysis must still be made to determine whether, and under what conditions, the impacts can be generalised and are transferable to other situations. The systematic use of randomised experiments prior to the introduction of new measures helps continuously accumulate more knowledge.[310]

Randomised experiments cannot be used in the case of all funding measures, for legal or even for purely practical reasons. In such cases, it is advisable to use quasi-experimental methods with control-group approaches which make it possible to determine the causal effects of the funding measure. The choice of methodology should be in line with the latest research.

If the selected evaluation period is too short, it is impossible to determine long-term or downstream effects conclusively. For this reason, the period of data collection and evaluation should be correspondingly long.

Current evaluation practice in Germany

Evaluation practice in Germany to date reveals a mixed picture. Meanwhile, evaluations or success checks are carried out on many R&I-policy measures. Since 2013, ex-post evaluations have been obligatory for legislative proposals above a specified annual funding volume, although they are not subject to fixed methodological standards, as they are in some other countries.[311] The Verein für Socialpolitik, among others, has pointed out the need for qualitative standards, and has prepared guidelines and recommendations for ex-post impact assessments.[312] Indeed, there is still a lot of catching up to do when it comes to the scientific quality of many evaluations. Even when evaluations are conducted, the evaluation results and associated research data are sometimes not published.[313] The result is not only a lack of transparency regarding the quality of the evaluations; above all, there is often also a lack of opportunities and incentives to check the quality of the studies and for the improvement of the evaluation quality.

Unlike with measures of labour-market policy in the USA,[314] for example, in Germany there is no systematic recording of evaluation studies and associated research data in the context of R&I policy. To date, there are no so-called clearing houses that would deliver a transparent and comparative overview of past evaluations at the national and international level, make it possible to identify best practices, and facilitate a scientific validation of the studies. Typically, the mandated evaluations are published in a decentralized way.

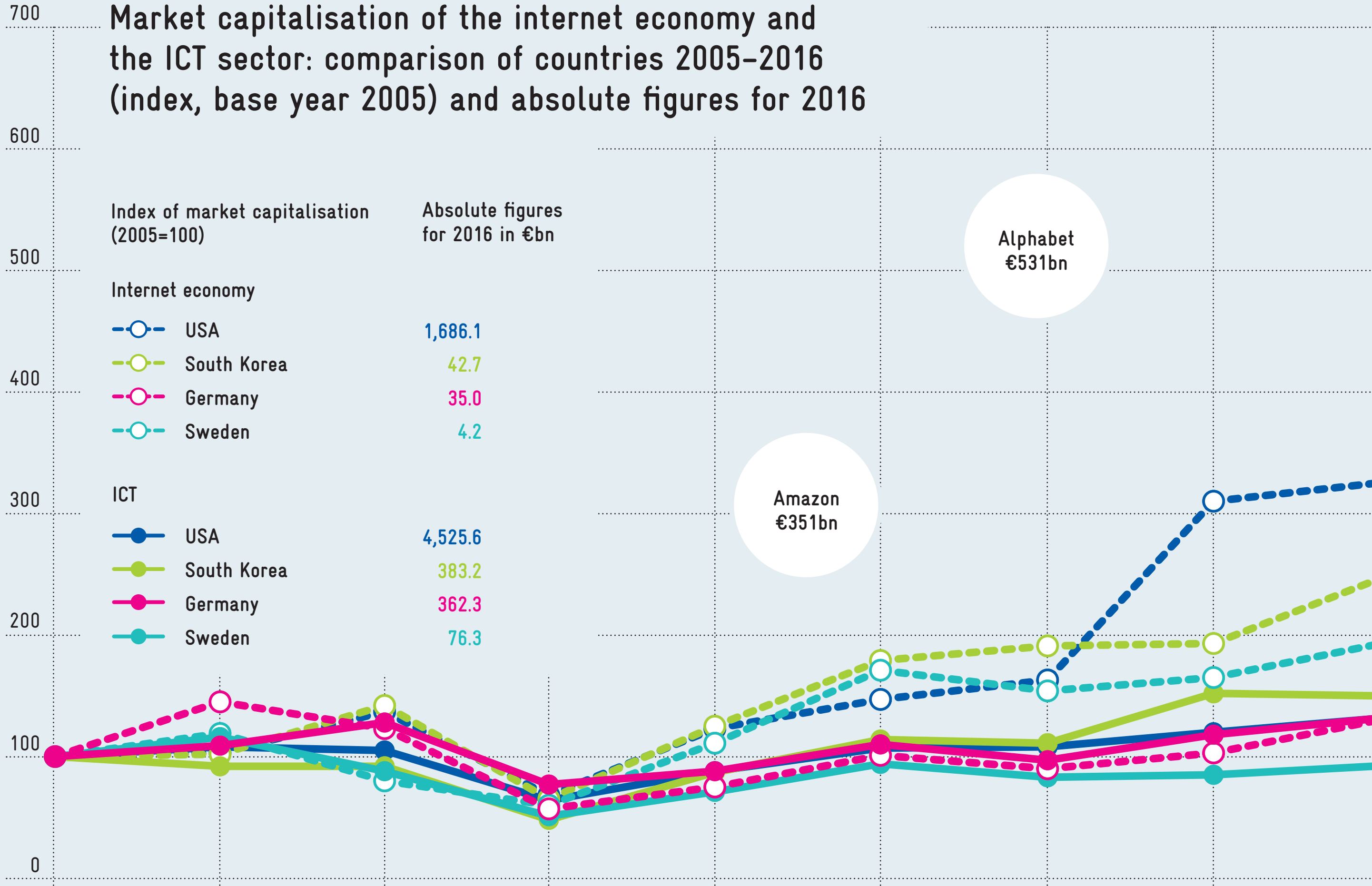
Pressure to act is being generated by the fact that, meanwhile, under the existing state-aid rules at the EU level, the federal ministries are legally obliged to conduct systematic evaluations of the relevant funding programmes – as in the case of the Central Innovation Programme for SMEs (ZIM).[315] The institutional integration of evaluation practice has recently been strengthened by the establishment of administrative departments and subject-specific divisions within the BMBF and the BMWi and by the development of evaluation guidelines at the BMBF. The latter focuses on the procedural aspects of evaluations, but, unlike the EU directives, does not prescribe any methodological standards.

Another important step in improving evaluation practice would be to improve the availability of government data for (research and) evaluation purposes. In the USA, for example, this is seen as an important state task.[316] In 2016, the US Congress passed a law setting up a Commission on Evidence-Based Policymaking. The Commission's task is to develop proposals on how the availability and use of public-sector administrative data can be guaranteed in order to ensure an evidence-based improvement in the design of political measures without violating the requirements of data protection.[317]

B 6 Digital change

Download
data

Market capitalisation of the internet economy and the ICT sector: comparison of countries 2005–2016 (index, base year 2005) and absolute figures for 2016



Source: Müller et al. (2016 and 2017).

2010
National e-government strategy
German e-government aims to become the international standard for effective and efficient administration by 2015.

E-government

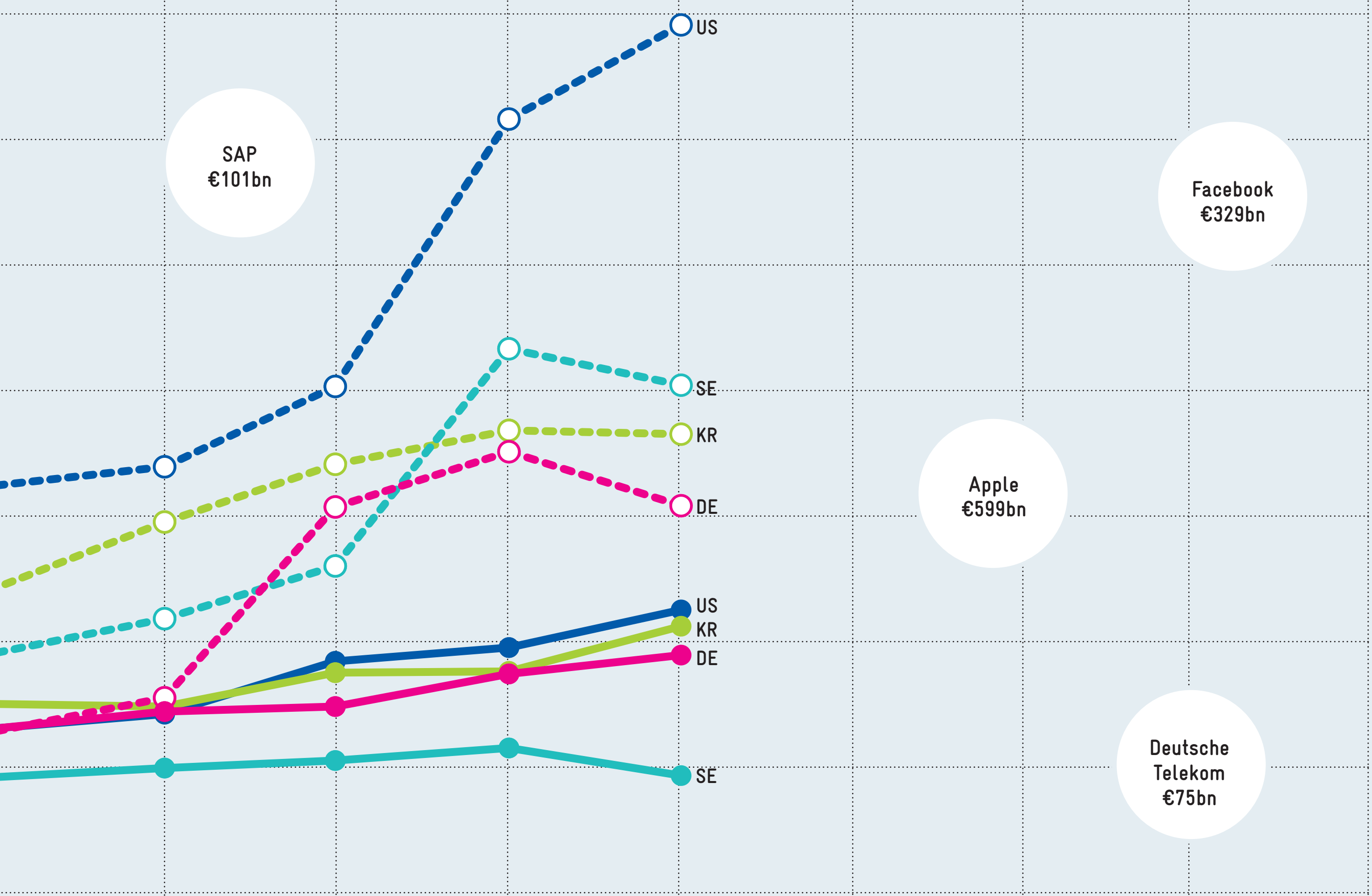
ELSTER
Elster online portal for electronic tax declaration opens

Establishment of IT Planning Council
Coordination of federal cooperation between the Federal Government and the Länder in the field of information technology

2005 2006 2007 2008 2009 2010 2011 2012

2016
Reorganisation of Federal and Länder financial relations
An amendment to the Basic Law gives the Federal Government legislative power to design access to the administrative services of the Federal Government and the Länder

2016
Online Access Improvement Act
The Federal Government, Länder and municipalities must offer their administrative services online within five years

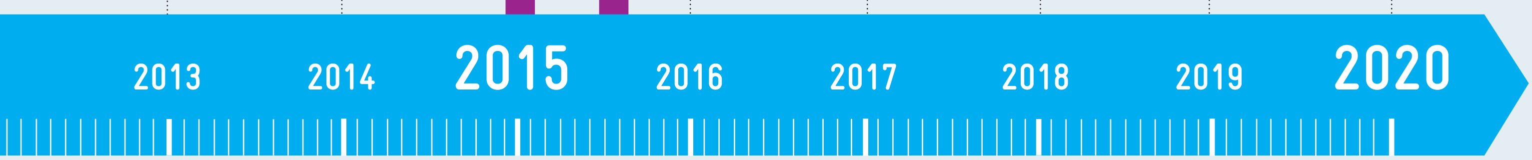


2016
Draft law amending the E-Government Act
If implemented, federal authorities would be obliged to make their data accessible to the public

2016
Germany's participation in the Open Government Partnership

GovData
The 'Data Portal for Germany' begins regular operations after a prototype phase lasting just under two years

Digitisation of the asylum procedure
Creation of a nationwide infrastructure for the registration and central storage of asylum seekers' data



B 6–1 Digital change and new business models

Digital change is currently happening at impressive – some would say frightening – speed. There are many driving forces behind this transformation. The performance of digital technologies continues to increase, enabling fast processing of even large amounts of data. Cost-effective and easily scalable access to IT infrastructure in the cloud[318] is lowering the barriers to market entry for young companies (start-ups). Networking and personalized communication devices are making it possible to merge previously unconnected data and to apply machine learning. The processing of data collected in the Internet of Things is supporting new applications, for example in the fields of health, sport, logistics, production and sales.

With internet-based technologies, intermediary economic activities can be almost entirely replaced by platforms. This opens up new sources of efficiency in the so-called 'sharing economy', e.g., Uber and AirBnB. On the other hand, potential sources of abuse have emerged, with political decision-makers responding – and in some cases overreacting. The use of Artificial Intelligence and autonomous systems is making it commercially reasonable to automate even activities requiring specific qualifications. Platforms allow orders (e.g., for tradespeople) to be passed on cost-effectively to freelancers on virtual marketplaces. The employment model of traditional labour contracts is coming under pressure. The changes are affecting all areas of the economy and life. In addition to the world of work, citizens' private lives are also changing profoundly. For example, voice recognition is bringing digital assistant systems into the personal sphere.

The state, businesses, and civil society face the immense task of shaping this change in a way that is in line with cultural and societal values, as well as ethical principles.

The digital economy in international comparison

The term digital economy is used to cover the classic ICT sector and the internet economy.[319] The chart at the beginning of this chapter shows the rapid development – and the great potential for value creation – of the internet economy and the ICT sector by international comparison over the last ten years, based on the market capitalization of companies in these two fields. In this period, the market capitalization of the internet economy has grown much faster than that of the 'classic' ICT industry in all the countries compared,[320] although the latter currently still dominates in terms of the absolute level of capitalization. The growth of the ICT industry is mainly driven by rising value creation in the service sector.[321]

The dominant position of US-based companies throughout the entire digital economy is remarkable, as is the strong growth of the internet economy: the market capitalization of US companies in 2016 (1,686 billion euros) was about 20 times the size of the entire internet economy in Germany (35 billion euros), Sweden (4 billion euros), and South Korea (43 billion euros) put together. Since 2005, the market capitalization of US companies has risen to seven times their original value; in South Korea and Sweden it has nearly quadrupled.

Young internet companies such as Facebook, Alphabet, Twitter or LinkedIn have shown very rapid growth over the last fifteen years, and in many cases have surpassed the market capitalization of well-established ICT corporations. The three financially strongest companies in Germany with (in some cases) important business activities in the ICT sector are Siemens, SAP, and Deutsche Telekom. Their growth was weak compared to the dynamics of the new internet companies in the US.

Expansion of the digital economy

Due to the increasing networking, more and more new lines of business and areas of activity are emerging in the digital economy. These are no longer limited to the initial application areas of data processing, telecommunications, and transmission technologies. Many of the transactions in the market for corporate acquisitions and disposals in the period from 2013 to 2015 indicate that new areas of application are currently being opened up which, up to now, have not been among the core activities of the digital economy.[322]

At the same time, most of these new activities are at present being driven by the financially strong corporations of the internet economy, above all by US and Asian companies. They have already acquired a number of companies from other industries.[323]

Start-ups as key actors

Digital economy business models frequently provide a starting point for innovative start-ups. About four out of five digital start-ups operate in the internet economy. In this context, it is remarkable that notably Berlin– a region that does not stand out as having a strong base of industrial companies – is benefitting from start-ups in the internet economy.[324] Due to the special role of start-ups, Germany's digital economy benefits directly from improved framework conditions for business start-ups and venture capital (cf. Chapters B 4-1 and B 4-2).

The growing importance of users

The importance of data-driven services continues to grow. Personal data from customers or users of digital services are important resources, since they secure long-term access to end customers.[325] At the same time, users are an important source of innovation for companies in the digital economy, since they create user-generated content. Takeovers and evaluations of companies with large numbers of users show that investors still consider the generation and use of personal data to be of great value.[326]

New business models in the digital economy

A key driver of digital change is the implementation of new digital business models. The 2016 Report of the Commission of Experts for Research and Innovation introduces new business models of the digital economy, for example in healthcare, banking, and the energy sector.[327] Established companies in these and other sectors must expect new intermediaries such as platform providers to occupy interfaces with end customers. [328]

As networking increases, the service sector in general will become even more important, while production alone is likely to lose some of its share of value added.[329] However, services are also of great importance for industrial companies.[330] For example, established car manufacturers increasingly define themselves as providers of mobility services. However, business models in the digital economy have drastically reduced the barriers of entry for new competitors in the service sector. Established companies must therefore now anticipate to be challenged faster and more frequently by such innovators.[331]

Digitization deficit among SMEs

Many businesspeople in Germany are aware that, in the course of digital change, they will have to reckon with fresh competition from increasingly important companies that play a key role in the value-creation network – for example with platform services.[332] Large companies have the resources to catch up by hiring business consultants and taking internal measures.

German SMEs, however, seem to have particular difficulties with implementing new digital business models. Surveys show that the smaller the business, the less frequently internet-based technologies and new business models are used.[333] The Commission of Experts currently believes that a large proportion of SMEs face significant problems as a result of digital change.[334]

Strengths in research and in specific areas of technology

In the view of the Commission of Experts, Germany's need to catch up in the field of digital technologies lies not so much in technologically oriented research as in the transfer and application of scientific results. In some technological fields – such as driver-assistance systems[335] – German companies can even be said to play a leading role. This is not the case in internet-related research and applications; independent studies did not determine any particular strengths among German companies in these areas.[336] As a general rule, production-related information technology in Germany is highly developed and represents a specific strength, which also finds international recognition. However, in view of the fact that the digital transition affects all industries and areas of life, this positioning is inadequate to enable Germany to assume a leading position in the innovation competition in the medium and long term, or to master digital change successfully.

Infrastructure for the digital economy

Digitization causes steadily increasing demands on the availability and performance of internet connections. Therefore, a continuous enhancement of the digital infrastructure has the effect of a key growth determinant for modern economies.[337] Compared to other countries, Germany is lagging behind according to almost all indicators of high-performance broadband development faster than 50 Mbit/s.[338] At the same time, it can be assumed that broadband speeds of 50 Mbit/s will no longer be fast enough in the foreseeable future.[339] Network operators expect an average private demand for internet speeds of 400 Mbit/s for downloads and 200 Mbit/s for uploads by 2025. Against this background, the Commission of Experts is of the opinion that the targets for improving the broadband infrastructure formulated by the Federal Government have long since ceased to be adequate.

E-government

B 6-2

Potential of e-government

The term e-government (electronic government) stands for processing governmental and administrative matters using information and communication technologies via electronic media. In e-government, public services and administrative matters are digitised and made available online.[340]

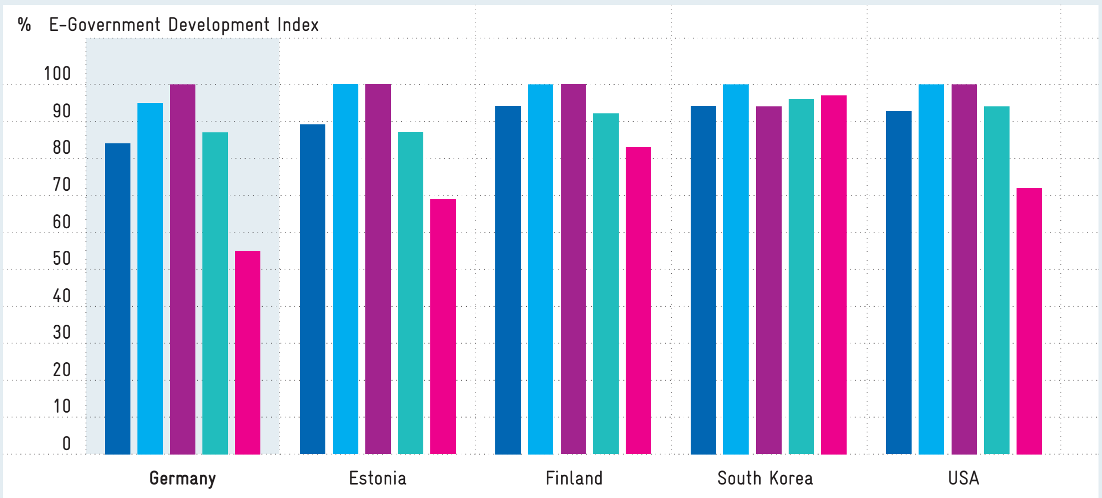
E-government can enhance the quality and scope of state services and increase transparency and reliability. Furthermore, the intensified use of e-government boosts the demand for IT solutions and can be used as a driver of innovation for the IT and internet industry.[341] E-government is also an important area of application for innovation-oriented public procurement (cf. Chapter B 5-2). Innovative products and services that are already on the market can be used for the provision and operation of the technical infrastructure. However, products and services that are not yet on the market can also be developed and deployed for their specific purpose. Some countries, such as the Netherlands and South Korea, have been expediting the development of e-government for years as part of a demand-oriented innovation policy.[342]

In their 2010 national e-government strategy, the Federal Government, the Länder and the municipalities formulated the goal of making Germany's e-government the international standard for effective and efficient administration by 2015. This goal was not met.[343]

Fig. B 6-2-1

Download data

Quality levels of German e-government services by international comparison, 2016



Source: UN DESA (2016).

E-government by international comparison

Germany is lagging behind in e-government and is therefore wasting important innovative and value-creation potential. The United Nations E-Government Development Index[344] shows that the quality of government-related services in South Korea, Estonia and the USA are markedly further developed than in Germany (cf. Figure B 6-2-1). The E-Government Development Index reflects the state of development of e-government services provided by all UN member states on the basis of a four-stage measure. The first and second stages comprise unidirectional forms of interaction, such as the provision of information by authorities or links on the websites of other institutions (Stage 1), and one-way electronic communication e.g. with downloadable documents (Stage 2). Services provided at Stage 3 allow two-way communication and interaction – e.g. applying for, issuing and paying for licences and certificates. Countries at Stage 3 and above meet the requirements of full digitisation, i.e. a transaction can be executed without changing the information-carrying medium. Stage 4 services are defined as fully interlinked services comprising interactive apps for citizen surveys, discussion forums and individualised services.[345]

Although Germany's e-government has now reached the level of the leading nations – Estonia, Finland, South Korea and the USA – in simple forms of interaction such as the provision of information by authorities, Germany is a long way behind the leading nations when it comes to the more advanced Stage 4 services, such as individualised services.[346]

E-government services fragmentary and not very user-friendly

E-government services in Germany are fragmentary and often not fully digitised. This is aggravated by the fact that the existing services are not user-friendly. The aspect of user friendliness is not covered by the E-Government Development Index. In addition to full digitisation, in order to be user-friendly an e-government service needs to broadly publicise the online services that are available; it also needs to be clearly structured, easy to operate and transparent. Ideally, the electronic information and services are bundled and offered in one place: in a 'one-stop shop'. E-government is used less intensively by citizens in Germany than in other countries as a result of the fragmentary range of services and low level of user-friendliness.[347]

Lack of user-friendliness of e-government services is also a problem from the point of view of businesses. Although almost all key services for companies have been fully digitised in Germany, the level of user-friendliness is criticised. The main complaint is the lack of clear structures, the difficulty of finding online services, and the lack of a one-stop shop.[348]

Improvement of Federal/Länder coordination

Up to now, the expansion of e-government in Germany has been based on the principle of voluntariness; there are hardly any legally binding requirements. Since the interests of the federal actors in the development of e-government differ considerably, the lack of higher-tier and legally binding requirements has led to a confusing and technically heterogeneous range of e-government services.[349] Although the IT Planning Council was set up in 2010 by Federal and Länder governments as a political control body to coordinate federal cooperation in the field of information technology, the IT Planning Council only had very limited resources and political power at its disposal.[350]

An important step towards overcoming this unsatisfactory situation was taken in October 2016 with the decision to reorganise the financial relations between the Federal Government and the Länder.[351] Following an amendment to the Basic Law adopted in December 2016 (new Article 91c, paragraph 5), this reorganisation gives the Federal Government the legislative competence to design access to the administrative services of the Federal and Länder authorities, including the municipalities. The accompanying law – the Online Access Improvement Act (Onlinezugangsverbesserungsgesetz) – adopted by the Cabinet parallel to this amendment to the Basic Law, regulates the process by which the constitutional requirements are to be further developed. The law stipulates that the Federal Government, Länder and local authorities must also offer their administrative services online within five years and make them accessible via a network of Federal and Länder administrative portals.[352] Citizens and companies should be able to access all online-enabled administrative services from any administrative portal barrier-free and without media breaks using a single user account.[353]

The Commission of Experts strongly welcomes this development. These changes open up the possibility to harmonise the quality of e-government in Germany with international standards in the coming years.

In order to achieve this goal, the Federal Government – as called for by the Regulatory Control Council – should make active use of its extended regulatory powers and quickly submit workable solutions for developing e-government. This also includes providing the planned digitisation budget with sufficient financial resources.[354]

Open government data in Germany

The digitisation of public administration generates huge amounts of digitally usable data. If appropriate account is taken of data protection, such data can be made available as open government data on online portals and used by businesses and civil-society actors to develop new services and innovative business models. Furthermore, open government data are an important source of data for science.[355]

In Germany, government data are published on a wide variety of portals at the Länder and municipal levels. Furthermore, 'GovData – The Data Portal for Germany' began regular operations as a national data portal at the beginning of 2015 after a prototype phase lasting about two years. The G8 Open Data Charter of June 2013 forms the basis for the provision of government data. In this charter, Germany and the other G8 states agreed on basic principles on the implementation of open data. In particular, government data are to be open by default.[356] However, the 'open by default' principle has not as yet been implemented across the board in Germany. In fact, as a rule, the respective authorities in Germany decide themselves which data they post on the data portal. As a result, the quality and quantity of the data posted on GovData has so far lagged behind comparable data portals in other industrialised countries.[357]

This deficit is partly caused by the inconsistent approach of the Länder: GovData is only supported by ten of the sixteen Länder.[358] Bavaria, Hesse, Lower Saxony, Saarland, Saxony-Anhalt and Thuringia do not support the initiative, and their data are not published on GovData.[359]

The defensive and inconsistent approach greatly restricts the value of the data portal.[360] In order to help the principle of open government data achieve a breakthrough and to accelerate the hitherto slow pace of cultural change in the administration, the Federal Government submitted a draft law for the implementation of open data principles in December 2016.[361] This draft law implements a project from the coalition agreement according to which the federal administration is to pioneer the provision of open data in uniform, machine-readable formats and under free license conditions.[362] The federal authorities are obliged to make the data they collect – in fulfilling their public-service remit – accessible to the public, unless there are important reasons against publication. In future, therefore, the authorities will no longer decide which data they publish, but only which data may not be published. This would make data openness the rule.[363]

However, the commitment to open data is not limited to the federal level. In the course of the reorganisation of financial relations between the Federation and the Länder signed in October 2016, the Länder committed themselves to drawing up their own open data laws, insofar as they did not have such laws already. In order to lay down standards for data access that are comparable Germany-wide, the Länder have committed themselves to modelling their laws in orientation on the Federal Government's draft law.[364]

Some Länder and municipalities have already set new standards when it comes to opening up their data stocks. With its transparency law, which came into force in 2012, Hamburg has shown that by-default access to government data can be provided within a short period of time when this is required by law and sufficient resources are simultaneously made available.[365] Rhineland-Palatinate followed Hamburg's example in 2015.[366] Cities like Bonn, Karlsruhe, Moers and Ulm already started publishing their data several years ago.

The Commission of Experts regards such a change in standard procedure (from secrecy to publication) as an important milestone in the development towards a more intensive use of public data and an improvement in the services provided by the public sector.[367]

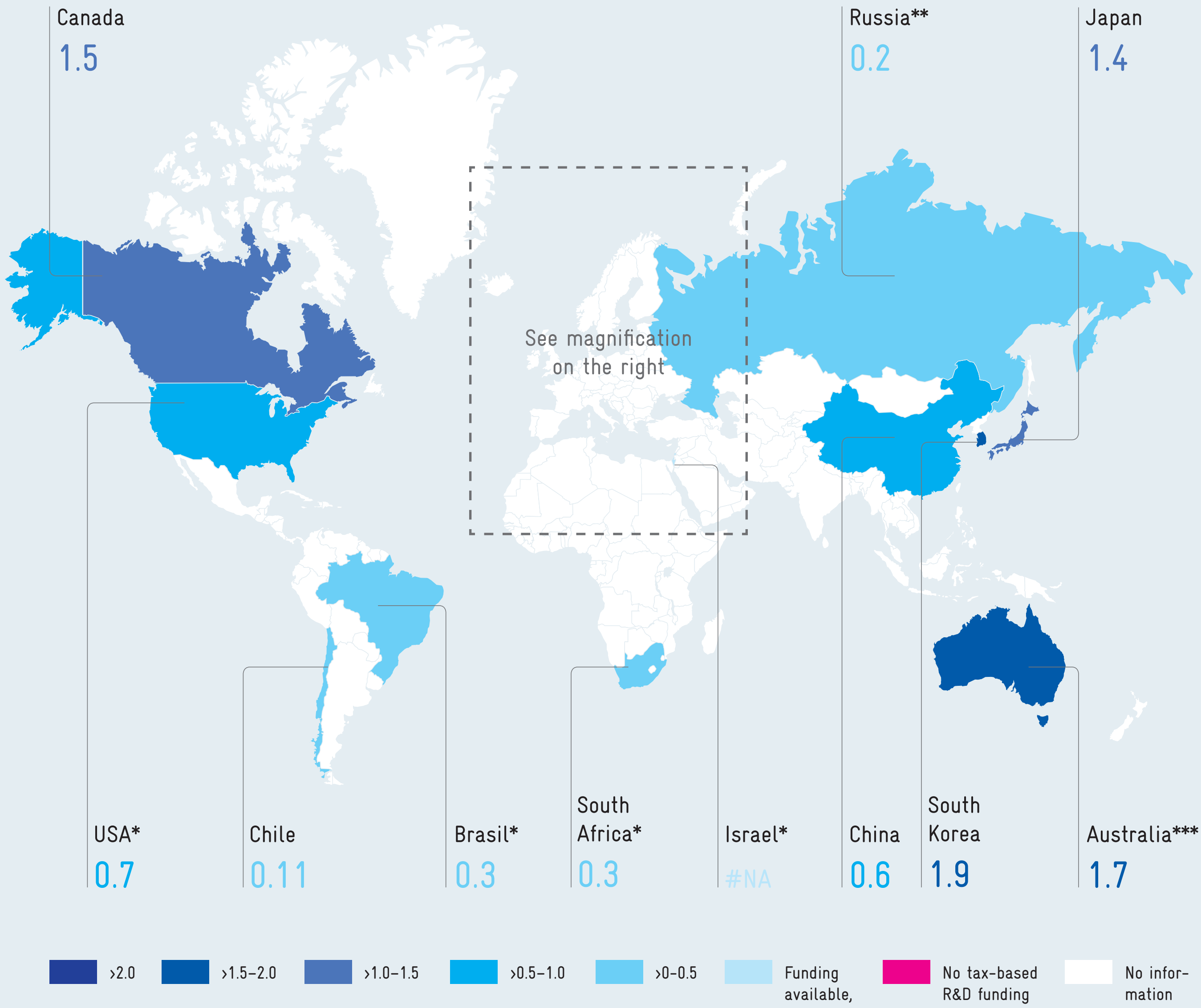
B 7 Options for funding R&D through tax credits

Download data

Most of the world's advanced industrial nations offer tax incentives to fund research and development. Up to now, Germany has not made use of this instrument.

B

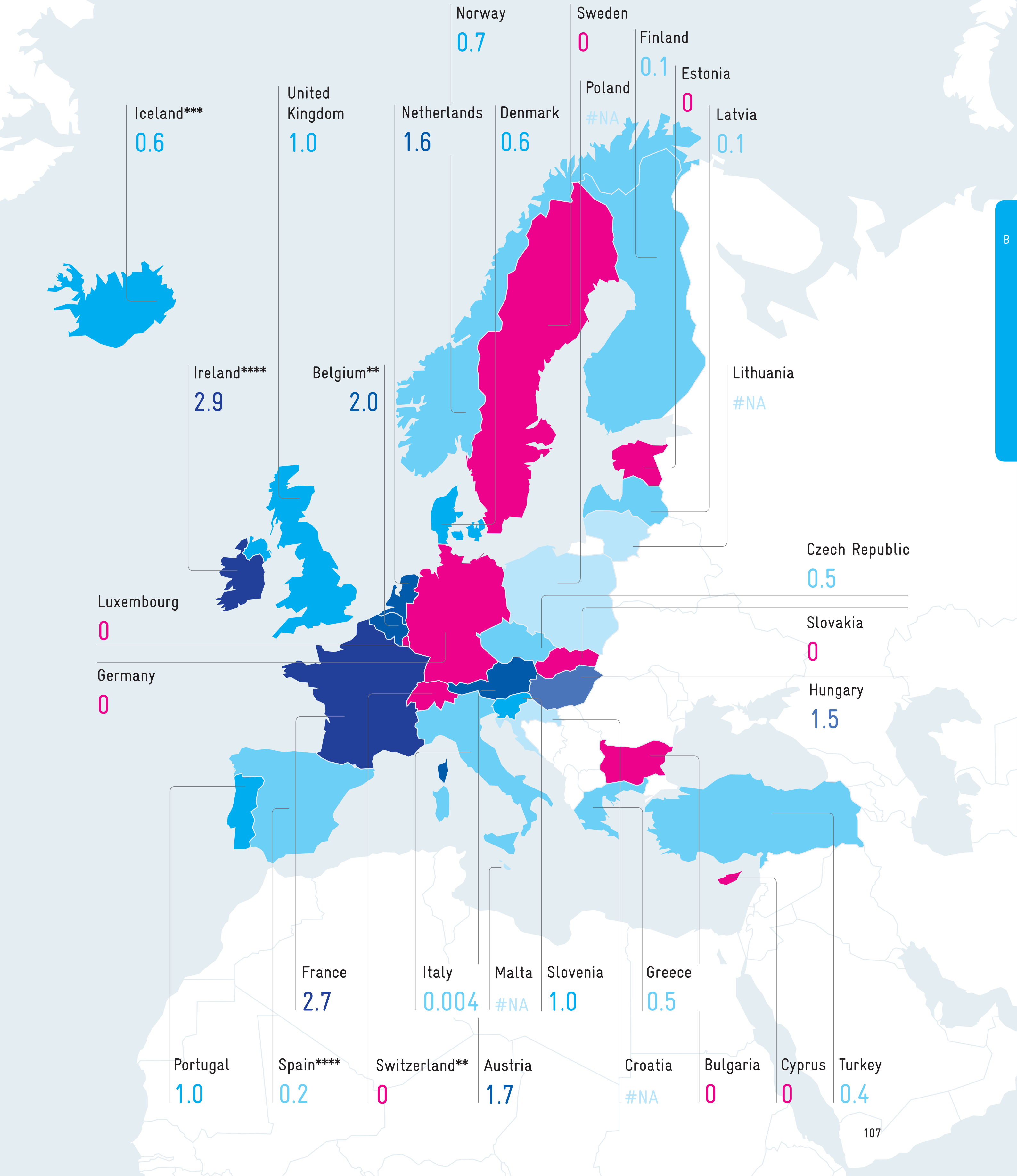
Extent of tax-based R&D funding in countries outside of Europe as a share of the gross domestic product (per mille) in 2015



* Figure from 2011 ** Figure from 2012 *** Figure from 2013 **** Figure from 2014

Source: OECD Science, Technology and Industry Scoreboard 2015 and Spengel et al. (2017). #NA = figures not available.

Extent of tax-based R&D funding in countries within Europe as a share of the gross domestic product (per mille) in 2015



B 7 Options for funding R&D through tax credits

B

B 7-1 Economic justification for the state funding of private R&D expenditure

State funding of private R&D activities is economically well justified.[368] R&D activity often generates more returns among consumers and companies than what the research companies receive.[369] The consumers of new or improved products receive benefits which are not completely absorbed by the price of these products. R&D activities also lead to positive externalities: other actors can build on the new knowledge created by R&D efforts and use it to (further) develop products and processes of their own. As a consequence, private returns from R&D activities are lower than the macroeconomic returns. The incentives to engage in private research efforts are therefore too low, resulting in under-investment in R&D. State funding measures aim to correct this market failure.

Not only knowledge externalities, but also information asymmetries cause the market for new ideas to fail.[370] The term 'asymmetric information' is used when one side of the market is better informed than the other. This applies in particular to the funding of R&D activities. It is far more difficult for external investors to estimate the chances of success than it is for the companies that are active in R&D. The information asymmetry leads to a smaller number of R&D projects being financed than macroeconomically reasonable. This form of financing constraints is especially problematic for relatively young and small companies, because they do not generally have the reserves needed to finance R&D.[371]

By taking funding measures, the state can make a contribution towards partially offsetting these forms of market failure accompanying private R&D activities. Both direct and indirect funding instruments can be used for this purpose. Direct funding instruments used in Germany first of all include project funding through specialist programs of the federal ministries; these are used to promote certain technologies or thematic fields. Furthermore, technology-unspecific subsidies for financing research and innovation projects are granted on application in some funding programs, e.g., the BMWi's Central Innovation Programme for SMEs (ZIM). The indirect funding instruments include, inter alia, R&D personnel-cost subsidies and tax concessions, special depreciation for R&D investment, and tax credits for R&D expenditure.

One advantage of direct funding is often seen in the possibility of directing funds to technologies or thematic fields considered to be particularly important. From an economic point of view, there is a fundamental advantage in being able to select specific projects that are expected to generate high social returns and would perhaps not be carried out without funding.[372] However, the funding institutions are subject to the same information asymmetries as external financiers, so that social returns are about as difficult to assess ex-ante as private returns.

One instrument used by the majority of the OECD and EU member states is the indirect funding of R&D through tax incentives (cf. chart at the beginning of the chapter). Many countries spend more on tax-based R&D funding than on direct state R&D funding (cf. Figure C 4-1). Up to now, Germany has not made use of the possibility of providing indirect funding via the tax system.

R&D funding through tax incentives has several advantages over direct funding measures. Direct R&D funding always requires applications and assessment procedures conducted by public authorities or their project promoters. It can therefore only be claimed for individual, specifically defined projects.[373] As a result, it may be fiscally well planned and applied in a targeted way, but involves a high level of uncertainty for companies as regards the approval of project applications. In addition, the companies always bear the costs of the application, including the cost of searching for a suitable funding instrument and formulating an application. Costs and the amount of time involved deter many companies from applying.[374]

In the case of tax-based R&D funding, eligibility is already established when proof is submitted that (qualifying) R&D expenditure has been made. The instrument thus gives the company more planning security as regards the promotion of R&D projects that involve risk. At the same time, significantly less administrative work is involved, both for the state and for the company that is applying, compared to classical project funding. The state does not need to either design a funding measure or assess applications. And companies do not need to search for a funding instrument or file an application.

Compared to a specific form of project funding, R&D funding through tax incentives has the additional advantage that R&D projects are also funded when they do not fit into the existing state funding portfolio in thematic terms. The instrument even has an impact if the state is not fully aware of the private actors' R&D potential; it thus has a broader effect.[375]

In addition, R&D funding through tax incentives can make a country more attractive in the global competition to become a location for multinational companies and research-intensive industries.[376] However, this aspect is generally not significant for small and medium-sized enterprises (SMEs) and young companies.

The Commission of Experts has repeatedly proposed that, in the future, Germany, as one of the leading economic nations, should aim to spend 3.5 percent of its gross domestic product (GDP) on R&D.[377] This would enable Germany to improve its technological competitiveness in the long term, and to catch up with leading innovative nations. The introduction of a tax-based system of R&D funding can be a major step towards this objective.

B 7-2 The distribution and design of R&D funding through tax incentives

28 of the 35 OECD countries[378] currently offer tax incentives for the implementation of private R&D projects. However, the respective systems of tax-based R&D funding are designed very differently from country to country. Box B 7-1 explains basic variations in design.[379]

International examples of good practice

Some countries can already look back on many years of successful implementation of R&D funding through tax incentives. The European Commission highlights some tried-and-tested programs as examples of good practice.[380] These include the programs in France, the United Kingdom, Ireland, the Netherlands, and Norway.[381] The following sections look at the design of the programs in these countries in more depth (cf. Table B 7-2).

All the countries mentioned were running at least one program designed as a volume-based tax credit for qualifying R&D expenditure in 2016. In almost all these programs that apply such a tax credit, the credit is granted on the company's income tax – except the WBSO program in the Netherlands, where the credit reduces the monthly wage tax payable by the company for its employees. Among the countries mentioned, there is only one scheme that reduces the basis for tax assessment: the R&D Tax Relief program in the United Kingdom.[382]

In the case of programs that are designed as a tax credit is set off against against the company's income tax, the subsidy rates vary between 10 percent (ATL program in the UK) and 25 percent (R&D Tax Credit in Ireland). In the Netherlands, the tax credit on wage tax for R&D personnel is 50 percent (WBSO program).[383] In most of the programs, the credit is capped at a certain level (CII in France, WBSO and RDA in the Netherlands, SkatteFUNN in Norway). The programs JEI in France, ATL in the UK, and R&D Tax Credit in Ireland have no cap.

When companies apply for the tax credit when losses have occurred, some programs allow a temporary offset by carrying the credit forward to subsequent years. The credit is immediately paid out to companies in the event of loss, for example, under the Norwegian SkatteFUNN program and – at least proportionately – under the UK's ATL program. In the Dutch WBSO program, the credit always has the effect of an immediate payment, because it is granted via the wage tax, which is payable regardless of the profit situation.

The CII and JEI programs in France specifically target SMEs and young companies. The R&D Tax Relief program in the UK has also recently been restricted to SMEs and grants an additional deduction in the basis for tax assessment amounting to 130 percent of the R&D expenditure. In Norway, the SkatteFUNN

Box B 7-1

Design variants of tax-based R&D funding

As a rule, tax-based funding of R&D is granted in the context of taxes on income – i.e. corporation tax (in the case of stock corporations), or personal income tax (in the case of sole traders and partnerships). The most important exception is funding in the context of wage-tax payments by companies (employers).[384]

In the tax-based funding of R&D, a fundamental distinction can be made between deductions from the tax base and tax credits (deductions from the tax debt).[385]

In most national tax systems, ongoing R&D expenditure – like other operating expenses – can be deducted directly from the tax base (assessment basis). They represent a tax-relevant expense (reducing entrepreneurial income). If a system of tax-based R&D funding is employed that also allows deductions from the tax base, this allows additional deductions[386] for R&D expenditure over and above the normal level, or accelerated depreciation on investments in plant and equipment in the R&D field. For example, SMEs in the United Kingdom can deduct a further 130 percent of R&D expenditure from the tax base in addition to ongoing R&D expenditure. The effective benefit for companies in these cases depends on the applicable tax rate and thus also on the company's legal form and other factors.

Alternatively (or in some cases in addition) to deductions from the tax base, some countries grant tax credits. Under such schemes, companies are granted a credit on their tax debt, calculated according to the level of their R&D expenditure. The amount of the tax credit (subsidy rate) ranges from 5 percent (Japan) to 100 percent (Hungary) of the recognised R&D costs.

Deductions from the tax base and tax credits for R&D expenditure are equally distributed within the EU. When other countries outside the EU[387] are included, it is shown that funding measures in the form of a tax credit are the more frequently used system.

Further important differentiation criteria as regards design include distinctions according to volume-based and incremental funding, the type of tax-deductible expenditure, the treatment of unused tax credits (when a tax debt is lower than the amount of credit due), and restricting funding to certain groups such as SMEs.

In the case of volume-based funding, the total expenditure on R&D is included in the tax credit, whereas in incremental funding only R&D expenditure in excess of a reference value is given preferential tax treatment. The reference value is determined by means of a comparison with the company's R&D expenditure in a reference period (usually before the respective reference year).

Deductible expenditure types can include spending on R&D personnel, expenditure on assets used in the context of R&D activities, and other R&D expenditure (e.g. consumables). In most countries, the qualifying types of R&D expenditure are categorised according to the OECD's Frascati Manual.[388]

If a company's tax credit derived from its R&D activity exceeds its tax debt in the year of tax assessment, a (pro-rata) payment of the tax credit is granted in some countries (for certain companies). This approach is especially relevant for young companies that are not yet generating any profits. There are also variants in which unused tax credits can be carried forward or back.

Tab. B 7-2

Download data

Design variants of tax-based R&D funding in selected countries

	Target group	Qualifying R&D expenditure	Deduction from the tax base		Tax credit (deduction from the tax debt)		Contract research eligible?
			Accelerated depreciation on R&D fixed assets	Additional deduction	Subsidy rate	Scope	
Jeune Entreprise Innovante (JEI) (France)	SMEs with other criteria: – younger than 8 years – R&D expenditure constitutes at least 15 % of total expenditure	According to Frascati Manual	–	–	Special regulation[1]		at the contracting company
Crédit d'Impot Innovation (CII) (France)	SMEs	Expenditure on prototype development	–	–	20 %	volume-based	at the contracting company
Above the Line (ATL) (United Kingdom)	Large companies	According to Frascati Manual	–	–	11 %	volume-based	at the contracting company
R&D Tax Relief (United Kingdom)	SMEs (formerly also large companies)[2]	Beyond Frascati Manual	100 % immediately	130 %/ (30 %)[2]	–	–	at the contracting company (SMEs); depends on contract type in the case of large companies[3]
R&D Tax Credit (Ireland)	All companies	According to Frascati Manual[4]	–	–	25 %	volume-based/incremental[5]	at the contracting company
Research and Development Promotion Act (WBSO) (Netherlands)	All companies (special rules for SMEs)	R&D personnel costs	–	–	35 % / 50 % / 14 %[6]	volume-based	at the contractor
Research & Development Allowance (RDA) (Netherlands)	All companies that receive WBSO funding	All R&D costs except personnel costs	–	–	15 % / 12 %[7]	volume-based	at the contractor
SkatteFUNN (Norway)	All companies (special rules for SMEs)	Beyond Frascati Manual	–	–	18 % / 20 %[8]	volume-based	at the contracting company

1) Complete abatement of corporate tax and social security contributions in the first year of participation in the programme, 50 % abatement in the second year.
2) In April 2016, ATL superseded the additional deduction of R&D expenditure from the tax base (30 % for large companies) under the R&D Tax Relief programme. In future, the latter will only apply to SMEs, for which an additional deduction of 130 % is possible.
3) Until April 2016: in the case of large companies at the contractor or the contracting company, if contracts are awarded to non-profit or scientific institutions.
4) R&D overhead costs can also be deducted.
5) Incremental for companies that already requested funding before 2003; volume-based for all subsequent years.
6) 35 % subsidy rate for R&D expenditure up to €250,000 under the general rule (50 % for start-ups); 14 % for R&D expenditure over €250,000.
7) 15 % subsidy rate (60 % RDA rate x 25 % tax rate) for R&D expenditure (excluding personnel costs) if balance-sheet profit is over €200,000; if profit is lower, the subsidy rate is 12 % (60 % RDA rate x 20 % tax rate).
8) 18 % under the general rule, 20 % for SMEs.

Source: European Commission (2014a), Jacobs (2016: 150ff.), updated and supplemented by Spengel et al. (2017) for 2016 on the basis of the country reports on http://www.ibfd.org.

program contains special regulations granting a higher subsidy rate for SMEs.[389]

Treating SMEs and large companies differently when designing the eligibility conditions can be economically reasonable, since SMEs are more affected by financing constraints and the costs of filing applications. The countries observed almost exclusively use the European Commission's definition of SMEs,[390] which states that a company is an SME if its annual turnover is less than 50 million euros or the annual balance sheet total does not exceed 43 million euros. At the same time, the workforce must not number more than 249. Only the United Kingdom uses a different definition. The rules applying there since 2008 state that companies with up to 499 employees and a balance sheet total of up to 86 million euros can benefit from the special funding of SMEs.

Qualifying R&D expenditure, contract research and double funding

As a rule, the tax-based funding in the recommended programs covers all R&D expenditure – designated R&D activities according to the OECD's Frascati Manual – except acquisition costs for land and certain overhead costs.[391, 392] The two complementary programs WBSO and RDA in the Netherlands represent a special case. With WBSO, only the (pro-rata) personnel costs of members of staff engaged in R&D activities serve as the basis for assessment on principle. The primary reason given for this is the objective of creating domestic R&D jobs.[393] The RDA program was set up as a complementary funding instrument to the WBSO and covers all R&D expenditure that does not relate to staff costs within the framework of a credit on corporation tax.

A company that awards a contract for research is eligible for tax credit on R&D expenditure under the French JEI and CII programs, the Irish R&D Tax Credit program[394], the Norwegian SkatteFUNN program, and in the UK, where SMEs can claim for contracted R&D to reduce the basis for tax assessment under the R&D Tax Relief program. Thus, in most cases funding under these programs also applies to external research contracts awarded to foreign companies.[395] By contrast, under the Dutch system (WBSO and RDA) a contracting company's expenditure on contract research is excluded from funding. Nevertheless, companies that carry out R&D contracts, even if they have no property rights to the results of the research, can apply for funding, provided that the staff involved is employed within the country.

The term double funding is used, on the one hand, if a direct subsidy and a tax-based funding are granted simultaneously for the same R&D expenditure. On the other hand, there can be double funding if the contract research is tax-deductible for both the contracting and the contracted company. To avoid such double funding, in almost all the programs examined the direct project funds paid out to companies and the expenditure on research carried out by contracted third parties are deducted from the R&D expenditure that might qualify for a tax-based funding. Only the difference is eligible for tax-based funding. If, for instance, a tax credit is to be used as an R&D funding instrument, this is only granted on the amount of qualifying R&D expenditure that remains after deduction of the funding that has already been granted.[396]

Administration and administrative costs

Some of the programs mentioned approve funding in advance (CII[397] in France, WBSO and RDA in the Netherlands, SkateFUNN[398] in Norway), some in retrospect (JEI in France, R&D Tax Credit in Ireland, R&D Tax Relief and ATL in the UK). Almost without exception, the eligibility of R&D activities is assessed by the respective Ministry of Research or Economics or by authorities that are independent of the Ministry of Finance. Most of the administrative process is handled via online portals. In the case of the Dutch program WBSO, the administration costs are estimated at 2 cents per euro of credit for the authorities and 8 cents for the company.[399]

Current proposals for R&D funding through tax incentives in Germany

By way of comparison with existing arrangements in the programs mentioned, Box B 7-3 summarises current proposals that have been discussed in Germany. In addition, the European Commission has proposed a uniform framework for corporate taxation that includes options for R&D funding through tax incentives.

B 7-3 Effects on R&D and innovation activities

This section describes the most important empirical findings on the effectiveness of R&D funding through tax incentives in various countries. Although the economic literature on R&D tax credit instruments is very extensive, not all studies can be assumed to provide reliable results.[400] The Commission of Experts therefore limits its further discussion to a group of studies whose methods are particularly reliable.

Disproportionate increase in R&D expenditure by reducing the R&D costs

Most international studies on the effectiveness of R&D tax incentive instruments aim to measure the change in R&D expenditure as a result of the tax-based R&D funding ('input additionality').[401] Few studies examine the effects on the output of R&D and innovation (e.g. patent applications, introduction of innovations, or turnover generated by innovations) and very few calculate the macroeconomic impact, taking into account possible spillover effects, economies of scale, and indirect demand effects on other investments. Against this background, the following section only looks at evaluation results on input additionality.

Table B 7-4 shows a selection of studies whose methods are particularly reliable, and their findings relating to the impact of tax-based R&D funding on the amount of private R&D expenditure.[402] 15 of the 20 studies contain information on the effect of the so-called R&D user costs[403] on the level of R&D expenditure. They determine by what percentage R&D expenditure changes when the costs of an R&D unit (R&D user costs) are reduced by a certain percentage. Taking the average of the study results, a reduction in the user cost of 1 percent led to an increase in R&D expenditure of 1.7 percent.[404] Reducing the R&D user costs thus led to a disproportionate increase in R&D expenditure.

Some studies make a distinction between short-term and long-term effects. Short-term effects are being measured for the year after the introduction or modification of an R&D tax-based funding. Long-term effects relate to periods of between three and five years – although the selected time intervals between the different studies vary. According to the studies that make such a distinction, the average short-term effects are 0.4 percent, the long-term ones 1.17 percent.[405]

The incrementality ratio – i.e., the change in R&D expenditure per currency unit of foregone tax revenue – was determined in 9 of the 20 evaluations examined. The average incrementality ratio was 1.33, i.e., 1.33 euros of additional R&D expenditure was mobilized per euro of foregone tax revenue.[406]

When the field is extended beyond the 20 studies shown, it is above all the range of the results for the two indicators that increases. Here, too, however, the average result is a disproportionate increase in R&D expenditure compared to the funding.[407]

Particularly strong, positive effects for SMEs

SMEs benefit in particular from the introduction of tax-based R&D funding. A study conducted in the Netherlands in 2012 calculated that a 1 percent reduction in R&D user costs led SMEs to increase their R&D expenditure by 1.1 percent in the long term. By contrast, large-scale companies affected by this measure only increased their R&D expenditure by 0.25 percent.[408] Similarly, a recent study on the effects of raising the cap under the Canadian tax-credit system comes to the conclusion that significantly higher effects can be expected for SMEs than for large-scale companies.[409]

Possible wage effects

If the introduction of R&D funding through the tax system creates incentives for companies to invest more in R&D but the supply of R&D personnel on the labor market is tight in the short term, the higher demand for R&D personnel can lead to a wage increase that absorbs at least part of the higher R&D expenditure. A study from the Netherlands comes to the conclusion that the wages and salaries paid to researchers rise by about 20 cents for every euro by which R&D personnel expenditure is reduced through funding.[410] This effect is well known, but does not exclusively apply to the instrument of R&D funding through tax incentives, but generally for large public expenditures in the field of R&D. Indeed, the price signals associated with this wage increase are necessary to increase the supply of qualified research personnel in the medium term.

Box B 7-3

Current political initiatives in Germany and the EU

The Federal Government has considered the introduction of a form of tax-based R&D funding on several occasions in the past. Above all, the 2009 coalition agreement between the CDU/CSU and FDP stated: "We are striving for a tax-based promotion of research and development that triggers additional research stimuli particularly for small and medium-sized enterprises."[411] However, that agreement was not implemented. The coalition agreement of the present government did not include the tax-based funding of R&D.

In March 2016, the Bündnis 90/Die Grünen parliamentary group tabled a draft law on the introduction of tax-based R&D funding for SMEs (according to the European Commission's definition).[412] The bill proposed a tax credit ('research bonus') with a 15 percent subsidy rate that included all qualifying R&D expenditure and would apply to companies with up to 249 employees. The credit would be offset against payable corporate tax and be paid out directly in full if the tax debt was too low. The total amount of the subsidy would be capped at €15 million per company and R&D project.[413] The eligibility of the R&D expenditure would be confirmed ex-ante by certification. The draft was rejected in the Bundestag's financial committee in September 2016.[414]

In May 2016, the Länder Bavaria and Lower Saxony tabled a proposal for a tax-based 'research premium' – limited to R&D personnel costs – in the parliament's Upper House (Federal Council, Bundesrat).[415] The proposal targets SMEs according to the European Commission's definition and provides for a tax credit with a 10 percent subsidy rate. In addition, the initiative also proposes examining the economic, fiscal and state-aid consequences of extending eligibility to companies with up to 499 employees. The research premium aims to reduce the tax debt of the applicant company via the tax assessment. A reimbursement is made if the premium exceeds the tax debt. No caps are proposed. Certification by external technology specialists would confirm the eligibility of the R&D expenditure ex-ante. In June 2016, the Bundesrat called on the Federal Government to submit a draft law on the introduction of a research premium in line with the above-mentioned basic points.[416]

In October 2016, the European Commission proposed a uniform framework of corporate taxation for business activities in the EU internal market.[417] The proposal includes a form of tax-based R&D funding in which all qualifying R&D expenditure up to a threshold of €20 million would allow a reduction of the tax base by an additional 50 percent of R&D expenditure. Above the threshold, there would be an additional reduction in the tax base by 25 percent of the R&D expenditure that exceeds the threshold. In addition, the proposal provides for a special regime for enterprises with fewer than 50 employees and an annual turnover of less than €10 million – 'and/or' a balance sheet total of €10 million. For these small companies, it is to be possible to reduce the tax base by an additional 100 percent of the qualifying R&D expenditure.

Tab. B 7-4

Download data

Study results on the effectiveness of tax-based R&D funding: impact of R&D user costs and tax-revenue shortfalls on R&D expenditure in different countries

Study	Percentage change in R&D expenditure if the R&D user costs are reduced by 1 percent.	Increase in R&D expenditure per currency unit of tax-revenue shortfalls (incentive effect)	Countries and investigation period	Design of tax-based R&D funding
Rao (2016)	2.0		USA, 1981–1991	incremental, 20 % credit (base and alternative variant), additional credit for contract research at tertiary education institutions
Bernstein and Mamuneas (2006)	0.725		USA, 1954–2000	
Nadiri and Kim (1996)	1.09		USA, 1964–1991	
Tillinger (1991)		0.19	USA, 1980–1985	
GAO (1989)		0.26	USA, 1981–1985	
Agrawal et al. (2016)	1.5		Canada, 2000–2003	volume-based, additional deduction of 100 %
Dagenais et al. (1997)	0.07 short term vs. 1.08 long term	0.98	Canada, 1975–1992	volume-based, 5–10 % credit, different caps, deviations at the regional level
Guceri (2016)	1.18		UK, 2003–2012	volume-based, additional deduction of 50–75 % for SMEs and 25–30 % for large companies
Dechezleprêtre et al. (2016)	2.6	1.7	UK, 2006–2011	
Mulkay and Mairesse (2013)	0,4		France, 2000–2007	transition from incremental to volume-based (30 % credit up to €100m and 5 % above)
Mulkay and Mairesse (2008)	5.47		France, 1983–2002	incremental, 25–50 % credit, €6.1m cap since 1991
Asmussen and Berriot (1993)		0.26	France, 1985–1989	
Mairesse and Mulkay (2004)	2.73	2.8	France, 1980–1997	
Duguet (2012)		2.33	France, 1993–2003	
Parisi and Sembenelli (2003)	1.5 to 1.77 (different model variants)		Italy, 1992–1997	incremental, 25–50 % credit
Labeaga Azcona et al. (2014)	0.40 to 0.55 long term (different model variants)		Spain, 2001–2008	volume-based, 20–30 % credit, 42–50 % additional incremental credit
Lokshin and Mohnen (2012)	0.2 to 0.5 short term vs. 0.4 to 0.8 long term (different model variants)	0.42 to 3.24 (different model variants)	Netherlands, 1996–2004	up to 35 % of R&D personnel wage costs
Cornet and Vroomen (2005)		0.6	Netherlands, 2000–2001	
Bloom et al. (2002)	0.14 short term vs. 1.09 long term		G7, Australia, Spain, 1979–1997	(study on several countries)
Westmore (2013)	0.16 short term vs. 1.0 long term		OECD countries, 1983–2008	(study on several countries)

Source: Spengel et al. (2017) and written information provided by the ZEW.

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Mobilization of companies not engaged in research

Experience from other countries shows that the introduction of R&D funding through tax incentives leads to a measurable increase in the number of companies engaging in R&D.[418] In principle, the introduction of R&D tax incentives can lead to more companies claiming for their R&D activities in order to benefit from the funding, even though they have not begun any additional R&D activities.[419] However, a study of the British system comes to the conclusion that such a possible 'relabelling' did not have a significant impact on the expansion of the R&D expenditure after the introduction of the R&D funding through tax there.[420] The Commission of Experts believes that R&D tax incentives can have a genuine mobilization impact.

At the same time, it is known that numerous actors engaged in R&D who are entitled to a funding through tax do not make use of it.[421] Possible reasons for this are administrative costs, which are perceived as too high, and the desire to avoid possible conflicts with tax authorities if there is uncertainty about the correct definition of the kind of R&D expenditure that qualifies for funding. In the view of the Commission of Experts, any R&D funding scheme via the tax system must be designed in a way that avoids these uncertainties as far as possible by providing for clear definitions and requirements.

The mobilization of private R&D will probably lead to an overall increase in innovation expenditure. In its 2016 Report, the Commission of Experts showed that innovation expenditure is several times higher among German SMEs with continuous R&D than in the case of SMEs that engage in research only occasionally or not at all. This means that an increase in the number of companies continuously engaged in R&D is likely to lead indirectly to an increase of innovation expenditure.[422] However, this effect cannot be reliably quantified.

In the light of the available analyses, the Commission of Experts underlines its assessment that R&D funding through tax incentives should supplement the tried-and-tested instruments of direct project funding.[423]

B 7-4 Assessment of fiscal effects

A distinction needs to be made between two effects when assessing the fiscal impact of R&D funding through tax incentives. The first is that there are shortfalls in tax revenue, since the fiscal authorities grant tax benefits to companies engaging in R&D. The second is that growth stimuli are triggered by the additional R&D activity, which in turn cause higher tax revenue. These positive effects in the form of welfare and growth gains are difficult to identify and trace back to their cause (cf. Section B 7-3). There are therefore no reliable estimates for medium- to long-term increases in tax revenue.[424] However, the Commission of Experts reckons that R&D tax incentives are at least cost-neutral in terms of their long-term impact on tax revenue.

By contrast, direct shortfalls in tax revenue can be quantified quite accurately. When assessing these shortfalls, it should be borne in mind that in Germany it is large companies that account for most R&D expenditure. Figure B 7-5 illustrates the extent to which private sector R&D expenditure in Germany could be reached with tax incentives. It shows the cumulative distributions of R&D expenditure and the number of companies engaging in R&D.[425]

Taking the example of a funding scheme offering a volume-based tax credit with 10 percent subsidy rate and a cap of 2 million euros per company, 91 percent[426] of German companies engaging in R&D (all those with R&D expenditure of up to 20 million euros) would be able to make use of the funding with a 10 percent subsidy rate. This means that tax-based funding could potentially cover 5.59 billion euros of total private internal R&D expenditure in Germany. The remaining 9 percent of companies that are active in R&D whose eligible R&D expenditure exceeds 20 million euros would each receive two million euros in tax credits.

More precise estimates of the fiscal effects must take into account the design of tax-based R&D funding, since this has a significant influence on the level of expected tax revenue shortfalls. The financial consequences of alternative designs for Germany were comprehensively quantified in a recent study conducted by the Centre for European Economic Research (ZEW) on behalf of the Commission of Experts.[427]

Table B 7-6 shows the tax revenue shortfalls estimated for 2013 at subsidy rates varying between 3 and 15 percent.[428] The study assumes that there is no cap and that the tax credit is reimbursed if the company makes a loss. In this case, there is a simple linear relationship between the subsidy rate and the volume of funding: a doubling of the subsidy rate also doubles the volume of tax credit.

According to the study, a 10 percent tax credit on qualifying R&D expenditure would have led to a shortfall in tax revenue amounting to 6.8 billion euros.[429] SMEs (as defined by the European Commission[430]) would have accounted for about 529 million euros of the tax credit.[431] Across all subsidy rates, SMEs would have received 7.8 percent of the total amount of tax credit. This relatively small percentage for SMEs reflects the fact that R&D expenditure is highly concentrated among large companies.

The estimates presented here assume a 100 percent participation rate by eligible companies.[432] However, the participation rate is not expected to be this high in reality. Rather, the actual rate is influenced by a whole range of factors. These include in particular complementary direct project funding, the available R&D infrastructure, the respective corporate and industry structures, and the competitive pressure and costs of using the tax incentive. The tax revenue shortfalls expected in the context of R&D tax credits therefore tend to be overstated.

If the qualifying R&D expenditure had been restricted to R&D personnel expenditure and assuming a 10 percent subsidy rate, the hypothetical loss of revenue would have been about 3.3 billion euros in 2013. SMEs would have accounted for approximately 274 million euros (applying the European Commission's definition of SMEs).[433] It is assumed that the tax credit is offset against the eligible company's wage tax.

Finally, the study looks into design variants that focus on SMEs; diverging from the European Commission's SME criteria, it also compiles differentiated estimates of tax revenue shortfalls by varying

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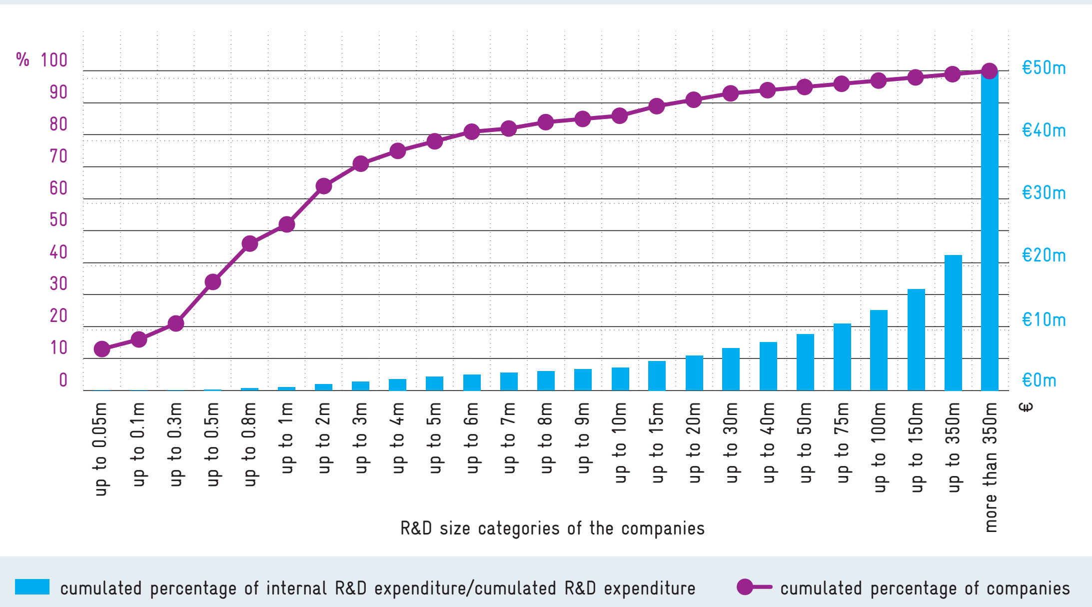
Fig. B 7-5

Download data

Distribution of internal R&D expenditure in the German economy in 2015

Cumulated percentage of R&D-active companies according to R&D size categories, cumulated percentage of internal R&D expenditure, and cumulated R&D expenditure



Legend:
- In the case of a volume-based tax credit with a 10 % subsidy rate and a credit cap of €2m per company, 91 % of companies engaging in R&D (all with up to €20m of R&D expenditure) would benefit from the funding.
- This alone means that €5.59bn of total private internal R&D expenditure would be covered.
- The remaining 9 % of companies that are active in R&D, whose eligible R&D expenditure exceed €20m, would each receive €2m as a credit.

Source: own diagram based on written information provided by SV Wissenschaftsstatistik.

Tab. B 7-6

Download data

Tax-revenue shortfall as a result of tax-based R&D funding in Germany at different subsidy rates in 2013

Figures in billions of euros

Rate of tax credit (subsidy rate)	Non-SMEs	SMEs	Total
3 %	1,882	158	2,041
5 %	3,137	264	3,402
8 %	5,019	423	5,443
10 %	6,274	529	6,804
12 %	7,529	635	8,164
15 %	9,412	794	10,206

Based on the assumption of volume-based funding and reimbursement in the event of a loss.
SMEs are defined according to the European Commission's recommendation (2003/361/EC): up to 249 employees, up to €50m turnover or up to €43m balance sheet total. The distinction between SMEs and non-SMEs for 2013 was based on the SMEs' and non-SMEs' shares of total expenditure in 2007.
Source: Spengel et al. (2017).

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employment size classes. This differentiation makes it possible to estimate tax revenue shortfalls for design variants aiming to promote SMEs with more than 249 employees. In Germany, the Institut für Mittelstandsforschung (IfM), for example, defines the group of SMEs as all companies with up to 499 employees and an annual turnover of less than 50 million euros.[434]

Table B 7-7 shows the estimated shortfall in tax revenue when a tax credit limited to qualifying R&D personnel expenditure is applied to different workforce classes – up to 249, 499 or 999 employees – with subsidy rates varying between 5 and 30 percent.[435] The calculation focuses only on the workforce classes; the other criteria of an SME definition – i.e., annual balance sheet total and annual turnover – are abstracted. This leads to different estimates of tax revenue shortfalls. For example, assuming a subsidy rate of 10 percent and restricting the scheme to the group of companies with up to 249 employees, the revenue loss would have been around 343 million euros.

The findings show that the tax revenue shortfall rises by approximately 50 percent when the workforce threshold is increased from 249 to 499. Raising the workforce threshold from 249 to 999 increases tax revenue shortfalls by about 100 percent.[436]

The Commission of Experts reiterates its statement on the positive effects: i.e., that, according to the analyses presented in section B 7-3, an average of 1.33 euros of additional private R&D expenditure is mobilized for every euro of public tax revenue shortfall. The growth effects triggered by this additional research expenditure lead to higher tax revenues in the medium term which may more than compensate for the short-term tax revenue shortfalls.

Options for action and recommendations B 7-5

In view of the broad-based empirical evidence in support of a positive subsidy impact, the Commission of Experts recommends the introduction of tax-based R&D funding as a supplement to the existing and proven direct project funding measures.

Gear R&D tax credits towards SMEs

A key question is whether a tax incentive instrument should be introduced for all R&D active companies or only for certain groups of companies such as SMEs. The economic justification for R&D funding – i.e,. that tax revenue losses are offset by the positive externalities caused by R&D – applies equally to large and small companies. In addition, it is often argued that in view of the international competition between locations, large-scale companies in particular should not be excluded from any tax-based promotion of R&D because they are in a significantly better position to locate their R&D globally in order to benefit from different national tax laws. This is correct in prin-

Tab. B 7-7

Download data

Tax-revenue shortfalls when a tax credit is limited to R&D personnel expenditure, in different workforce-size classes of qualifying companies and with varying subsidy rates in 2013

Figures in billions of euros

	Workforce-size classes			
Subsidy rate	up to 249 employees	up to 499 employees	up to 999 employees	unlimited
5 %	171	258	360	1,632
10 %	343	516	721	3,265
15 %	514	775	1,082	4,898
20 %	686	1,033	1,443	6,531
25 %	857	1,291	1,804	8,164
30 %	1,029	1,550	2,165	9,797

The companies are categorised solely according to workforce-size classes.
Other criteria such as annual balance sheet total or annual turnover are not taken into account.

Source: Spengel et al. (2017).

B

ciple. However, there are also good reasons in favor of focusing R&D tax incentives on SMEs, because they are affected particularly seriously by financing constraints.

According to recent surveys, the current lack of internal sources of finance represents a barrier to innovation for 30 percent of German SMEs.[437] They are therefore often dependent on more expensive external sources of finance, such as loans or access to venture capital.[438] When companies have recourse to public project funding, the administrative costs of applying carry relatively more weight for SMEs than for large corporations.

Against the background of these financing constraints, German SMEs can only realize a small number of R&D projects at any one time, making it more difficult for them to limit the risk of bad investments via diversification.

State financing of R&D in SMEs in Germany has recently been lagging behind important European reference countries – partly because no tax-based funding instrument has been offered.[439] On average, direct public funding of R&D in SMEs in Germany in 2012 and 2013 corresponded to only 0.25 per mille of the gross domestic product. By comparison, in the same period, France spent 1.72 per mille of its GDP and financed approximately 85 percent of its funding of R&D in SMEs via tax measures.[440]

Against this background, the Commission of Experts makes the following recommendations:

- The Commission of Experts regards the above-mentioned financing constraints of SMEs in particular as an important reason for focusing any tax-based R&D funding on the group of SMEs that would verifiably benefit most from the measure.[441]
- There is evidence in favor of initially applying the European Commission's recommended definition of SMEs, not least because this would avoid a collision with the EU's state aid rules.[442] However, it is a good idea to examine to what extent it is possible to deviate from this definition – as the United Kingdom does. As a next step, R&D tax credits could be extended to companies with up to 499 or 999 employees, if macroeconomically reasonable.
- The possibility of a subsequent gradual extension of the scheme to include larger companies can then be examined in the light of further experience.

Remove financing constraints, exclude double funding

Irrespective of which definition of SME size is used, the following principles should be observed when designing a tax-based R&D funding scheme:

- It should be possible to apply for the funding – and have it approved – in advance, in order to exclude the uncertainties of ex-post approval. As far as possible, the funding should have an immediate impact on liquidity.
- If the instrument of tax credit is selected, and the credit due exceeds the respective tax debt, it must be possible for this amount to be paid out directly. Alternatively, it should be possible to carry it forward to subsequent years. The tax credit should certainly not be forfeited.
- Double funding should be excluded. In particular, research contracts should not be subsidized simultaneously at both the contracting and contracted company.

Keep the administration lean

- The OECD's Frascati Manual can be used for defining tax relevant R&D expenditure. It provides internationally acknowledged criteria for differentiating between basic research, applied research, and experimental development.[443] R&D personnel expenditure should be limited to directly attributable unit costs. Any additional consideration of overhead costs is administratively complex and not very transparent; it should therefore not be envisaged.
- The Commission of Experts recommends having the review and approval of qualifying R&D expenditure carried out by institutions that are independent of the Ministry of Finance. These should be accredited institutions that have experience in the administration of R&I projects and employ technology experts (e.g. using a similar approach to the procedure in the Netherlands).
- Recognition of eligibility must be legally binding for the companies. However, tax audits to verify the correctness of information, e.g. on the scope and nature of the R&D carried out, should not be affected by this.
- The Commission of Experts calls for the introduction of standardized, online-based application procedures in order to keep administrative costs low.

Design alternatives of tax-based R&D funding

In the Commission of Experts' assessment, tax-based R&D funding should take the form of a tax credit. In contrast to schemes linked to the basis for tax assessment, the level of funding by a tax credit is not influenced by the tax rate of the company to be funded, which can vary greatly in Germany – depending on the legal form of the company. In other words, the funding should benefit both corporate entities and partnerships to the same extent. Furthermore, the Commission of Experts considers a volume-based system of funding to be more transparent and administratively easier to handle than incremental funding.

More specifically, the Commission of Experts suggests choosing one of the two following variants.

Variant 1: Tax credit on all R&D expenditure within the framework of corporate taxation

- This variant is the most widespread internationally; it is also the most closely studied in terms of its expected impact. In this model, the tax credit would include all qualifying R&D expenditure, i.e., staff costs, the cost of instruments and equipment, the cost of the buildings used for the research project, as well as the costs of feasibility studies, consulting services, and certification (of R&D expenditure's eligibility for funding). Because all different kinds of R&D expenditure would be included equally, no systematic preference would be given to certain economic sectors or technologies that use individual forms of R&D expenditure particularly intensively. This can be seen as an advantage of this variant.
- In the case of expenditure on contract research, the funding scheme would target the contracting company.[444] Funding for contract research benefiting the contracting company would be especially important for SMEs that have few corporate R&D resources of their own and therefore award external contracts to tertiary education institutions, research organisations, and other companies. On the other hand, research contracts awarded to foreign contractors whose research findings contribute to knowledge generation and externalities outside Germany would also receive support.
- The tax credit would be offset against payable corporate tax; in the event of a loss, or if the tax debt is lower than the tax credit, it would be either carried forward or paid out (pro-rata). Therein lies a disadvantage of the model, especially for SMEs: there would be no positive liquidity effects until the financial authorities have issued the tax assessment notice. In certain circumstances, disbursements would not be made until more two years after the original expenditure.[445]

Variant 2: Tax credit on R&D personnel expenditure to be offset against wage tax

- Using a similar approach to the WBSO program in the Netherlands, the tax credit could be linked to the level of R&D personnel costs and deducted from the wage tax payable by the company.[446] The model has the following advantages:
- Wage tax is subject to smaller fluctuations than the corporate income tax payable by the company as a whole and must be paid irrespective of the company's profit situation. This makes it easier to plan the subsidy effect for companies and the fiscal effect for the public sector. In addition, wage tax is paid monthly, so that the tax credit would have a positive impact at the same time as the personnel expenditure is paid. This immediate liquidity effect would be of particular relevance for companies with major financial restrictions, and especially for start-ups.
- As an indirect effect, in addition to providing an incentive to increase R&D activities, the reduced personnel costs could boost the demand for R&D staff subject to social insurance contributions and thus generate more positions in regular employment. Limiting the tax credit to R&D personnel expenditure would also make the scheme easier to administer than one applying to all R&D expenditure. Both the declaration costs for the tax payer and the control costs for the tax authorities would be lower. At the same time, if the basis for funding were limited to R&D personnel (as a subset of all R&D input factors), there would be less potential for abuse.
- Expenditure on contract research could not be taken into account at the contracting company. The instrument at the contracted company would nevertheless target the R&D contracts.
- One disadvantage of this variant is that companies and industries with different levels of labor intensity in their R&D operations would receive different levels of funding.

How the shortfall in tax revenue is distributed among the Federal and Länder governments is basically independent of the variant chosen – and thus also of the tax to which the funding relates.[447]

The Commission of Experts regards both variants as useful additions to the existing set of R&D funding instruments. However, having weighed up the advantages and disadvantages of the two variants, the Commission of Experts prefers the second. The most important arguments here are better planability and the stronger liquidity effects. Since these are particularly important for SMEs, the Commission of Experts believes variant 2 would generate stronger promotional effects for this group.

Regardless of which of the above-mentioned basic variants is chosen, the introduction of R&D funding through tax incentives should be accompanied by a solid, scientifically-founded evaluation framework (cf. Chapter B 5-3).

STRUCTURE AND TRENDS

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C 8 Production, value added and employment

Overview

Measuring and reporting Germany's performance as a location for research and innovation is an integral part of the annual reports of the Commission of Experts for Research and Innovation. The process involves compiling a number of indicators which allow conclusions to be drawn on the dynamics and efficiency of Germany's research and innovation system. For the sake of clarity, the indicators are divided into eight thematic sets. Based on these indicator sets, the performance of the German research and innovation system is presented in an intertemporal comparison; it is also compared with the most important competing countries.[448] Furthermore, individual indicators are shown at the Länder level to reveal differences in performance within Germany. Most of the indicators have been drawn from studies on the German innovation system commissioned by the Commission of Experts. In addition to the indicators listed here, these studies also offer comprehensive further material for indicators and analysis. All the studies can be accessed and downloaded on the Commission of Experts' website. The same applies to all the charts and tables in the Report and to the related data sets.

C 1 Education and qualification

Investment in education and a high level of qualification strengthen a country's medium- and long-term innovative capacity and its economic growth. The indicators listed in section C 1 provide information on qualification levels, as well as an overview of Germany's strengths and weaknesses as an innovation location. To facilitate an assessment of Germany's performance at the international level, these findings are compared with figures from other industrialised countries.

C 2 Research and development

Research and development processes are essential for developing new products and services. As a rule, a high level of R&D intensity has positive effects on competitiveness, growth and employment. R&D investments and activities by companies, tertiary education institutions and governments therefore provide an important source of information for assessing a country's technological performance. Section C 2 gives insights into how Germany's R&D activities compare with those of other countries, how much the individual Länder invest, and which sectors of the economy are especially research-intensive.

C 3 Innovation behaviour in the private sector

Innovation activities by companies aim to create competitive advantage. In the case of a product innovation, a new or improved good is launched onto the market. By definition, this good differs from any other goods previously sold on the market. The launch of a new or improved manufacturing process is referred to as a process innovation. Section C 3 depicts the innovation behaviour of the German economy by showing the innovation intensity of industry and knowledge-intensive services, and the percentage of turnover that is generated with new products, in an international comparison.

C 4 Financing research and innovation

The financing of business and, in particular, R&D activities is a key challenge, above all for young, innovative enterprises. Since these companies initially generate little or no turnover, self-financing is often not an option. Debt financing is also difficult, as it is not easy for investors such as banks to assess the success prospects of innovative business start-ups. Alternative methods of corporate financing include raising equity or venture capital, as well as public funding. Section C 4 describes the availability of venture capital and public R&D funds in Germany and other countries.

C 5 New enterprises

Business start-ups – especially in research- and knowledge-intensive sectors – challenge established companies with innovative products, processes and business models. The creation of new companies and the market exit of unsuccessful (or no longer successful) companies is an expression of innovation competition for the best solutions. The business dynamics described in section C 5 is therefore an important aspect of structural change. Young enterprises can open up new markets and leverage innovative ideas – especially in new fields of technology, when new demand trends emerge, and in the early phase of transferring scientific knowledge to the development of new products and processes.

C 6 Patents

Patents are intellectual property rights for new technical inventions. Thus, they often provide the basis for exploiting innovations on the market, while at the same time supporting coordination and the transfer of knowledge and technology between the stakeholders in the innovation system. Section C 6 presents the patent activities of selected countries, while also examining the extent to which these countries have become specialised in the fields of high-value and cutting-edge technology.

C 7 Scientific publications

The continuous creation of new knowledge greatly depends on the efficiency of the respective research and science system. Using bibliometric data, section C 7 depicts Germany's performance in this field by international comparison. A country's performance is determined on the basis of its researchers' publications in scientific journals. The perception and importance of these publications is measured by the number of citations.

C 8 Production, value added and employment

Levels of work input and value creation in a country's research- and knowledge-intensive sectors – as percentages of the economy as a whole – reflect the economic importance of these sectors and allow conclusions to be drawn on the country's technological performance. Section C 8 depicts the development of value added and productivity in research-intensive industries and knowledge-intensive services by international comparison. The section also provides insights into Germany's global trade position in the fields of research-intensive goods and knowledge-intensive services.

Education and qualification C 1

The percentage of the working population in Germany with tertiary qualifications (ISCED 5+6 and ISCED 7+8) was 30.7 percent in 2015, 0.6 percentage points higher than in the previous year (C 1-1). The percentage of people with low qualifications (ISCED 0-2) also rose slightly compared to the previous year from 9.6 to 9.8 percent. Of all the countries compared, Italy had by far the highest proportion of low-skilled employees. They made up 31.7 percent of all employed people.

The number of new tertiary students as a percentage of the relevant age group (C 1-2) rose sharply again in Germany. The figure grew by 5 percentage points to 64 percent between 2013 and 2014. It was thus 4 percentage points below the OECD average of 68 percent.

In 2015 there were 444,859 school-leavers in Germany qualified for higher education (C 1-3). The rate of qualified school-leavers, i.e. the number of school-leavers qualified for tertiary education as a percentage of the relevant age group, was thus 53 percent. Two years earlier in 2013, the rate of qualified school-leavers was 57.8 percent, almost 5 percentage points higher. The rate of qualified school-leavers for 2016 is expected to have risen again significantly.

The number of first-time graduates (C 1-4) increased again to 317,102 in 2015. At the same time, the percentage of first-time graduates who completed their degrees at a university amounted to 56.8 percent in 2015, having fallen again relative to those who graduated at universities of applied science (UAS). The number of first-time graduates in engineering (among others) showed marked growth. Their number increased from 62,606 in 2014 to 64,984 in 2015; as a percentage of all graduates, the figure rose from 16.5 percent in 2005 to 20.5 percent.

There was a further increase in the number of foreign students in Germany (C 1-5). In the 2015/16 winter semester, 251,542 Bildungsausländer – i.e. students who obtained their university entrance qualification abroad – were enrolled at German tertiary education institutions. Their number was 15,684 up on the previous year, and had risen by 62,092 compared to the winter semester of 2005/06.

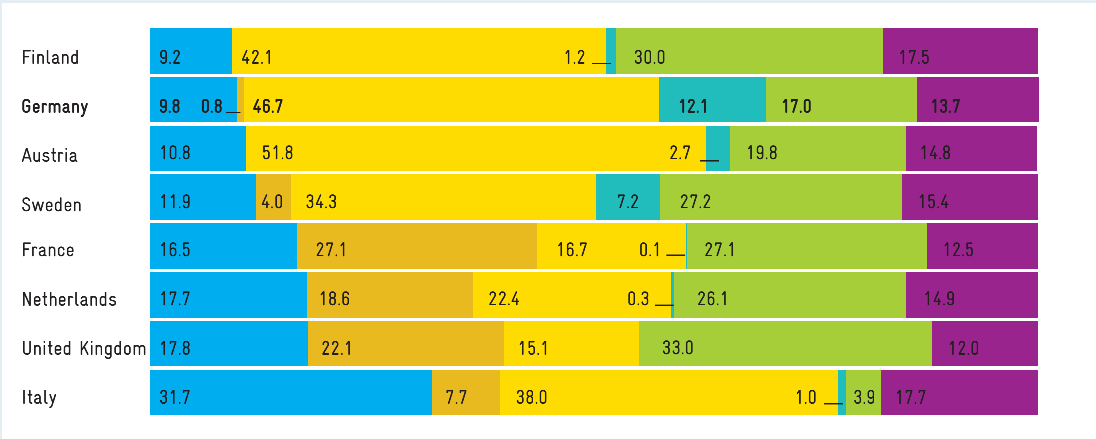
The number of Bildungsinländer, i.e. foreign students who obtained their university entrance qualification in Germany, rose to 88,763 in the 2015/16 winter semester. Their number has risen by 29,856 since the 2005/2006 winter semester.

Participation by firms in further education (C 1-6) rose across all sectors and all size categories between 2005 and 2014. The corporate further-education rate rose from 42.7 percent in 2005 to 53.6 percent in 2014 – an increase of almost 11 percentage points. Participation in further education increased particularly strongly among small companies with fewer than 50 employees. This figure rose from 40.5 percent in 2005 to 51.4 percent in 2014.[449]

Fig. C 1-1

Download data

Qualification levels of gainfully employed persons in selected EU countries, 2015 (as percentage)



Classification of the ISCED qualification levels*.

- ISCED 0–2: (Pre)primary and lower secondary education
- ISCED 3*: General and vocational upper secondary education without direct access to tertiary education
- ISCED 3**: General and vocational upper secondary education with direct access to tertiary education
- ISCED 4: Technical college / university and completion of an apprenticeship
- ISCED 5+6: Short, career-related tertiary education (2 to less than 3 years), bachelor's degree, training as a master craftsman or technician or equivalent vocational school qualification
- ISCED 7+8: Master's degree, PhD or equivalent qualification

* UNESCO uses the ISCED classification of educational levels as standards for international comparisons of country-specific education systems. They are also used by the OECD.

Source: Eurostat, European Labour Force Survey. Calculation by CWS in Gehrke et al. (2017a).

C

Tab. C 1-2

Download data

Number of new tertiary students as a percentage of the relevant age group in selected OECD countries and China

University entry rate: number of new tertiary students as a percentage of the relevant age group

OECD countries	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013[1)]	2014	2014*
France	–	–	–	–	–	–	–	39	41	–	–	–
Germany	**37**	**36**	**35**	**34**	**36**	**40**	**42**	**46**	**53**	**59**	**64**	**57**
Japan	40	41	45	46	48	49	51	52	52	–	80	–
South Korea	49	54	59	61	71	71	71	69	69	–	–	–
Sweden	79	76	76	73	65	68	76	72	60	56	62	56
Switzerland	38	37	38	39	38	41	44	44	44	76	80	45
United Kingdom	52	51	57	55	57	61	63	64	67	58	61	54
USA	63	64	64	65	64	70	74	72	71	52	52	51
OECD average	**53**	**54**	**56**	**56**	**56**	**59**	**61**	**60**	**58**	**67**	**68**	**61**
China	–	–	–	–	–	17	17	19	18	–	–	–

1) The table shows the university entry rates according to the ISCED classification for levels 5, 6 und 7. Please note: figures from 2013 were compiled according to ISCED 2011, figures before 2013 according to ISCED 97; this table is therefore not comparable with previous years. ISCED 2011 used here has nine levels, while ISCED 1997 had only seven. ISCED 2011 has four instead of two levels in the field of higher education (ISCED 1997: Levels 5A and 6; ISCED 2011: Levels 5 to 8); in addition, it enables a distinction to be made between 'general and vocational upper secondary education without direct access to tertiary education (ISCED 3*)' on the one hand, and 'general and vocational upper secondary education with direct access to tertiary education (ISCED 3**)' on the other. Cf. Fig C 1-1 on the classification of the ISCED qualification levels.

* Adjusted rate excluding international students beginning tertiary education.

Sources: OECD (ed.): Education at a Glance. OECD indicators, various years in Gehrke et al. (2017a).

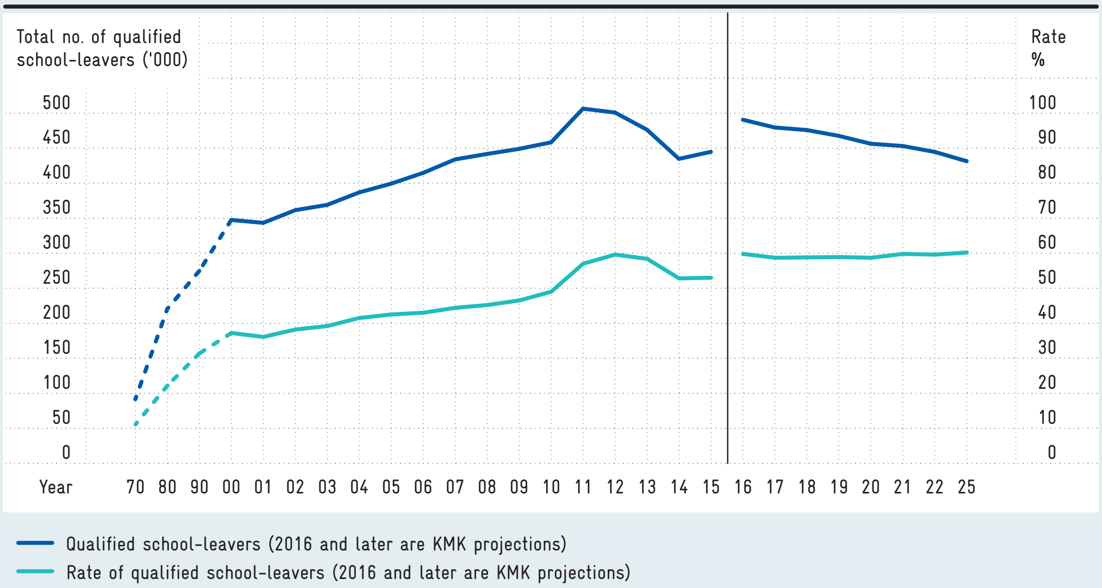
C

Fig. C 1-3

Download data

School-leavers qualified for higher education in Germany, 1970 to 2025 (figures for 2016 and later are projections)

School-leavers qualified for higher education have either a 'general' or 'technical' school-leaving certificate* (in Germany Abitur).
Rate of qualified school-leavers: number of school-leavers qualified for higher education as a percentage of the relevant age group.



Source for actual values: Federal Statistical Office (2016), in Gehrke et al. (2017a).
Source for projections: Statistical Publications of the Standing Conference of Education Ministers in: Gehrke et al. (2017a).
* Since 2013, the actual figures no longer include school-leavers who have passed the academic part of the 'technical' Abitur but must still do a period of professional practical training according to the respective Länder rules to fully qualify for tertiary education.

Tab. C 1-4

Download data

Number of first-time graduates and subject-structure rates

First-time graduates and subjects structure rates: the subject structure rate indicates the percentage of first-time graduates in a specific subject or subject group. First-time graduates are persons who successfully complete a first degree.

	2005	2007	2009	2010	2011	2012	2013	2014	2015
Total number of graduates	**207,936**	**239,877**	**287,997**	**294,330**	**307,271**	**309,621**	**309,870**	**313,796**	**317,102**
Percentage of women	50.8	51.8	51.7	52.1	51.4	51.3	51.5	51.1	51.1
Percentage of university graduates	60.8	62.4	62.0	62.0	62.1	61.3	59.9	59.0	56.8
Linguistic and cultural sciences	**35,732**	**43,827**	**53,003**	**54,808**	**56,140**	**55,659**	**56,313**	**57,016**	**55,596**
Percentage for subject group	17.2	18.3	18.4	18.6	18.3	18.0	18.2	18.2	17.5
Law, economics and social sciences	**76,566**	**85,838**	**101,391**	**102,315**	**105,589**	**105,024**	**105,105**	**106,710**	**109,122**
Percentage for subject group	36.8	35.8	35.2	34.9	34.4	33.9	33.9	34.0	34.4
Medicine/ health sciences	**11,817**	**13,358**	**15,142**	**15,222**	**15,686**	**15,856**	**16,534**	**17,331**	**17,935**
Percentage for subject group	5.7	5.6	5.3	5.2	5.1	5.1	5.3	5.5	5.7
Agriculture, forestry, nutrition sciences	**5,312**	**5,661**	**6,787**	**6,215**	**6,563**	**6,405**	**6,193**	**6,042**	**6,484**
Percentage for subject group	2.6	2.4	2.3	2.1	2.1	2.1	2.0	1.9	2.0
Art, art history	**9,678**	**10,399**	**11,541**	**11,820**	**12,525**	**12,866**	**12,542**	**11,913**	**11,514**
Percentage for subject group	4.7	4.3	4.0	4.0	4.1	4.2	4.0	3.8	3.6
Mathematics, natural sciences	**30,737**	**38,417**	**47,782**	**48,561**	**49,593**	**48,231**	**46,707**	**47,046**	**46,317**
Percentage for subject group	14.8	16.0	16.6	16.5	16.1	15.6	15.1	15.0	14.6
Engineering sciences	**34,339**	**38,065**	**47,004**	**49,860**	**55,631**	**60,259**	**62,007**	**62,606**	**64,984**
Percentage for subject group	16.5	15.9	16.3	16.9	18.1	19.5	20.0	20.0	20.5

Source: Federal Statistical Office and research in DZHW-ICE, in Gehrke et al. (2017a).

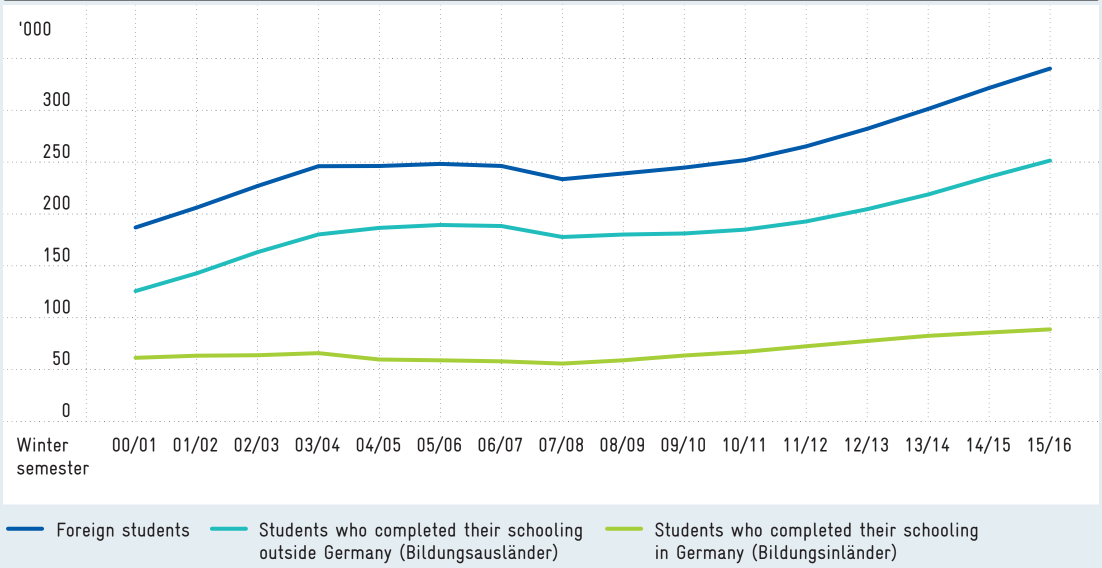
C

Fig. C 1-5

Download data

Foreign students at German tertiary education institutions

Foreign students are defined as persons without German citizenship.These can be divided into students who obtained their higher education entrance qualification in Germany (Bildungsinländer) and those who obtained this qualification abroad (Bildungsausländer).



Source: Federal Statistical Office and research in DZHW-ICE, in Gehrke et al. (2017a).

Tab. C 1-6

Download data

Percentage participation of individuals and companies in further training

Individual further-education rate: percentage of people who participated in a further-education measure in the four weeks prior to the time of the survey. Corporate participation in further training: companies where employees were released for training or whose training costs were paid.*

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
a) Individual further-education rate	5.2	4.6	4.9	5.5	5.0	4.9	4.9	5.1	4.9	4.8	4.9
Gainfully employed persons	**6.4**	**5.7**	**5.9**	**6.4**	**5.8**	**5.6**	**5.6**	**5.9**	**5.6**	**5.5**	**5.5**
low (ISCED 0-2)	1.6	1.3	1.5	1.7	1.4	1.3	1.0	1.4	1.4	1.3	1.2
medium (ISCED 3-4)	4.5	4.0	4.1	4.4	4.2	3.9	3.9	4.1	3.9	4.2	4.3
high (ISCED 5-8)	12.1	11.2	11.4	12.2	10.6	10.5	10.3	10.6	10.1	9.4	9.3
Unemployed persons	**3.1**	**2.8**	**3.1**	**4.9**	**4.3**	**3.9**	**4.6**	**3.8**	**3.6**	**3.7**	**3.7**
low (ISCED 0-2)	2.0	1.1	2.5	2.4	2.7	3.5	3.6	3.1	2.9	2.8	2.6
medium (ISCED 3-4)	2.8	3.0	2.9	5.3	4.0	3.2	4.0	3.6	3.4	3.3	3.4
high (ISCED 5-8)	6.1	5.6	5.4	8.1	8.4	8.3	10.0	6.6	5.4	6.4	6.3
Inactive persons	**2.0**	**1.6**	**1.7**	**2.3**	**1.9**	**2.0**	**1.9**	**1.6**	**1.8**	**1.8**	**2.0**
low (ISCED 0-2)	0.9	0.9	0.8	1.4	1.8	1.6	1.5	1.4	1.4	1.3	1.7
medium (ISCED 3-4)	2.0	1.3	1.7	1.8	1.5	1.8	1.9	1.4	1.5	1.6	1.6
high (ISCED 5-8)	4.2	4.2	3.5	5.4	3.4	3.6	2.7	2.8	3.5	3.4	3.7
b) Corporate participation in further training	**42.7**	**-**	**45.5**	**49.0**	**44.6**	**44.1**	**52.6**	**53.1**	**52.1**	**53.6**	**-**
By sector											
Knowledge-intensive manufacturing	55.7	-	65.3	65.1	52.6	55.9	62.9	65.5	66.7	69.9	-
Non-knowledge-intensive manufacturing	32.4	-	33.2	37.8	32.5	33.3	41.2	43.2	41.8	43.0	-
Knowledge-intensive services	58.8	-	63.2	68.3	58.7	57.1	68.7	67.2	67.4	67.0	-
Non-knowledge-intensive services	34.9	-	37.3	39.4	38.0	37.5	44.9	45.3	44.3	46.0	-
Non-commercial economy	46.9	-	49.9	53.8	51.9	51.2	59.0	60.3	58.4	61.9	-
By company size											
< 50 employees	40.5	-	43.2	46.9	42.5	41.8	50.5	50.9	49.8	51.4	-
50 – 249 employees	82.9	-	85.1	86.7	81.3	83.3	90.8	89.7	90.1	90.8	-
250 – 499 employees	95.6	-	95.2	95.9	92.0	93.3	95.9	96.5	97.0	96.9	-
≥ 500 employees	97.0	-	95.3	97.8	96.0	97.9	98.4	97.8	99.1	99.1	-

All figures are provisional. Cf. C 1-1 for information on ISCED.
Population a): all persons aged between 15 and 64.
Population b) all establishments with at least one employee subject to social insurance contributions.
Source a): European Labour Force Survey (special evaluation). Calculations by ZEW in Gehrke et al. (2017a).
Source b): IAB Establishment Panel (special evaluation). Calculations by ZEW in Gehrke et al. (2017a).
* Question in the IAB Establishment Panel: "Were employees released to participate in in-house or external training measures and/or were the costs of training measures paid wholly or in part by the establishment?"

C 2 Research and development

In 2015, R&D intensity (C 2-1) in Germany increased again and amounted to 2.99 percent of gross domestic product. The three-percent target was thus reached. R&D intensity also increased in the UK and Sweden: Sweden from 3.15 to 3.26 percent and the UK slightly from 1.68 to 1.70 percent. By contrast, R&D intensity in France decreased minimally from 2.24 to 2.23 percent, continuing the stagnation of R&D intensity that has been observed for several years. There are no current data for China, Switzerland, South Korea or the USA. However, South Korea has by far the highest R&D intensity figures of all the reference countries for 2014 with 4.29 percent.

In Germany, the budget estimate for civil R&D (C 2-2) rose again last year. In 2015, the budgetary estimate, i.e. the financial resources set aside in the state budget, was thus 71 percent above the initial level in 2005. The budget estimates rose much more in Switzerland and South Korea, although the data for 2015 are not yet available.

The distribution of gross domestic expenditure on R&D by performing sector (C 2-3) shows that the corporate share in Germany fell from 69.3 percent in 2005 to 67.7 percent in 2015. The tertiary education institutions' share of R&D expenditure rose in the same period from 16.5 to 17.4 percent, public R&D expenditure from 14.1 to 14.9 percent.

No new data are available for the indicators on the R&D intensity of Germany's Länder (C 2-4) or on R&D expenditure by companies (C 2-5). The tables have been taken over without comment from the 2016 Report.

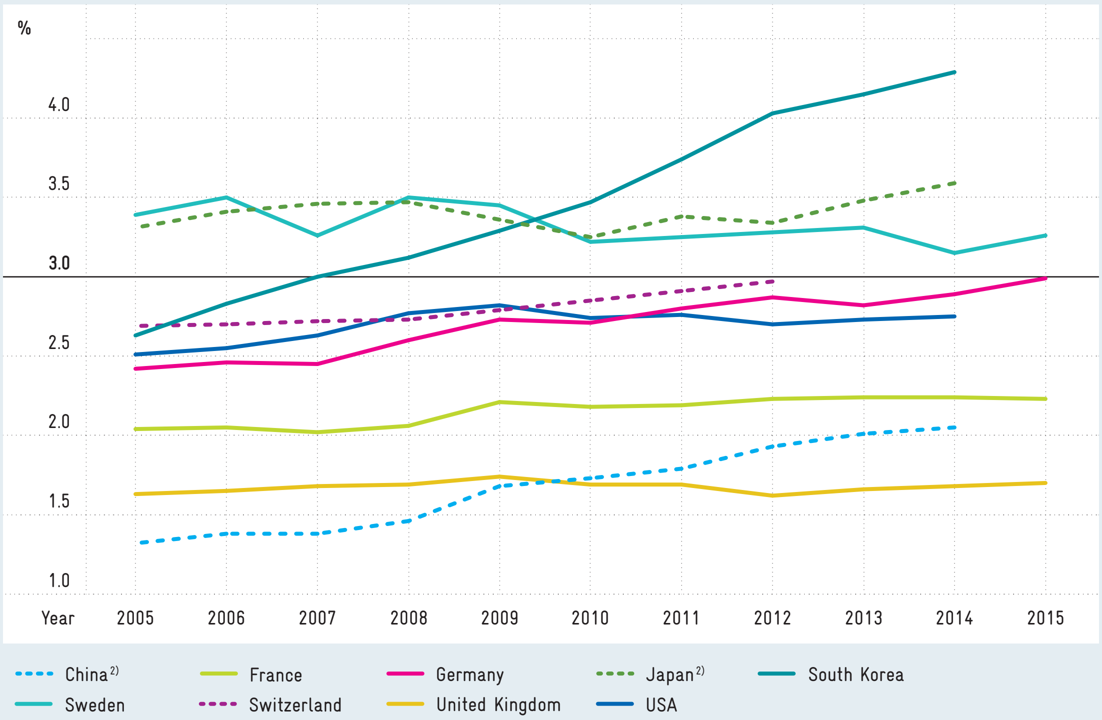
The indicator 'internal corporate R&D expenditure as a percentage of turnover from the company's own products' (C 2-6) again documents an increase in the average R&D intensity in the manufacturing sector for 2015. This development is borne primarily by the automotive engineering industry, the pharmaceutical and chemical industries, and electrical equipment. By contrast, R&D intensities have been declining since 2013 in the sectors IT equipment, electrical engineering, optics and aerospace.[450]

Fig. C 2-1

Download data

R&D intensity in selected OECD countries and China, 2005 to 2015 (as percentage)

R&D intensity: percentage of an economy's gross domestic product (GDP) spent on research and development.[1]



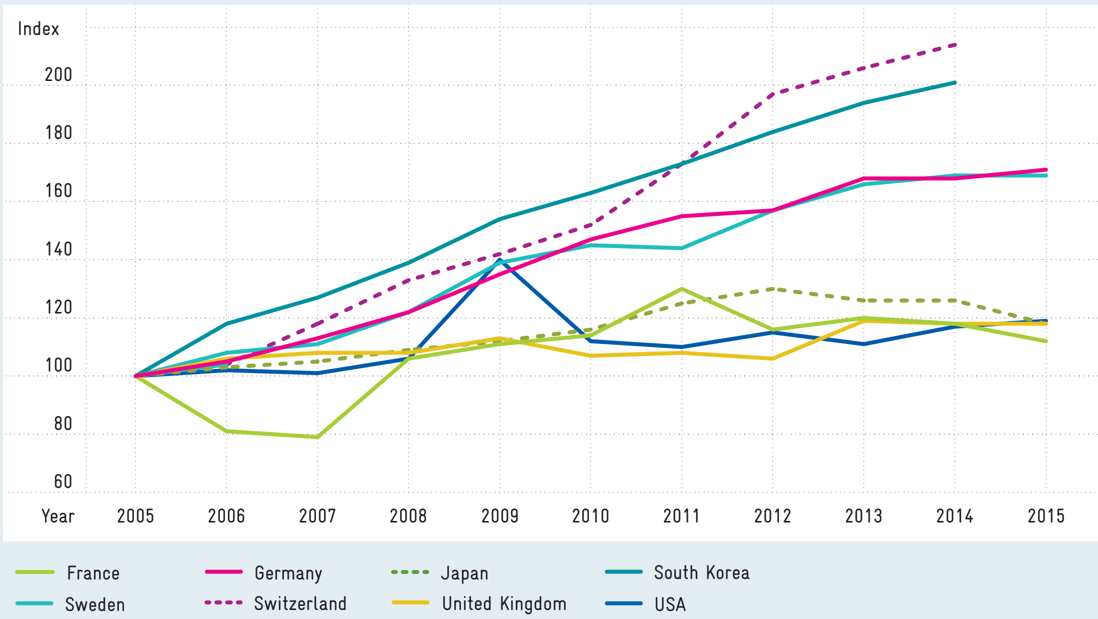
[1] Gross domestic product based on the methodology of the European System of National and Regional Accounts (ESA 2010).
[2] Gross domestic product based on the methodology of the ESA 2005. Some of the data for Switzerland were estimated.
Japan 2008, France 2010, South Korea 2007, break in the series in China in 2009.
Source: OECD, EUROSTAT. Calculations and estimates by CWS in Schasse (2017).

Fig. C 2-2

Download data

State budget estimates for civil R&D

R&D budget estimates: the chart shows the amounts set aside in the budget to finance R&D.



Index: 2005 = 100, data partially based on estimates.
Source: OECD, EUROSTAT. Calculations and estimates by CWS in Schasse (2017).

C

Tab. C 2-3

Download data

Distribution of gross domestic expenditure on R&D (GERD) by performing sector, 2005 and 2015

Gross domestic expenditure on research and development (GERD) in industry, the higher education sector and the public sector.

	2005					2015				
		of which by … (in percent)					of which by … (in percent)			
Countries	GERD in USD m	private sector	higher edcation sector	public sector	private non-profit*	GERD in USD m	private sector	higher edcation sector	public sector	private non-profit*
France	39,236	62.1	18.8	17.8	1.3	59,341	65.1	20.3	13.1	1.5
Germany	**64,299**	**69.3**	**16.5**	**14.1**	**-**	**111,180**	**67.7**	**17.4**	**14.9**	**-**
Japan[1]	128,695	76.4	13.4	8.3	1.9	166,861	77.8	12.6	8.3	1.3
South Korea[1]	30,618	76.9	9.9	11.9	1.4	72,267	78.2	9.0	11.2	1.5
Sweden	10,500	72.8	22.0	4.9	0.3	15,109	69.5	26.9	3.4	0.2
Switzerland[2]	7,470	73.7	22.9	1.1	2.3	13,571	69.3	28.1	0.8	1.8
United Kingdom	34,081	61.4	25.7	10.6	2.3	45,476	65.7	25.6	6.8	1.9
USA[3]	328,128	68.9	14.3	12.3	4.4	499,299	72.0	13.3	10.6	4.0
China[1]	86,828	68.3	9.9	21.8	-	368,732	77.3	6.9	15.8	-

[1] 2014 instead of 2015 [2] 2004 instead of 2005 [3] 2015 provisional.
Private non-profit organisations are included under the 'public sector' in some countries (e.g. Germany).
Source: OECD, EUROSTAT. Calculations by CWS in Schasse (2017).

Tab. C 2-4

Download data

R&D intensity of Germany's Länder, 2003 and 2013 (as percentage)

R&D intensity: Länder expenditure on research and development as a percentage of their gross domestic product, broken down by sectors.

	2003				2013			
Länder	Total	private sector	public sector	higher education sector	Total	private sector	public sector	higher education sector
Baden-Württemberg	3.76	2.97	0.37	0.41	4.80	3.87	0.42	0.52
Bavaria	3.00	2.41	0.24	0.36	3.16	2.41	0.32	0.43
Berlin	3.65	1.85	1.01	0.78	3.57	1.50	1.23	0.84
Brandenburg	1.18	0.34	0.55	0.29	1.55	0.45	0.74	0.36
Bremen	2.63	1.35	0.61	0.67	2.67	1.01	0.97	0.70
Hamburg	1.71	1.03	0.33	0.35	2.32	1.33	0.47	0.51
Hesse	2.46	2.01	0.16	0.29	2.83	2.18	0.23	0.42
Lower Saxony	2.80	2.05	0.31	0.44	2.84	1.92	0.39	0.52
Mecklenburg-West Pomerania	1.30	0.27	0.53	0.50	1.83	0.48	0.71	0.64
North Rhine-Westphalia	1.74	1.06	0.26	0.42	1.94	1.11	0.33	0.49
Rhineland-Palatinate	1.73	1.24	0.15	0.34	2.13	1.54	0.17	0.43
Saarland	1.06	0.39	0.24	0.43	1.42	0.55	0.41	0.46
Saxony	2.23	1.03	0.60	0.60	2.74	1.11	0.81	0.82
Saxony-Anhalt	1.18	0.29	0.38	0.51	1.42	0.42	0.50	0.50
Schleswig-Holstein	1.10	0.49	0.31	0.31	1.47	0.75	0.37	0.35
Thuringia	1.89	1.01	0.39	0.50	2.20	1.05	0.52	0.63
Germany	**2.46**	**1.72**	**0.33**	**0.42**	**2.83**	**1.91**	**0.42**	**0.50**

Source: SV Wissenschaftsstatistik in Schasse et al. (2016).

C

Tab. C 2-5

Download data

Internal R&D spending by companies: origin of funds, economic sector, company size and technology category, 2013

Internal corporate R&D: R&D that is conducted within the company, either for the company's own purposes or commissioned by a third party.

	Internal R&D expenditure				
	Total	of which financed by			
		industry	state	other domestic residents	other countries
	in €'000	as percentage			
All companies active in research	**53,296,234**	**91.7**	**3.0**	**0.2**	**5.0**
Manufacturing industries	46,048,715	92.8	2.0	0.2	5.0
Chemical industry	3,346,601	93.8	1.6	0.0	4.6
Pharmaceutical industry	4,074,886	86.8	0.5	0.0	12.7
Plastics, glass and ceramics	1,261,748	92.2	2.6	0.7	4.6
Metal production and processing	1,273,337	80.7	8.5	0.2	10.7
Electrical engineering/electronics	9,472,033	94.6	2.8	0.1	2.4
Mechanical engineering	5,388,201	95.8	2.0	0.5	1.7
Vehicle equipment	19,204,835	93.1	1.3	0.2	5.4
Other manufacturing industries	2,027,074	91.0	3.7	0.1	5.2
Remaining sectors	7,247,519	85.1	9.7	0.2	5.0
fewer than 100 employees	2,859,712	78.4	16.8	0.4	4.5
100–499 employees	4,708,916	88.2	6.4	0.3	5.1
500–999 employees	3,214,604	90.9	4.6	0.1	4.4
1,000 employees and more	42,513,002	93.1	1.6	0.2	5.1
Technology categories in industry					
Cutting-edge technology (> 9 percent of turnover spent on R&D)	13,404,548	90.4	3.2	0.0	6.3
High-value technology (3–9 percent of turnover spent on R&D)	27,113,163	94.4	1.1	0.2	4.3

Source: SV Wissenschaftsstatistik. In: Schasse et al. (2016).

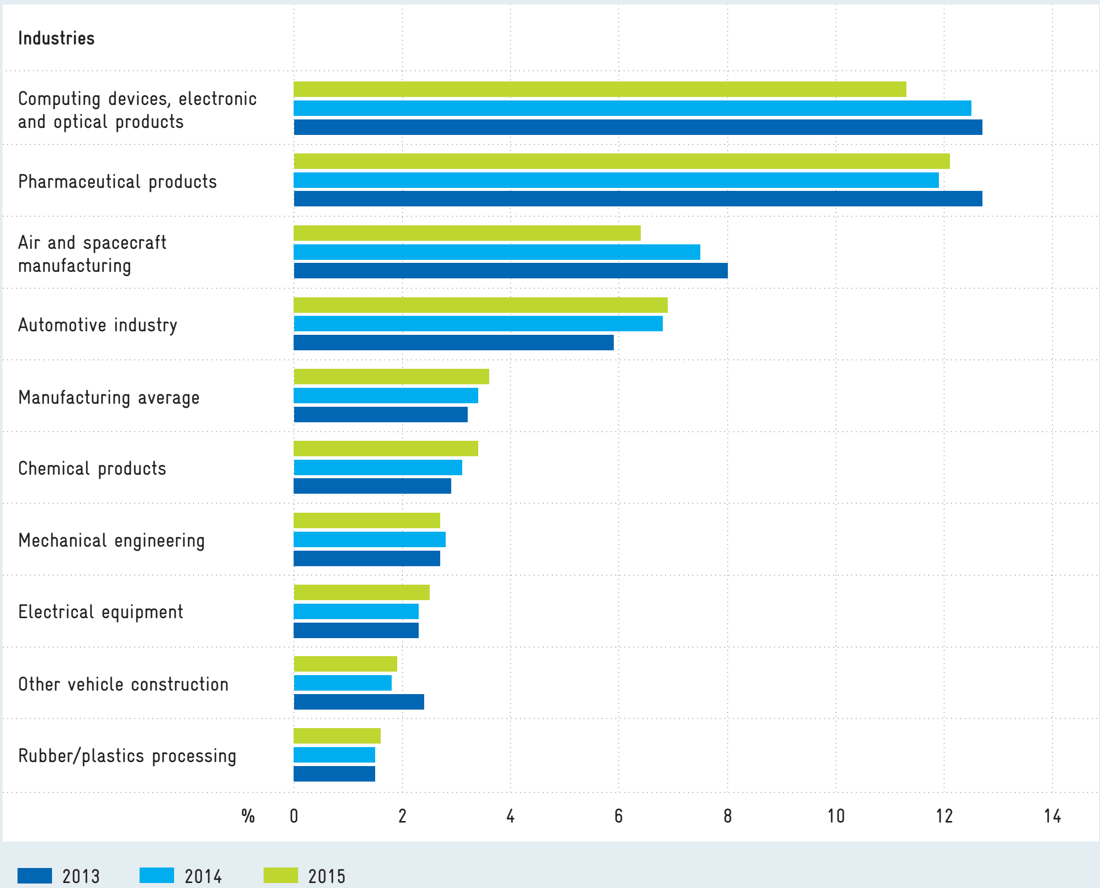
C

Fig. C 2-6

Download data

Internal corporate R&D expenditure as a percentage of turnover from the company's own products, 2013, 2014 and 2015

Internal corporate R&D: R&D that is conducted within the company, either for the company's own purposes or commissioned by a third party.



Figures net, without input tax. 2013: break in series.
Source: SV Wissenschaftsstatistik, Statistisches Bundesamt (Federal Statistical Office), corporate results for Germany. Calculations by CWS in Schasse (2017).

C 3 Innovation behaviour in the private sector

The Europe-wide Community Innovation Surveys (CIS) are conducted every two years and provide the underlying data for the international comparison of the private sector's innovation behaviour (C 3-1).[451] Coordinated by Eurostat and based on a harmonised methodology, the CIS are conducted in all EU member states and a number of other European countries. The CIS are based on a largely uniform questionnaire and directed at businesses with ten or more employees in the manufacturing industry and selected services sectors. The current analysis relates to 2014 (CIS 2014). In that year, the innovation intensity of the research-intensive industries in Germany amounted to 7.0 percent. It was thus higher than that of most reference countries. However, Sweden's innovation intensity was considerably higher at 11.1 percent in the research-intensive industries.

The data on innovation behaviour in the German private sector, as shown in charts C 3-2 to C 3-4, are based on the Mannheim Innovation Panel (MIP), an annual innovation survey that has been conducted by the Centre for European Economic Research (ZEW) since 1993.[452] Data from the MIP constitute the German contribution to the CIS. In addition to the data to be reported to Eurostat, the panel also includes data on businesses with five to nine employees.

The innovation intensity (C 3-2) of R&D-intensive industries amounted to 8.8 percent in 2015, thus again equalling the peak figure reached in 2013. In other industry the figure was much lower at 1.4 percent. After a decline in 2014, innovation intensity in the knowledge-intensive services (excluding financial services) rose by 0.5 percentage points to 5.3 percent in 2015. In the field of financial services, the rate was 0.7 percent in 2015, as in the previous year. The level of innovation intensity was the same in other services in 2015.

The percentage of turnover generated by new products in 2015 in the R&D-intensive industries was significantly higher, at 34.1 percent, than in knowledge-intensive services (10.4 percent), other industry (7.4 percent) or other services (4.9 percent).

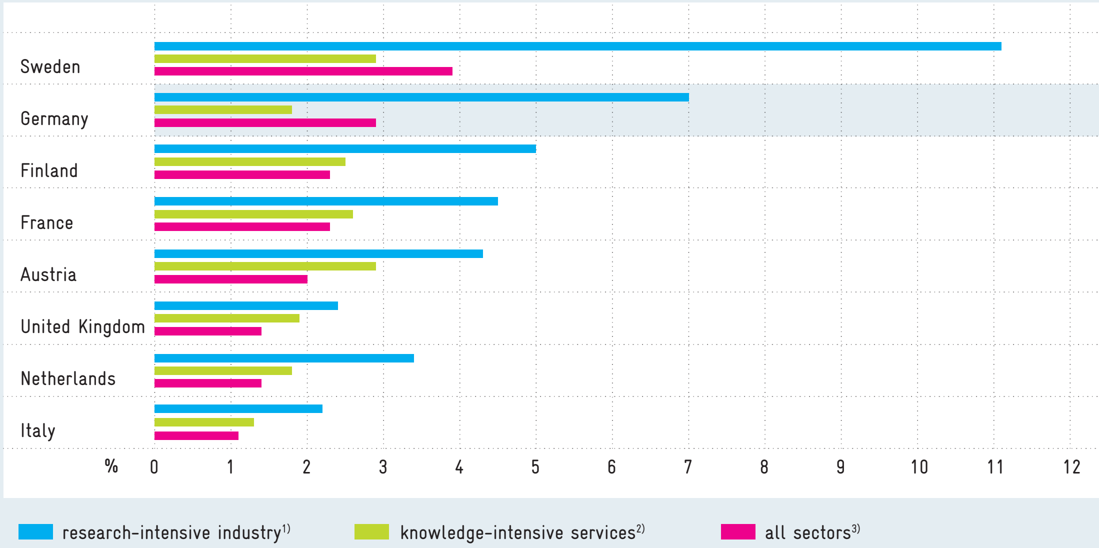
Standardisation is an important factor in the commercialisation of innovative technologies. At the international level, standards are developed by the committees of the International Organisation for Standardisation (ISO). By participating in these committees, a country can make a significant impact on global technical infrastructures (C 3-4).[453] German companies are more frequently involved in the work of the ISO than those of any other country.

Fig. C 3-1

Download data

Innovation intensity in 2014 by European comparison (as percentage)

Innovation intensity: innovation expenditure by companies as a percentage of their total turnover.



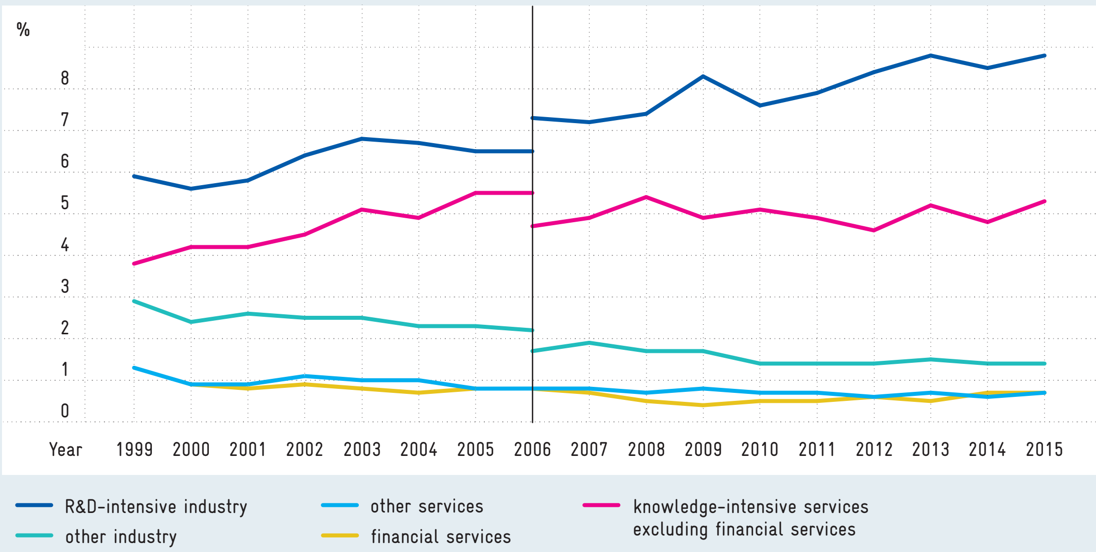
[1] Research-intensive industry: divisions 19–22, 25–30 of WZ classification. Since data are not available for all sectors in all countries, the definition of research-intensive industries used in the European comparison differs from the definition normally used by the EFI.
[2] Knowledge-intensive services: divisions 58–66, 71–73 of WZ classification. Since data are not available for all sectors in all countries, the definition of knowledge-intensive services used in the European comparison differs from the definition normally used by the EFI.
[3] All sectors: divisions 5–39, 46, 49–53, 58–66, 71–73 of WZ classification.
Source: Eurostat, Community Innovation Surveys 2014. Calculations by ZEW (Centre for European Economic Research).

Fig. C 3-2

Download data

Innovation intensity in industry and knowledge-intensive services in Germany (as percentage)

Innovation intensity: innovation expenditure by companies as a percentage of their total turnover.

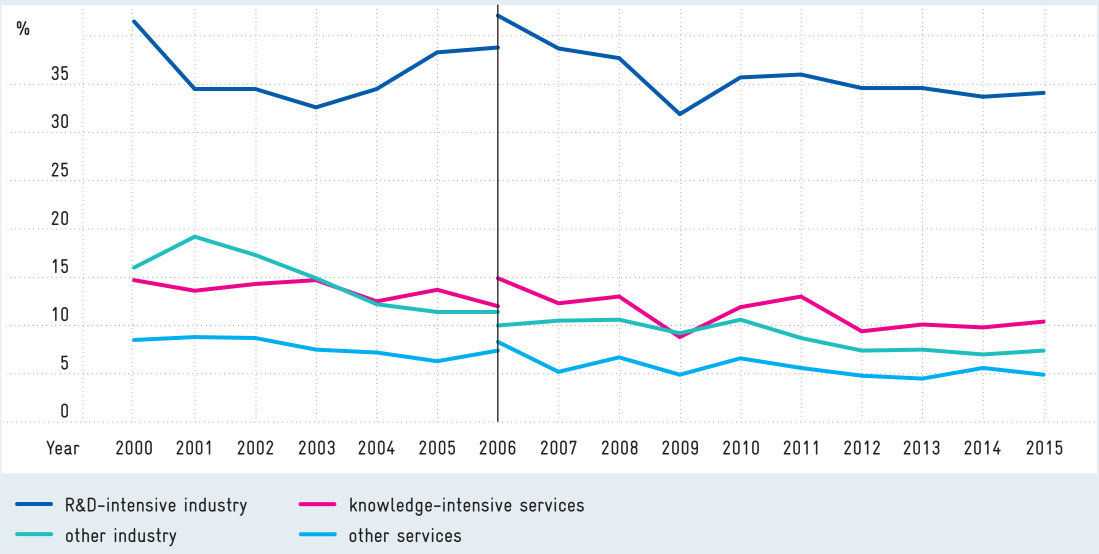


2006: break in the time series. Figures for 2015 are provisional.
Source: Mannheim Innovation Panel. Calculations by ZEW (Centre for European Economic Research).

Fig. C 3-3

Download data

Percentage of turnover generated by new products in industry and knowledge-intensive services

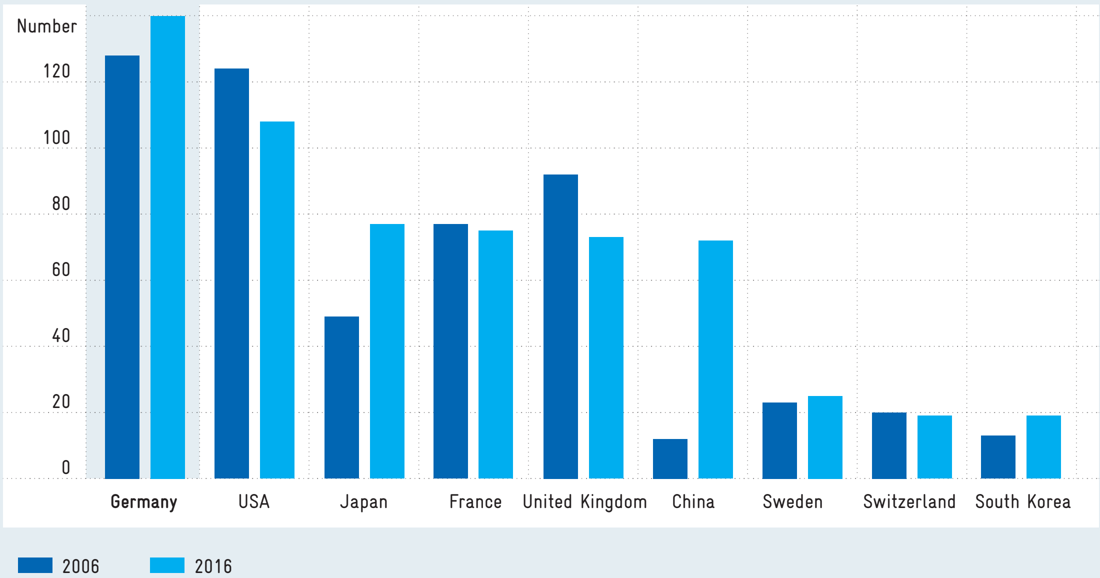


2006: break in the time series. Figures for 2015 are provisional.
Source: Mannheim Innovation Panel. Calculations by ZEW (Centre for European Economic Research).

Fig. C 3-4

Download data

Number of secretariats listed by the technical committees and subcommittees of the International Organisation for Standardisation (ISO)



Source: own diagram based on ISO (2007: 15) and
http://www.iso.org/iso/home/about/iso_members.htm (last accessed on 07 November 2016).

C

Financing research and innovation

C 4

Public financing of research and development (R&D) in the private sector makes a distinction between direct R&D funding (project funding) and indirect R&D funding (in particular tax-based R&D funding). Figure C 4-1 shows direct and indirect R&D funding as a percentage of gross domestic product in selected countries. The bulk of resources allocated to project funding goes into application-oriented research. Project funding directed at specialised programmes usually promotes specific technologies. However, when it comes to funding programmes that are not specific to individual technologies, the government does not exert any influence on the nature or contents of the technologies funded. Tax-based R&D funding represents an indirect form of R&D funding. Here, companies receive tax credits proportionately to the amount of their R&D expenditure. Although this instrument is available to businesses in most OECD countries, up to now Germany has not made use of this form of funding (cf. on this also Chapter B 7).

Financing constitutes a major challenge for many innovative companies – not only in the start-up phase, but also during the growth phase. Internal financing of investments is rarely an option, as these companies initially generate little or no turnover with which to fund investment and pay for current expenditure. Borrowing outside capital in the form of bank loans is also difficult, as it is not easy for banks to assess the companies' success prospects. Therefore, young, innovative enterprises can often only establish themselves on the market with the help of private investors who provide venture capital during the start-up and growth phases.

Figure C 4-2 provides an overview of venture-capital investment as a percentage of national GDP in selected European countries. It shows that in Germany this figure is still relatively low by European comparison. The highest venture-capital investments in 2015 were recorded in Finland and Switzerland. Sweden, which occupied the top position by international comparison in 2014, fell back to third place in 2015. In Germany, venture-capital investment as a percentage of GDP rose slightly in 2015.

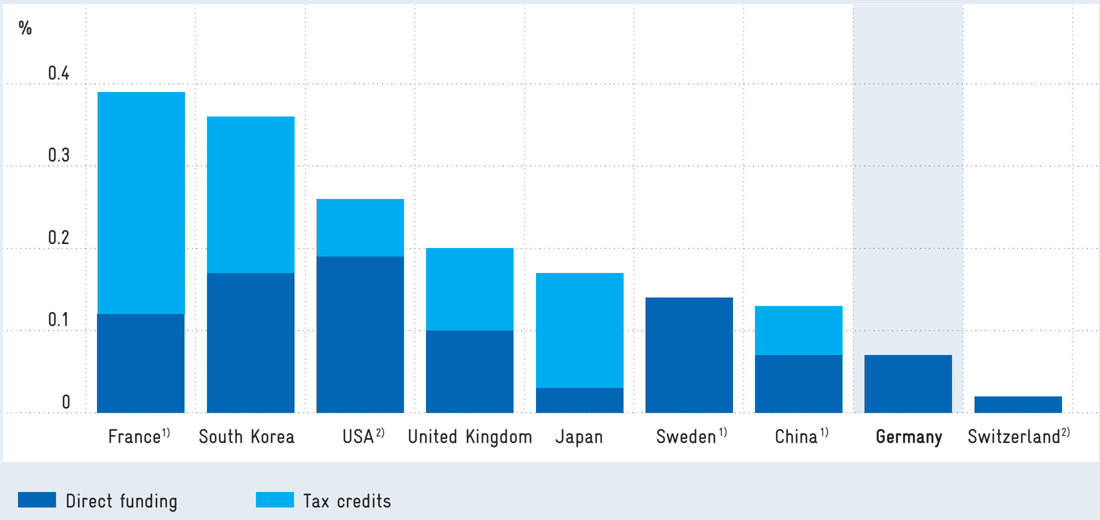
German venture-capital investment also increased in absolute terms in 2015 compared to the previous year (C 4-3). The growth is mainly due to the development in 'later stage' investment. Venture-capital investment only rose slightly in the 'early stage' field, which comprises the seed and start-up phases (C 4-3).

Fig. C 4-1

Download data

R&D spending in the business sector directly and indirectly funded by the public sector in 2014 as a percentage of national GDP

In the public funding of the private-sector R&D, a distinction is made between direct R&D funding (project funding) and indirect funding through R&D tax credits.



[1] 2013. [2] 2012.
Source: OECD (2015 and 2016d).

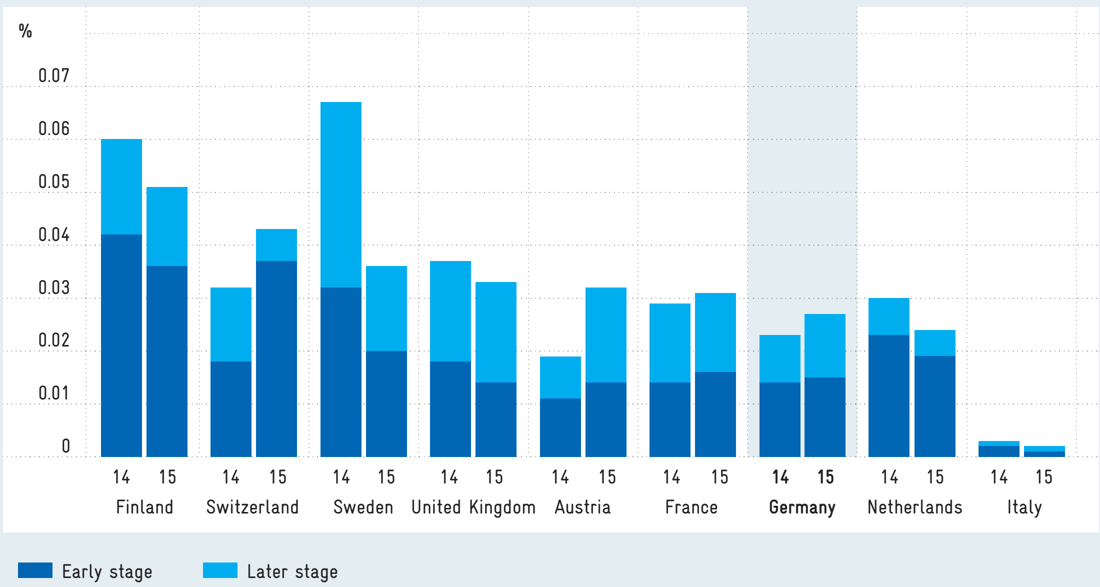
C

Fig. C 4-2

Download data

Venture-capital investment as a percentage of national gross domestic product in 2014 and 2015

Venture capital is defined here as temporary equity investments in young, innovative, non-listed companies.



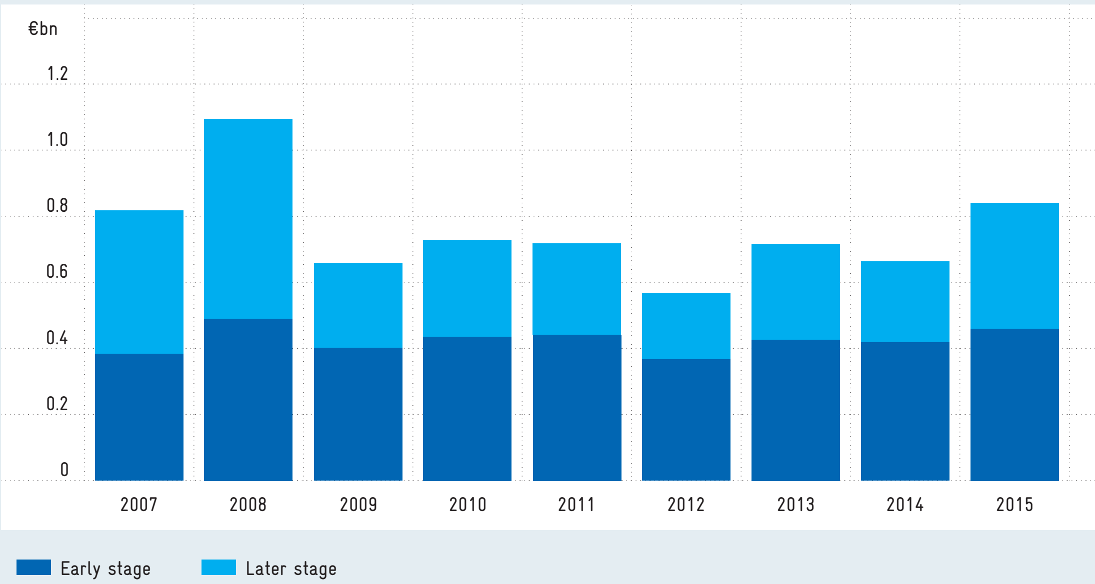
Investments according to registered office of the portfolio companies.
Early stage comprises the seed phase and the start-up phase.
Source: EVCA (2016), Eurostat. Own calculations.

Fig. C 4-3

Download data

Development of venture-capital investment in Germany, 2007 to 2015, in billions of euros

Venture capital is defined here as temporary equity investments in young, innovative, non-listed companies.



Investments according to registered office of the portfolio companies.
Early stage comprises the seed phase and the start-up phase.
Source: EVCA (2016).

C

C 5 New enterprises[454]

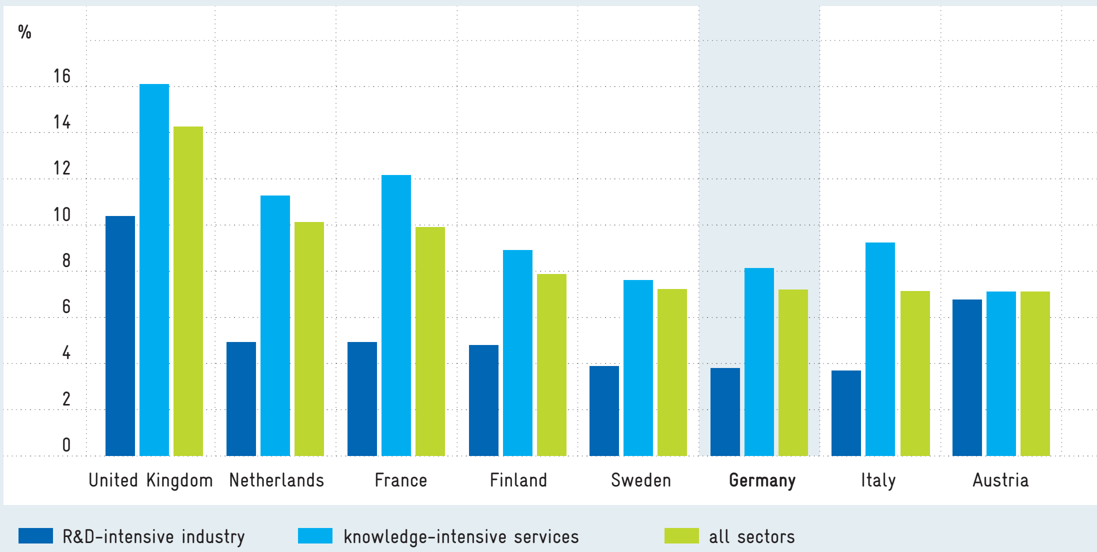
An international comparison of start-up rates – i.e. the number of start-up businesses as a percentage of the total number of companies – is only possible at the European level.[455] The Business Demography Statistics provided by Eurostat are used for this purpose (C 5-1). They constitute part of the European Union's Structural Business Statistics (SBS), an official database that is based on evaluations of the individual member countries' business registers. The figures for Germany are provided by the Federal Statistical Office's business demography statistics, which are derived from the German business register.[456] In 2014, the start-up rate in Germany was around 7.2 percent, well below the figure for the UK (14.3 percent), which had the highest rate of the countries examined here. Even in R&D-intensive industries (3.8 percent) and knowledge-intensive services (8.1 percent), Germany's start-up rates were well below those of the leader UK (10.4 percent and 16.1 percent respectively).

The figures on company dynamics in the knowledge economy shown in charts C 5-2 to C 5-4 are taken from an evaluation of the Mannheim Enterprise Panel (MUP) conducted by the Centre for European Economic Research (ZEW). The MUP is a ZEW panel dataset of businesses located in Germany. It is compiled in cooperation with Creditreform, the largest credit information bureau in Germany. The definition of 'company' used by the MUP is restricted exclusively to economically active companies; 'start-ups' are only original, newly formed companies.[457] The start-up rate shown in Figure C 5-2 is calculated on the basis of different data from those used in the Business Demography Statistics, which means that a direct comparison cannot be drawn here.[458] According to the data provided by the MUP, the start-up rate in the knowledge-based economy in 2015 was 4.7 percent, 2.8 percentage points lower than ten years earlier (C 5-2). The rate has been relatively stable since 2012.

The closure rate in the knowledge-based economy was 4.4 percent in 2015, 0.9 percent lower than in 2014 (C 5-3). In all the sectors of the knowledge economy examined, the current rate was lower than in the previous year. The comparison of the Länder reveals significant differences in start-up rates within Germany (C 5-4). Berlin had the highest start-up rates of all Länder: across all industries (7.2 percent), in R&D-intensive industries (5.6 percent), and in knowledge-intensive services (7.3 percent). Thuringia recorded the lowest start-up rates across all industries (3.4 percent), Saxony-Anhalt in R&D-intensive industries (2.5 percent), and Thuringia and Mecklenburg-West Pomerania in knowledge-intensive services (3.4 percent respectively).

Start-up rates in 2014 by international comparison (as percentage)

Start-up rate: number of start-ups in relation to the number of companies.



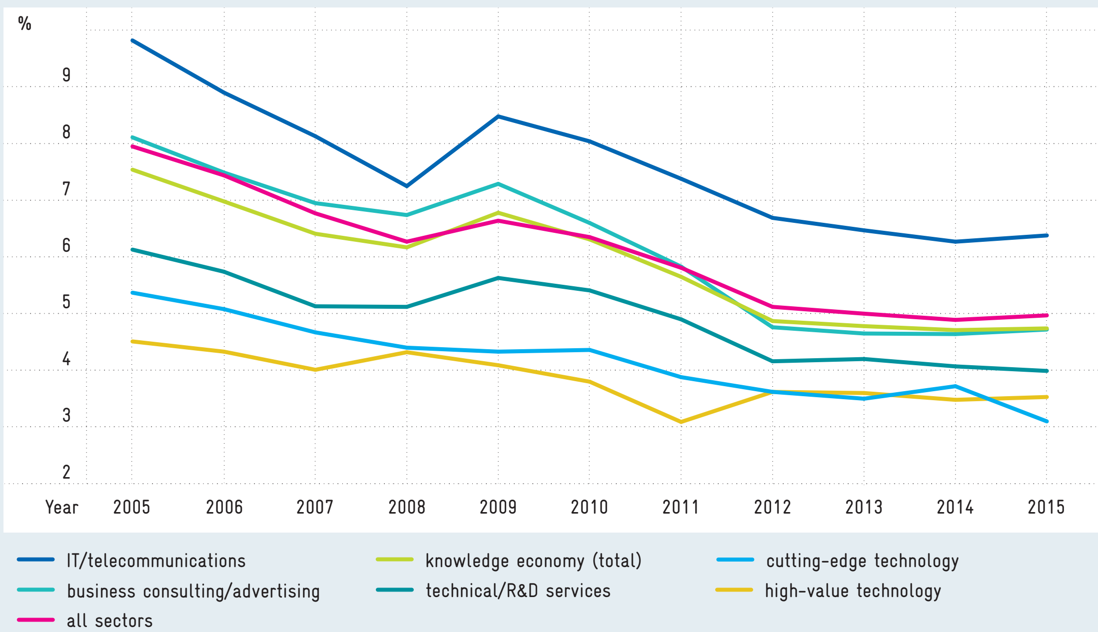
Source: Business Demography Statistics (Eurostat). Calculations by ZEW in Müller et al. (2017b).

Fig. C 5-1

Download data

Start-up rates in Germany's knowledge economy, 2005 to 2015 (as percentage)

Start-up rate: number of start-ups in relation to the number of companies.



All figures are provisional.
Source: Mannheim Enterprise Panel (ZEW). Calculations by ZEW in Müller et al. (2017b).

Fig. C 5-2

Download data

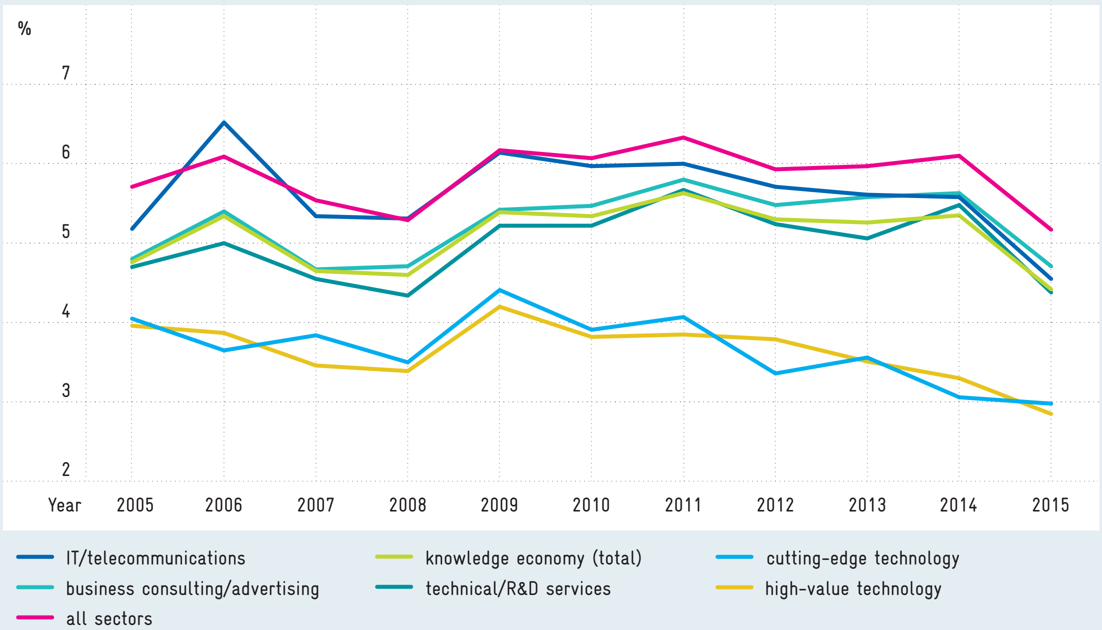
C

Fig. C 5-3

Download data

Closure rates in Germany's knowledge economy, 2005 to 2015 (as percentage)

Closure rate: number of companies that close down during the course of a year as a percentage of all companies.



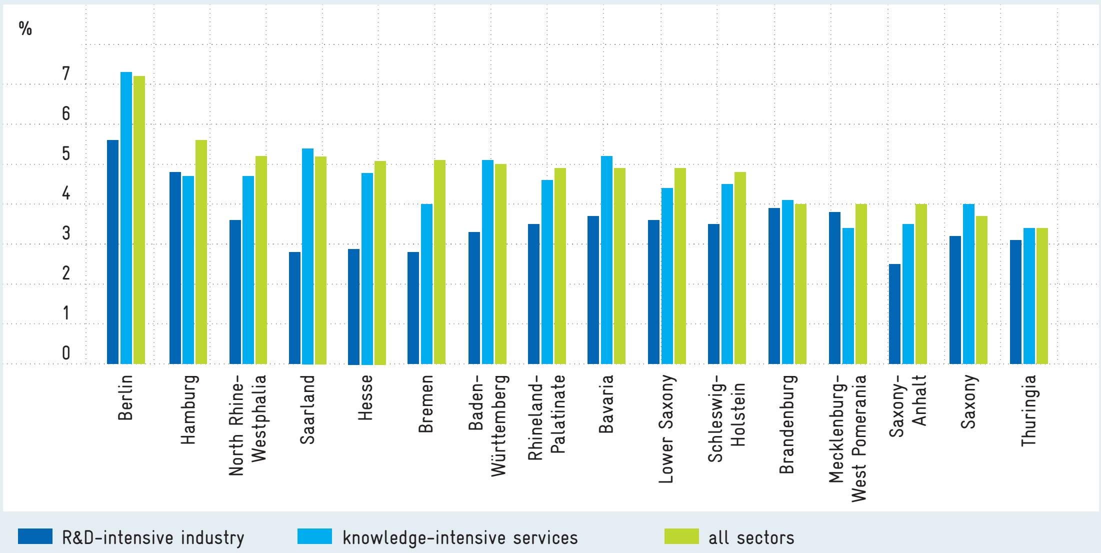
All figures are provisional.
Source: Mannheim Enterprise Panel (ZEW). Calculations by ZEW in Müller et al. (2017b).

Fig. C 5-4

Download data

Start-up rates by Länder, 2013 to 2015 (as percentage)

Start-up rate: number of start-ups in relation to the number of companies.



All figures are provisional.
Source: Mannheim Enterprise Panel (ZEW). Calculations by ZEW in Müller et al. (2017b).

Patents C 6

Since the international financial and economic crisis, transnational patent applications have been stagnating both in Germany and in other major European economies (C 6-1). By contrast, the USA, China and South Korea in particular have recorded high growth rates. China has caught up with Germany and is now one of the leading nations in transnational patent applications alongside Germany, the USA and Japan.

While the USA are in the lead in terms of the absolute number of applications in 2014, they are not among the frontrunners with regard to patent intensity (i.e. patent applications per million of the working population; C 6-2). As in the previous year, the leaders here are Switzerland, Finland and Sweden, followed by Japan, Germany and South Korea. Patents are an important instrument for securing market shares in the context of the international technology trade. A high patent intensity therefore reflects both a strong international orientation and a pronounced export focus on the part of the respective economy.

Further conclusions on a country's technological performance can be drawn from patent activities in the field of R&D-intensive technologies. This sector is made up of industries that invest more than 3 percent of their turnover in R&D (R&D intensity). R&D-intensive technology comprises the areas of high-value technology (R&D intensity between 3 and 9 percent) and cutting-edge technology (R&D intensity over 9 percent).

International comparisons show that Germany is highly specialised in high-value technology (C 6-3) as a result of its traditional strengths in the automotive, mechanical-engineering and chemical industries. Only Japan is more specialised in this field.

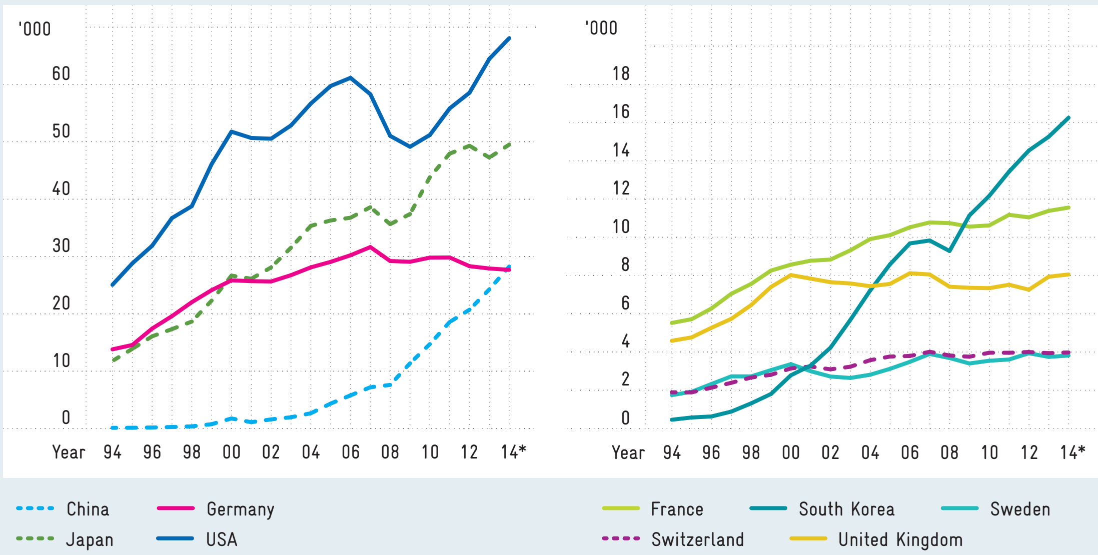
By contrast, China, South Korea and the USA are particularly specialised in cutting-edge technology (C 6-4).

Fig. C 6-1

Download data

Development of the number of transnational patent applications in selected countries over time

Transnational patent applications comprise applications of patent families with at least one application filed at the World Intellectual Property Organization (WIPO) via the Patent Cooperation Treaty (PCT) procedure, or one application filed at the European Patent Office.



* The figures for 2014 were projected on the basis of the average annual growth rate from 2009 to 2013.
Source: EPA (PATSTAT). Calculations by Fraunhofer ISI in Neuhäusler et al. (2017)

Tab. C 6-2

Download data

Absolute number, intensity and growth rates of transnational patent applications in the field of R&D-intensive technology in 2014

The R&D-intensive technology sector comprises industries that invest more than 3 percent of their turnover in research and development. Intensity is calculated as the number of patents per million of gainfully employed persons.

	absolute [1]	intensities [1]	intensities in R&D-intensive technology	growth (2004 = 100) [1]	growth in R&D-intensive technology (2004 = 100)
Total	**258,980**	**–**	**–**	**140**	**150**
Canada	3,908	220	139	117	126
China	28,242	37	27	1,059	1,413
EU-28	74,743	342	197	110	116
Finland	2,099	858	507	115	105
France	11,555	438	266	117	127
Germany	**27,673**	**694**	**394**	**98**	**102**
Italy	5,337	240	125	99	106
Japan	49,502	779	495	140	152
Netherlands	4,373	531	297	103	104
South Korea	16,254	635	425	225	244
Sweden	3,818	800	561	136	164
Switzerland	3,979	877	458	111	109
United Kingdom	8,059	263	161	108	115
USA	68,053	465	308	120	126

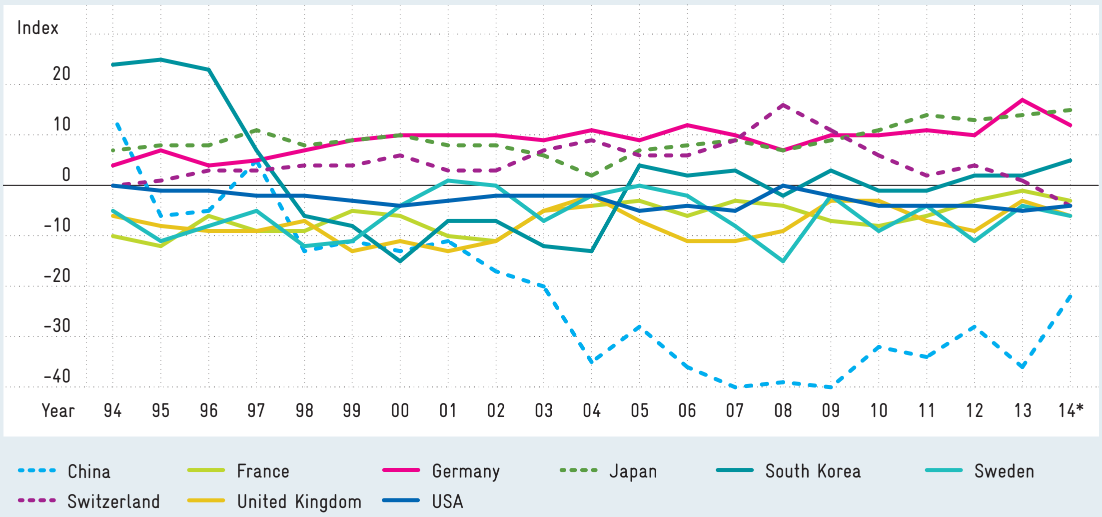
[1] Figures refer to all industries.
The figures for 2014 were projected on the basis of the average annual growth rate from 2009 to 2013.
Source: EPA (PATSTAT). OECD (MISTI). Calculations by Fraunhofer ISI in Neuhäusler et al. (2017).

Fig. C 6-3

Download data

Development of the specialisation index in selected countries over time in the field of high-value technology

The specialisation index is calculated on the basis of all transnational patent applications worldwide.
Positive or negative values indicate whether the observed country's level of activity in the respective field is higher or lower than the world average.



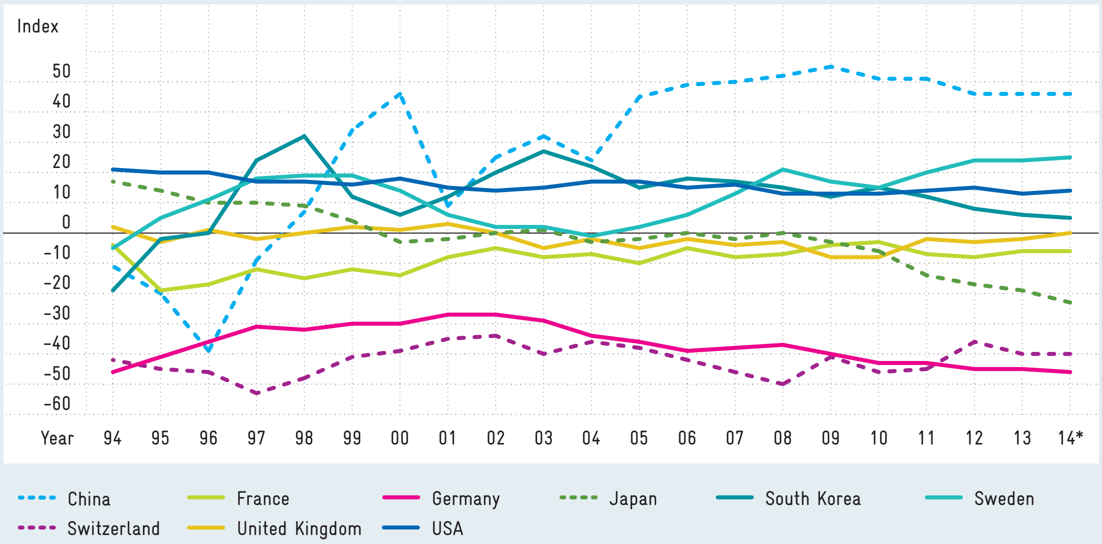
* The figures for 2014 were projected on the basis of the average annual growth rate from 2009 to 2013.
Source: Questel (EPPATENT, WOPATENT). EPA (PATSTAT). Calculations by Fraunhofer ISI in Neuhäusler et al. (2017).

Fig. C 6-4

Download data

Development of the specialisation index in selected countries over time in the field of cutting-edge technology

The specialisation index is calculated on the basis of all transnational patent applications worldwide.
Positive or negative values indicate whether the observed country's level of activity in the respective field is higher or lower than the world average.



* The figures for 2014 were projected on the basis of the average annual growth rate from 2009 to 2013.
Source: Questel (EPPATENT, WOPATENT). EPA (PATSTAT). Calculations by Fraunhofer ISI in Neuhäusler et al. (2017).

C

C 7 Scientific publications

A large proportion of new technologies and services is based on developments and results from science. The performance of a country's research and science system, as measured by scientific publications, is of particular importance for future technological developments and the resulting economic gains. Bibliometric indicators and metrics are regularly used as yardsticks for evaluating scientific achievements and can therefore help estimate the performance of a research and science system in both quantitative and qualitative terms.

The bibliometric database Web of Science (WoS) covers worldwide publications in scientific journals as well as citations of these publications. The research affiliation of scientists referenced in the database makes it possible to assign individual publications to a specific country. Fractional counting is employed in cases where several co-authors from different countries contribute to a publication. The indicators used to assess the performance of a research and science system are its share of publications worldwide in 2005 and 2015 (quantitative indicator) and qualitative indicators (obtained via citations) based on the international alignment (IA), the scientific regard (SR), and the excellence rate of publications for the years 2005 and 2013 respectively.

Looking only at the number of publications, individual countries' shares of all WoS publications changed considerably between 2005 and 2015 (C 7-1).[459] China in particular more than doubled its share of publications from 6.6 to 16.1 percent. The shares of South Korea, Brazil and India also increased during this period. By contrast, lower shares were recorded in particular by the established science systems of the USA, Western Europe, Israel and Japan. Germany's share fell from 6.0 to 4.5 percent. Despite the massive increase in publications from China, some countries in Europe still succeeded in keeping their share stable over time, or even to increase it slightly. These countries include Denmark, Poland and Spain, among others.

Looking at the qualitative indicators, the following picture emerges. In 2013, scientists above all in Switzerland, the Netherlands and the USA succeeded in placing their publications primarily in scientific journals with an international audience (IA, C 7-2). According to this quality indicator, Germany was on a comparable level with the UK, Sweden and Israel in 2013, having successfully caught up with these countries since 2005, albeit without quite reaching the top group. By contrast, since 2005 scientists from the USA seem to have lost ground in terms of both the quantity (see above) and the quality in a relative comparison. Most of the BRICS countries – with the exception of Brazil – succeeded in improving their position in the index over time; however, they are still well below the average.

The scientific regard (SR) of publications shows that in 2013 publications from Switzerland, the USA, Denmark, and also China were cited particularly frequently in scientific journals by international comparison – more frequently than publications from the UK or Germany (C 7-3). Germany has worsened slightly since 2005. Almost all the BRICS countries have improved, and this shows itself in an overall convergence over time.

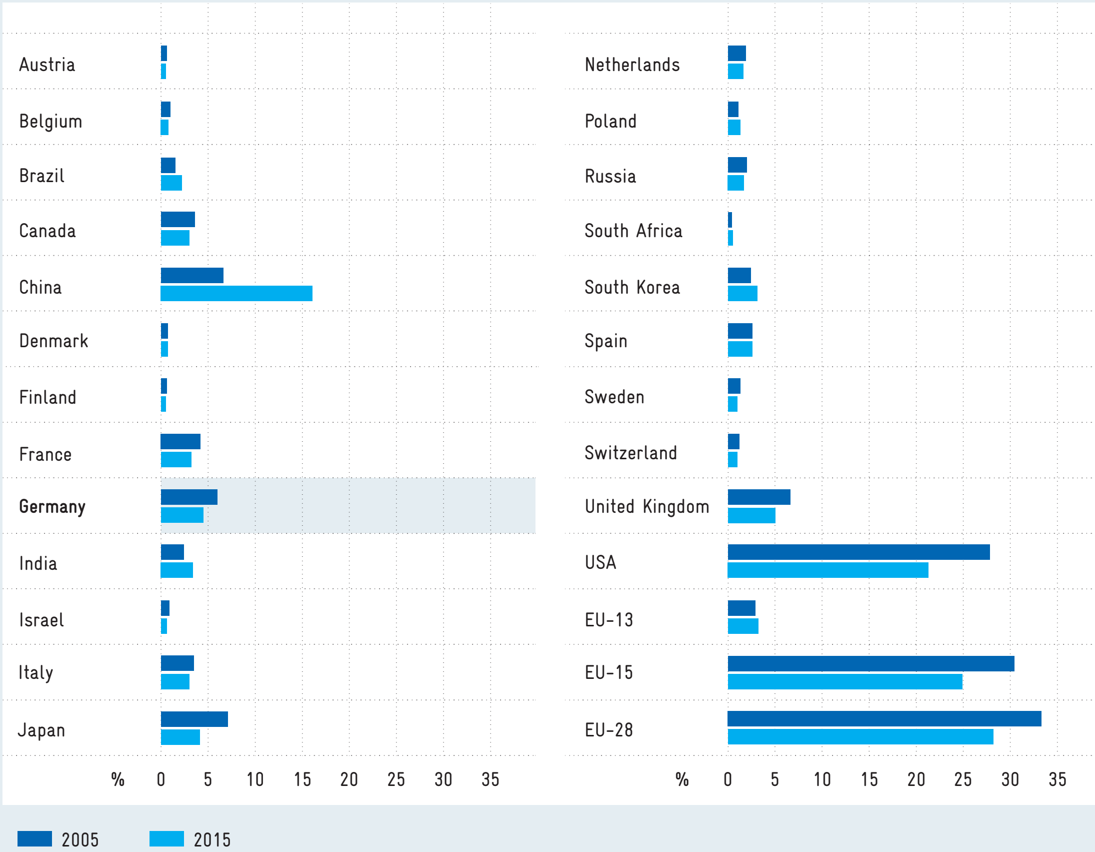
Another important quality indicator is the so-called excellence rate (no illustration) – i.e. the weighted share of a country's specialised publications among the top 10 percent of the most cited publications worldwide. This rate indicates a slight improvement in Germany's position over time.[460] One remarkable aspect is a rapid increase in the number of excellent Chinese publications. China has thus continuously increased not only the number but also the quality of its publications and has caught up with Western levels.

Fig. C 7-1

Download data

Percentages of all publications in the Web of Science from selected countries and regions, 2005 and 2015

The analysis concentrates on countries' shares, rather than on absolute figures, to compensate for changes caused mainly by the ongoing expansion of data collection.



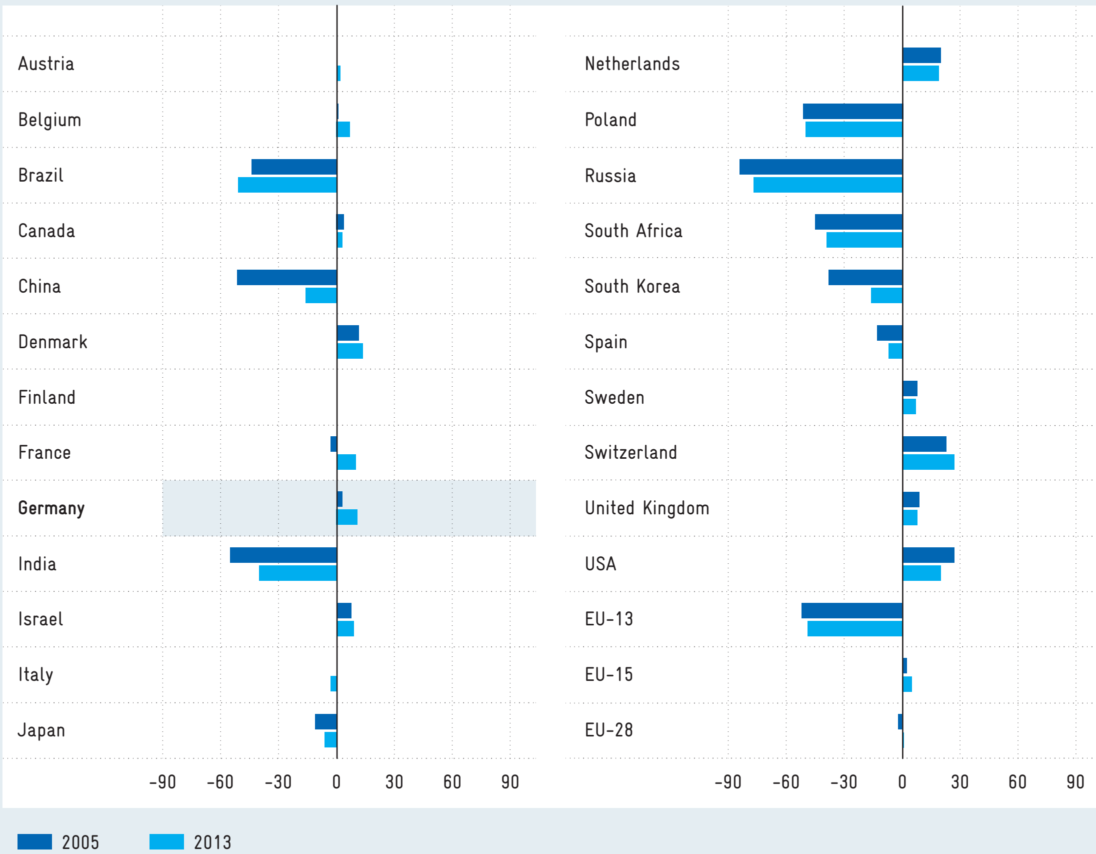
Source: Web of Science. Research and calculations by Fraunhofer ISI in Frietsch et al. (2017a). Fractional counting.

Fig. C 7-2

Download data

International alignment (IA) of publications in the Web of Science from selected countries and regions, 2005 and 2013 (index values)

The IA index indicates whether a country's authors publish in internationally more highly recognised or less highly recognised journals relative to the world average. Positive or negative values indicate an above-average or below-average IA.



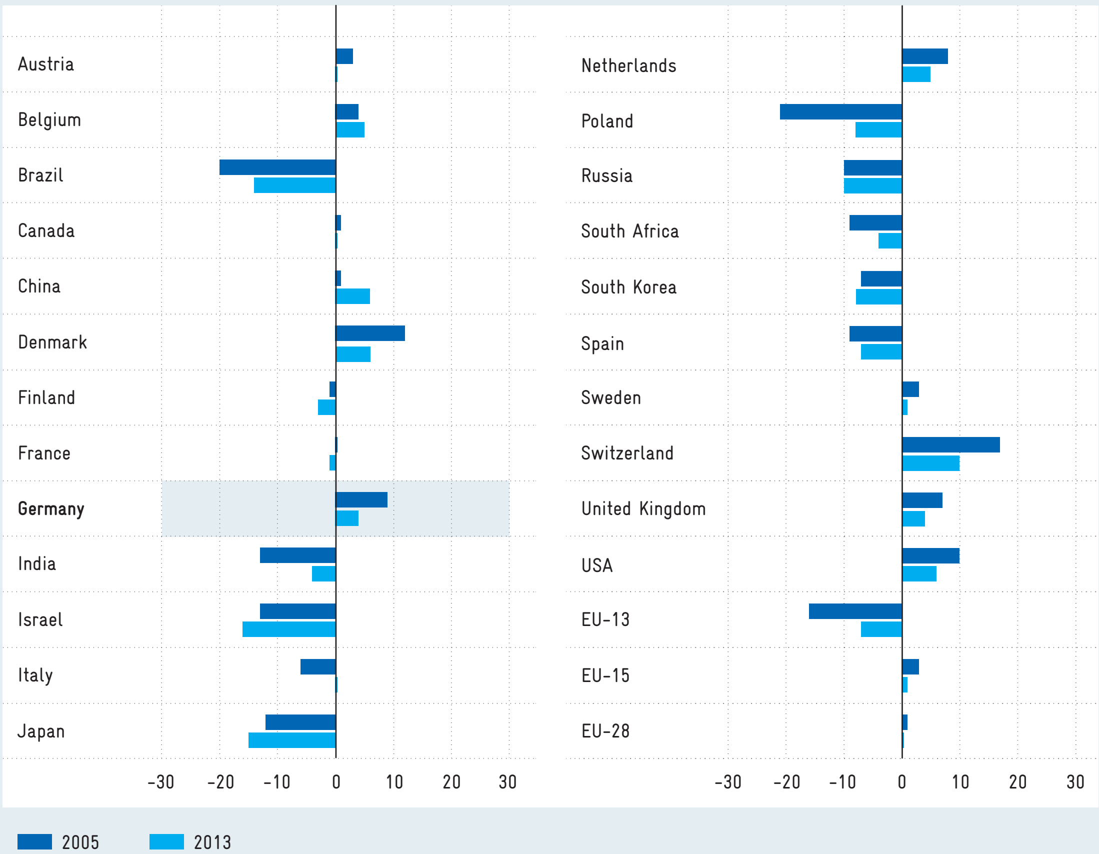
Source: Web of Science. Research and calculations by Fraunhofer ISI in Frietsch et al. (2017a). Fractional counting.

Fig. C 7-3

Download data

Scientific regard (SR) of publications in the Web of Science from selected countries and regions, 2005 and 2013 (index values)

The SR index indicates whether a country's articles are cited on average more or less frequently than other articles in the journals in which they appear. Positive or negative values indicate an above-average or below-average scientific regard. The index is calculated without self-citations.



Source: Web of Science. Research and calculations by Fraunhofer ISI in Frietsch et al. (2017a). Fractional counting.

C 8 Production, value added and employment[461]

A country's specialisation pattern in foreign trade can be measured using the RCA indicator,[462] which shows a product group's export/import ratio relative to the export/import ratio of the manufacturing sector as a whole. As in previous years, Germany again showed a comparative advantage in trade in R&D-intensive goods in 2015 (C 8-1). R&D-intensive goods are made up of high-value technology goods and cutting-edge technology goods. Germany has a positive comparative advantage only in terms of trade in high-value technology; trade in cutting-edge technology displays a negative comparative advantage. France, the UK and the USA have positive RCA indicator figures for cutting-edge technology, as have Switzerland and South Korea, which still had negative figures in 2000; Japan and China have a negative RCA indicator over the entire period. Sweden, too, has had negative figures since 2010.

The contribution of research- and knowledge-intensive industries to a country's value added allows conclusions to be drawn about the country's technological performance by international comparison (C 8-2). Of the countries studied, Germany has the highest share of value added in the field of high-value technology. In 2014, it amounted to 8.6 percent of total German value added. In the field of cutting-edge technology, Germany's figure of 2.8 percent is much lower than Switzerland's (8.1 percent) and South Korea's (7.8 percent). In all the countries examined, knowledge-intensive services contribute much more to national value added than research-intensive industries. However, with a value-added share of 25.5 percent they play a more minor role in Germany than in other European countries and the USA.

After a sharp fall in 2009, gross value added in Germany has again been rising continuously since 2010 (C 8-3). Although, at 2.7 percent, growth in knowledge-intensive services was lower in 2014 than in the previous year (2013: 3.5 percent), a marked increase in value added was again recorded in non-knowledge-intensive services (5.4 percent compared to 2.9 percent in 2013). In 2014, the increase was 5.5 percent in knowledge-intensive manufacturing (2013: 0.5 percent), and 3.7 percent in non-knowledge-intensive manufacturing (2013: 1.2 percent).

Among the different commercial sectors of the economy in Germany the services sector was the main source of the increase in employment subject to social insurance contributions between 2008 and 2015 (C 8-4). Employment rose by 12.6 percent in non-knowledge-intensive services, and by 16.3 percent in knowledge-intensive services during this period. Employment subject to social insurance contributions rose by only 1.7 percent in the non-knowledge-intensive manufacturing industry, and by 5.6 percent in the knowledge-intensive manufacturing sector.

Tab. C 8-1

Download data

Revealed comparative advantage (RCA) of selected countries in foreign trade in research-intensive goods, 2000 to 2015

A positive RCA value means that the export/import ratio for this product group is higher than it is for manufactured industrial goods as a whole.

Year	China [1]	France	Germany	Japan	South Korea	Sweden	Switzerland	United Kingdom	USA [2]
				R&D-intensive goods					
2000	-41	7	**11**	47	0	0	10	14	13
2005	-29	7	**10**	42	17	-1	18	14	17
2010	-27	6	**12**	33	19	-6	22	11	1
2015	-32	4	**13**	31	13	-5	28	3	1
				High-value technology goods					
2000	-17	5	**27**	86	5	-7	26	10	-13
2005	0	6	**27**	75	11	-2	24	4	-5
2010	-16	-2	**30**	61	7	-3	21	15	-10
2015	-8	-7	**28**	63	13	1	21	1	-14
				Cutting-edge technology goods					
2000	-66	11	**-27**	-10	-5	13	-30	19	47
2005	-53	8	**-34**	-14	24	1	4	33	55
2010	-35	20	**-35**	-22	33	-11	25	1	22
2015	-51	16	**-24**	-35	12	-22	41	8	27

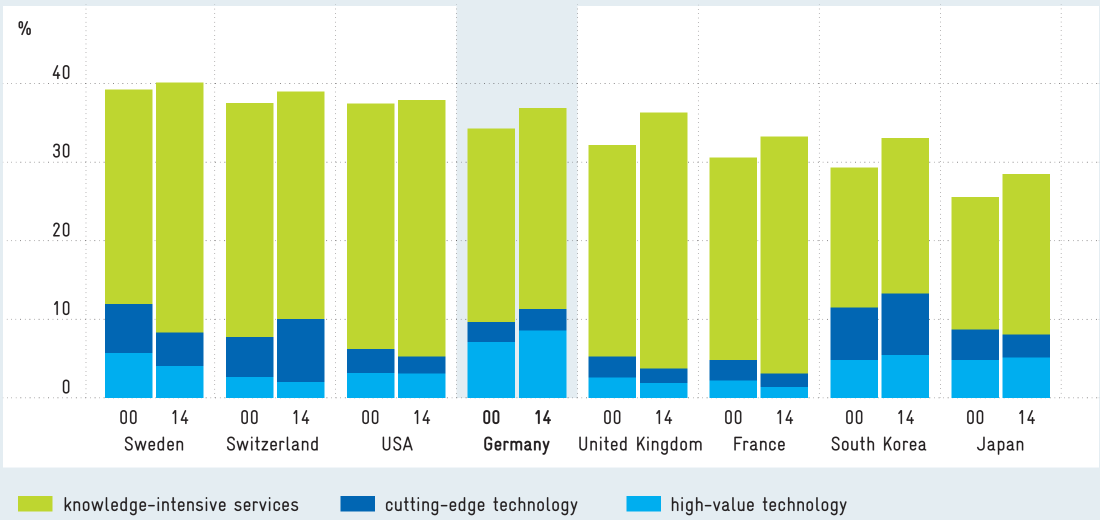
[1] Incl. Hong Kong. [2] From 2009, data for the USA were revised on the basis of national sources.
Source: UN COMTRADE Database. Calculations and estimates by CWS in Gehrke and Schiersch (2017).

Fig. C 8-2

Download data

R&D-intensive industries and knowledge-intensive services as a percentage of value added, 2000 and 2014

R&D-intensive industries have an above-average R&D intensity, while knowledge-intensive services are characterised by an above-average proportion of employees with tertiary education qualifications.



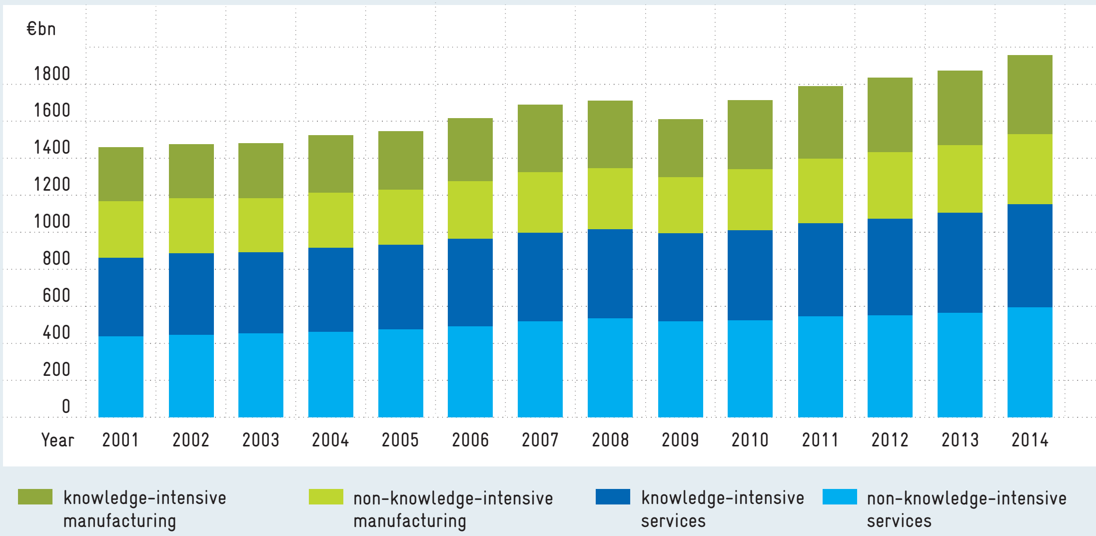
Source: OECD-STAN (2013), Eurostat (2016), EUKLEMS (2013, 2007), BEA (2016), Statistics Bureau, Ministry of Internal Affairs and Communications Japan (2013). Calculations and estimates by DIW Berlin in Gehrke and Schiersch (2017).

Fig. C 8-3

Download data

Development of gross value added in different economic sectors in Germany, 2001 to 2014, in billions of euros

Gross value added is the difference between the total value of all goods and services produced and the value of the intermediate inputs received for their production.



Not including agriculture, forestry, fisheries, public administration and services, real estate and housing, education, private households, social insurance, religious and other organisations, associations and trade unions.
Source: Statistisches Bundesamt (Federal Statistical Office), Fachserie 18, Reihe 1.4. Calculations by CWS in Gehrke and Schiersch (2017).

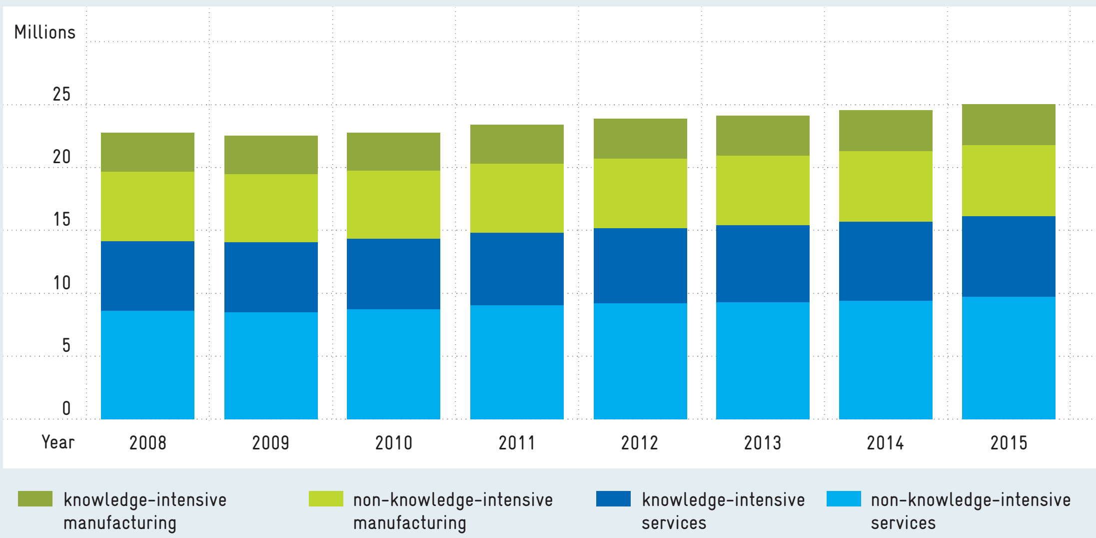
C

Fig. C 8-4

Download data

Development of the number of employees subject to social insurance contributions in different industrial sectors of the economy in Germany, 2008 to 2015

Employees subject to social insurance contributions comprise all employees who are liable to contribute to health, pension and long-term care insurance, and/or to pay contributions according to German employment-promotion law, or for whom contribution shares must be paid to statutory pension insurance or according to German employment-promotion law.



Source: Federal Employment Agency. Calculations by CWS in Gehrke and Schiersch (2017).

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D

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Infochart B 3
Innovation in established companies

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The contribution of SMEs to research and innovation in Germany: cf. Rammer et al. (2016).

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Governance

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List of abbreviations

D 3

ArbErfG	Arbeitnehmererfindungsgesetz (Employee Inventions Act)
ATL	Above the Line
BMBF	Bundesministerium für Bildung und Forschung (Federal Ministry of Education and Research)
BME	Bundesverband Materialwirtschaft, Einkauf und Logistik (German Association for Supply Chain Management, Procurement and Logistics)
BMVg	Bundesministerium der Verteidigung (Federal Ministry of Defence)
BMWi	Bundesministerium für Wirtschaft und Energie (Federal Ministry for Economic Affairs and Energy)
BRIC	Brazil, Russia, India, Chile
BRICS	Brazil, Russia, India, Chile, South Africa
BREKO	Bundesverband Breitbandkommunikation (Federal Association of Broadband Communication)
CII	Crédit d'Impot Innovation
CIS	Community Innovation Surveys/Survey
DFG	Deutsche Forschungsgemeinschaft (German Research Foundation)
EIF	European Investment Fund
ERP	European Recovery Programme
EU	European Union
FhG	Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung (Fraunhofer Society for the Advancement of Applied Research)
FONA	Forschung für Nachhaltige Entwicklung (Research for Sustainable Development)
G7	Group of seven leading industrialised nations (Germany, France, Italy, Japan, Canada, United Kingdom, United States
G8	Group of eight leading industrialised nations (G7 plus Russia)
GDP	gross domestic product
GG	Grundgesetz (Basic Law, Germany's constitution)
GO-Bio	Gründungsoffensive Biotechnologie (Start-up Offensive in Biotechnology)
GWK	Gemeinsame Wissenschaftskonferenz (Joint Science Conference)
HGF	Helmholtz-Gemeinschaft Deutscher Forschungszentren (Helmholtz Association of German Research Centres)
HTGF	High-Tech Gründerfonds (High-Tech Start-up Fund)
HTS	High-Tech Strategy
IA	International Alignment
ICT	information and communication technologies
IEKE	Internationale Expertenkommission Exzellenzinitiative (International Commission of Experts on the Excellence Initiative)
IfM	Institut für Mittelstandsforschung (Institute for Mittelstand (SME) Research)
IGF	Industrielle Gemeinschaftsforschung (Industrial Joint Research)
INVEST	Investitionszuschuss Wagniskapital (Investment Subsidy Venture Capital)
ISCED	International Standard Classification of Education
ISO	International Organisation for Standardisation

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IT	information technology
JEI	Jeune Entreprise Innovante
KOINNO	Kompetenzzentrum innovative Beschaffung (Competence Centre for Innovative Procurement)
KStG	Körperschaftsteuergesetz (Corporation Tax Act)
MIP	Mannheimer Innovationspanel (Mannheim Innovation Panel)
MNE	multinational enterprise
MOOC	massive open online course
MPG	Max-Planck-Gesellschaft zur Förderung der Wissenschaften (Max Planck Society for the Advancement of Science)
MUP	Mannheimer Unternehmenspanel (Mannheim Enterprise Panel)
OECD	Organisation for Economic Cooperation and Development
PFI	Pakt für Forschung und Innovation (Pact for Research and Innovation)
PCP	pre-commercial procurement
PISA	Programme for International Student Assessment
PPI	public procurement of innovation
R&D	research and development
R&I	research and innovation
RCA	revealed comparative advantage
RDA	Research and Development Allowance
SBIR	Small Business Innovation Research Programme
SkatteFUNN	Skattefradrag for Forskning og Utvikling i et Nyskapende Næringsliv
SMEs	small and medium-sized enterprises
SR	Scientific regard
SUS	Strukturelle Unternehmensstatistik (structural business statistics)
VIP+	Validierung des technologischen und gesellschaftlichen Innovationspotenzial wissenschaftlicher Forschung (Validation of the Technological and Societal Innovative Potential of Scientific Research)
WBSO	Wet bevordering speur- en ontwikkelingswerk
WGL	Wissenschaftsgemeinschaft Gottfried Wilhelm Leibniz (Leibniz Association)
WIPANO	Wissens- und Technologietransfer durch Patente und Normen (Knowledge and Technology Transfer using Patents and Standards)
WoS	Web of Science
WTO	World Trade Organisation
ZIM	Zentrales Innovationsprogramm Mittelstand (Central Innovation Programme for SMEs)
ZEW	Zentrum für Europäische Wirtschaftsforschung GmbH (Centre for European Economic Research)

List of figures, tables and boxes

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D

Economic sectors of R&D-intensive industries and knowledge-intensive industrial services[463]

D 5

R&D-intensive industrial sectors within the Classification of Economic Activities, 2008 edition (WZ 2008) (4-digit classes)

Cutting-edge technology

20.20 Manufacture of pesticides and other agrochemical products
21.10 Manufacture of basic pharmaceutical products
21.20 Manufacture of pharmaceutical preparations
25.40 Manufacture of weapons and ammunition
26.11 Manufacture of electronic components
26.20 Manufacture of computers and peripheral equipment
26.30 Manufacture of communication equipment
26.51 Manufacture of instruments and appliances for measuring, testing and navigation
26.60 Manufacture of irradiation, electromedical and electrotherapeutic equipment
26.70 Manufacture of optical instruments and photographic equipment
29.31 Manufacture of electrical and electronic equipment for motor vehicles
30.30 Manufacture of air and spacecraft and related machinery
30.40 Manufacture of military fighting vehicles

High-value technology

20.13 Manufacture of other inorganic basic materials and chemicals
20.14 Manufacture of other organic basic materials and chemicals
20.52 Manufacture of glues
20.53 Manufacture of essential oils
20.59 Manufacture of other chemical products n.e.c.
22.11 Manufacture of rubber tyres and tubes; retreading and rebuilding of rubber tyres
22.19 Manufacture of other rubber products
23.19 Manufacture and processing of other glass, including technical glassware
26.12 Manufacture of loaded electronic boards
26.40 Manufacture of consumer electronics
27.11 Manufacture of electric motors, generators and transformers
27.20 Manufacture of batteries and accumulators
27.40 Manufacture of electric lighting equipment
27.51 Manufacture of electric domestic appliances
27.90 Manufacture of other electrical equipment
28.11 Manufacture of engines and turbines, except aircraft, vehicle and cycle engines
28.12 Manufacture of fluid power equipment
28.13 Manufacture of other pumps and compressors
28.15 Manufacture of bearings, gears, gearing and driving elements
28.23 Manufacture of office machinery and equipment (excluding computers and peripheral equipment)
28.24 Manufacture of power-driven hand tools
28.29 Manufacture of other general-purpose machinery n.e.c.
28.30 Manufacture of agricultural and forestry machinery
28.41 Manufacture of machine tools
28.49 Manufacture of other machine tools
28.93 Manufacture of machinery for food, beverage and tobacco processing
28.94 Manufacture of machinery for textile, apparel and leather production
28.95 Manufacture of machinery for paper and paperboard production
28.99 Manufacture of other special-purpose machinery n.e.c.
29.10 Manufacture of motor vehicles
29.32 Manufacture of other parts and accessories for motor vehicles
30.20 Manufacture of railway locomotives and rolling stock
32.50 Manufacture of medical and dental instruments and supplies

Knowledge-intensive industrial services WZ 2008 (3-digit classes)

Knowledge-intensive services

Emphasis on finance and assets

411 Development of building projects
641 Monetary intermediation
642 Activities of holding companies
643 Trusts, funds and similar financial entities
649 Other financial service activities, except insurance and pension funding
651 Insurance
652 Reinsurance
653 Pension funding
661 Activities auxiliary to financial services, except insurance and pension funding
663 Fund management activities
681 Buying and selling of own real estate
683 Real estate activities on a fee or contract basis
774 Leasing of intellectual property and similar products, except copyrighted works

Emphasis on communication

611 Leitungsgebundene Telekommunikation
612 Drahtlose Telekommunikation
613 Satellitentelekommunikation
619 Sonstige Telekommunikation
620 Erbringung von Dienstleistungen der Informationstechnologie
631 Datenverarbeitung, Hosting und damit verbundene Tätigkeiten; Webportale
639 Erbringung von sonstigen Informationsdienstleistungen
Schwerpunkt technische Beratung und Forschung
711 Architectural and engineering activities and related technical consultancy
712 Technical testing and analysis
721 Research and experimental development on natural sciences and engineering
749 Other professional, scientific and technical activities n.e.c.

Emphasis on non-technical consulting and research

691 Legal activities
692 Accounting, bookkeeping and auditing activities; tax consultancy
701 Activities of head offices
702 Management consultancy activities
722 Research and experimental development on social sciences and humanities
731 Advertising
732 Market research and public opinion polling
821 Office administrative and support activities

Emphasis on media and culture

581 Publishing of books and periodicals; other publishing activities
582 Software publishing
591 Motion picture, video and television programme activities
592 Sound recording and music publishing activities
601 Radio broadcasting
602 Television programming and broadcasting activities
741 Specialised design activities
743 Translation and interpreting activities
823 Organisation of conventions and trade shows
900 Creative, arts and entertainment activities
910 Libraries, archives, museums and other cultural activities

Emphasis on health

750 Veterinary activities
861 Hospital activities
862 Medical and dental practice activities
869 Other human health activities n.e.c.

Glossary

D 6

Accelerator
In the field of business start-ups, the term accelerator refers to a funding programme that is limited in time and gives young start-ups access to the infrastructure they need to build up their own company. Essential elements of the accelerator infrastructure include access to financial resources, a customer network and advisory services in the sense of mentoring (usually provided by successful entrepreneurs).

Anchor investor
An anchor investor is an investor that acquires a large or the largest share in listed companies, start-ups or venture capital funds. In this way, the financing of the company is visibly secured, making it easier to attract the remaining funds required, since the confidence of interested investors is strengthened.

Basic funds
Basic funds are the budgetary funds of tertiary education institutions

Big data
The term big data covers technological developments in the field of data storage and processing that make it possible to integrate ever greater amounts of data in different formats and to process them more and more quickly. Big data offers an opportunity to keep control of the exponentially rising data volumes caused by the growing ubiquity of ICT, and above all, to use them to create value.

Business angels
Business angels are wealthy private individuals who provide capital and entrepreneurial know-how to innovative start-up entrepreneurs or to young, innovative companies. They invest some of their private assets directly in a company, without the aid of an intermediary, receiving company shares in return.

Cloud computing
The Federal Office for Information Security defines cloud computing (CC) as offering, using and invoicing IT services via the internet in a way that is dynamically adapted to requirements. These services are offered and used exclusively via defined interfaces and protocols. The range of services offered within the framework of cloud computing embraces the entire spectrum of information technology, including, among other things, infrastructure (e.g. computing power, memory), platforms and software.

Clusters
Economic clusters are agglomerations and cooperation networks of economic and scientific actors in R&D and production that are usually located in the geographical vicinity and work in related fields.

Clusters of Excellence
The Clusters of Excellence are one of the funding lines of the Excellence Initiative (cf. ibid). They serve to establish internationally visible and competitive research and training institutions at German university locations and to make scientifically necessary networking and cooperation possible. The aim is to both hone the profiles of the universities and create excellent research and career conditions for young scientists.

Community Innovation Surveys
The Community Innovation Surveys (CIS) is the European Union's most important statistical instrument for surveying innovation activities in Europe. The CIS analyse the economic effects of innovation on the basis of a survey of a representative sample of companies.

Curricular standard value (CNW)
The curricular standard value (Curricularnormwert, CNW) refers to the course-specific teaching workload (hours per week during the semester) required for the education of a student within the standard period of study. The CNW is specified in the capacity regulations (KapVO) of the Länder.

Cutting-edge technology
Cutting-edge technology goods refer to R&D-intensive goods (cf. ibid) in the production of which an average of more than 9 percent of turnover is spent annually on R&D.

Debt financing

is provided to companies by capital investors for a set period. In return, they expect the capital to be repaid with interest. In order to ensure the servicing of the loan, bankers require adequate planning of reliable future operating results and/or the provision of collateral.

Disruptive technologies

Disruptive technologies are defined as technical innovations that displace existing technologies, products or services. They are often characteristic of new markets. Disruptive technologies usually emerge unexpectedly for incumbent firms. Furthermore, the disruptive effect is often underestimated due to the initially small size of the relevant market segment. It only reveals itself over time, as the new technology starts displacing existing markets, products or services with strong growth.

Dual education system

The term ‘dual education system’ refers to professional training conducted in parallel at both the workplace and a vocational school. The workplace training is conducted according to a clearly defined training scheme for the respective profession, and the scholastic training is conducted according to the specifications of the respective education authority.

Early stage

‘Early stage’ describes the financing of a company’s early-phase development – beginning with the funding of research and the product design (seed phase), and continuing with the formation of the company until the beginning of operating business activities, and including product development and initial marketing (start-up phase). The seed phase is limited to R&D up to market maturity and the initial implementation of a business idea with a prototype; during the start-up phase a business plan is drafted, and production and product marketing begin.

E-government

E-government (electronic government) stands for using information and communication technologies via electronic media to run governmental and administrative processes. In e-government, public services and administrative matters are digitised and made available online.

EU-13 countries

The countries that joined the EU between 2004 and 2007 (Bulgaria, Czech Republic, Cyprus, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia and Slovenia) plus Croatia, which joined in 2013.

EU-15 countries

Countries that were already EU member states in April 2004 (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, and Sweden and the UK).

EU-28 countries

Since July 2013, the EU has comprised 28 member countries (Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden and the UK).

Excellence Initiative

The Excellence Initiative is an agreement between the Federal and Länder governments to promote science and research at German tertiary education institutions, with a view to enhancing international competitiveness. It is implemented by the German Research Foundation (Deutsche Forschungsgemeinschaft, DFG) and the German Council of Science and Humanities (Wissenschaftsrat, WR). Support is granted on the basis of three funding lines: graduate schools (cf. ibid), Clusters of Excellence (cf. ibid) and institutional strategies (cf. ibid). The current Excellence Initiative expires in 2017. The Excellence Strategy will be the follow-up programme (cf. ibid).

Excellence Strategy

The Excellence Strategy is the follow-up programme (with no time limit) for the Excellence Initiative, which expires in 2017 (cf. ibid). It comprises two funding lines. The Cluster of Excellence funding line is designed to support project-based funding in internationally competitive research fields at universities or university consortia. The Universities of Excellence funding line aims to strengthen universities or university consortia as institutions in the long term, and to further develop their leading international role in research on the basis of successful Clusters of Excellence.

Externalities

Externalities are defined as impacts of economic activities on third parties for which no compensation is paid. One example is knowledge externalities (cf. ibid).

Frascati Manual
The OECD's Frascati Manual specifies methods for collecting and analysing data on research and development. In 1963, OECD experts met for the first time with members of the NESTI group (National Experts on Science and Technology Indicators) in Frascati (Italy) in order to define key concepts such as 'research' and 'development'. The results of these discussions formed the basis of the first Frascati Manual. The Frascati Manual has been revised several times since then. The most recent edition dates from 2015.

Full digitisation
In the context of e-government, full digitisation means that applications and similar documents can be filled in and submitted by citizens, and examined and legitimised by the official authorities, without any change in the information-carrying medium, so that nothing needs to be printed out or filled in by hand.

Governance
Governance refers to the control and regulation system – in the sense of structures (organisation and workflows) – of a political-societal unit such as the state, an administration, municipality, private or public organisation. The term is often also used in the sense of the control or regulation of any organisation (such as a society or company).

Graduate school
The graduate schools are one of the funding lines of the Excellence Initiative (cf. ibid). They are designed to promote young scientists and create optimal research conditions for doctoral work within a broad, cross-disciplinary academic field, while simultaneously contributing to the development of a university's academic profile. Graduate schools offer far more possibilities than research training groups (cf. ibid).

Higher Education Pact
The Higher Education Pact is an agreement between the Federal and Länder governments that was launched in 2007 and is designed to continue until 2020. It aims on the one hand to secure sufficient study opportunities to meet demand, and, on the other, to intensify competition for research funding by financing the DFG programme allowance.

High-Tech Strategy (HTS)
The High-Tech Strategy is a policy initiative by the Federal Government to integrate innovation funding across all federal ministries. The current New High-Tech Strategy was adopted by the Federal Cabinet in September 2014.

High-value technology
High-value technology refers to R&D-intensive goods (cf. ibid) in the production of which, on an annual average, more than 3 percent, but not more than 9 percent, of turnover is spent on research and development.

Incremental funding (tax-based R&D funding)
In incremental, tax-based R&D funding, only R&D expenditure above a certain reference value is tax-deductible. The reference value is determined by means of a comparison with the company's R&D expenditure in a reference period (usually before the respective reference year).

Industry 4.0
In industrial production, machines, plants and products are connected to form an IT network of embedded systems to increase flexibility and efficiency. The term Industry 4.0, which was coined in Germany within the framework of the 2011 Hannover Messe (Hanover Trade Fair), thus focuses on the use of the 'Internet of Things' (cf. ibid) in an industrial context.

Innovation intensity
Innovation intensity is defined as spending on innovation as a percentage of turnover.

Input additionality
This term is used in the context of tax-based R&D funding. Input additionality describes the change in the level of entrepreneurial R&D expenditure as a reaction to the introduction (or to a change in the rate) of tax-based R&D funding.

Institutional strategies
Funding line of the Excellence Initiative (cf. ibid). Institutional strategies aim to strengthen universities as entire institutions and to establish them in the top group of international competition. The institutional strategies of each supported universities contain holistic strategies for funding top-level research at the university as a whole.

The Internet of Things
The use of information and communications technologies in everyday objects has created a connection between the real world and the virtual world. This networking of devices and people is called

the 'Internet of Things' (IoT) or 'Internet of Things and Services'. Examples include computer systems embedded into clothing which monitor the wearer's vital functions, imprinted chip codes which make it possible to track packages via the internet, and refrigerators which autonomously order foodstuffs when stocks are low.

Knowledge economy
The knowledge economy encompasses R&D-intensive industries and knowledge-intensive services (cf. ibid).

Knowledge externalities
In research and innovation, externalities occur in the form of knowledge spillover. Competing companies can gain knowledge by inspecting innovative products and processes, without having to bear the full cost of knowledge production themselves. Conversely, this means that innovating companies are unable to privatise the full social or societal returns on their product or process developments. The private returns on the innovation deviate from the social returns, so that, from a societal point of view, the innovating company will invest too little in the production of knowledge as a result.

Knowledge-intensive services
Knowledge-intensive services are primarily characterised by a workforce with an above-average percentage of employees who have tertiary education qualifications.

Later stage
'Later stage' describes the financing of business expansion in a young company which is already generating turnover and whose product is ready for the market.

Manufacturing industries
Manufacturing industries are by far the largest part of industry comprising all industrial sectors with the exception of the energy and construction industries. Defining sectors include the food industry, mechanical engineering, the manufacture of motor vehicles and motor-vehicle parts, the manufacture of metal products and the chemical industry.

Market failure
Market failure is a situation in which the result of market coordination deviates from the macroeconomically optimal allocation of goods or resources. The reasons for market failure might be the presence of externalities, public goods or information asymmetries.

Misallocation
A misallocation in the economic sense of the word is a suboptimal allocation and use of scarce resources (such as labour, capital, land or raw materials) in the production of goods.

One-stop shop
In public administration and business, a one-stop shop means the ability to carry out all the administrative steps needed to achieve a specific aim bundled in a one place.

Open government data
The term 'open government data' refers to data stocks that are made available to third parties for further use and distribution. Whether the data provided can be described as open depends on various factors, such as accessibility, formats, and the legal conditions governing how the data may be used. Data that are subject to data-protection regulations or are sensitive for security reasons are excluded from public use from the outset.

Open source
Open source or open-source code refers to software that anyone may study, use, change or copy at will.

Oslo Manual
The OECD's Oslo Manual contains specifications on the statistical gathering of information on innovation activities. This manual goes beyond the R&D definition used by the Frascati Manual (cf. ibid) and distinguishes between different forms of innovation. The Oslo Manual serves as the basis for the Community Innovation Surveys (CIS), which have been conducted four times in Europe to date. The most recent revision of the Oslo Manual dates from 2005.

PCT application
The international patent application process was simplified in 1970 with the adoption of the Patent Cooperation Treaty (PCT) under the umbrella of the World Intellectual Property Organization (WIPO, established in 1969). Instead of filing several separate national or regional applications, inventors from PCT countries can submit a single advance patent application to the WIPO, or another registered authority. This enables them to obtain patent protection in all 148 contracting countries. The priority date of the patent is the date on which the application is submitted to

the WIPO. The final decision on the countries where patent protection is to be granted must be taken within a period of 30 months (or 31 months at some authorities like the EPA). National or regional patent offices are nevertheless still responsible for the actual granting of patents.

Programme allowance
Programme allowances represent the second pillar of the Higher Education Pact 2020 (cf. ibid). Prior to the introduction of the Pact, it was the responsibility of the tertiary education institutions to meet the overhead costs for the implementation of a project. Now, applicants for projects funded by the German Research Foundation (DFG) receive a programme allowance to cover the indirect additional and variable costs connected with the funding. This amounts to 22 percent of the accountable direct project costs.

Quality Pact for Teaching
In June 2010, the Federal Government and the Länder launched the Programme for Better Study Conditions and Improved Teaching Quality, which will run until 2020. The Higher Education Pact (cf. ibid) thus received a third pillar. This funding line is not designed to improve the supervision of students and the quality of teaching across the broad university landscape. Rather, the programme aims to improve university staffing for teaching, supervision and advice and to provide further training for existing personnel.

R&D-intensive goods
R&D-intensive goods comprise cutting-edge technology goods (cf. ibid) and high-value technology goods (cf. ibid).

R&D intensity
R&D intensity is defined as expenditure on research and development (R&D) as a percentage of either a company's or a sector's total turnover, or of a country's gross domestic product.

Research and development (R&D)
The OECD's Frascati Manual (cf. ibid) defines research and development as systematic, creative work aimed at expanding knowledge – also with the objective of developing new applications.

Research and innovation (R&I)
Research and development (R&D) and R&I are not used synonymously. According to the OECD's Frascati Manual (cf. ibid), the term R&D comprises the three areas of basic research, applied research, and experimental development. Thus, R&D refers to only one aspect of R&I activities. According to the definition given in the OECD's Oslo Manual (cf. ibid), innovations include the introduction of new or essentially improved products (goods and services), processes, and marketing and organisational methods. Innovation expenditure comprises spending on internal and external R&D, innovation-related machines and materials, product design, the market launch of new products, and other innovation-related goods and services.

Research training groups (Graduiertenkollegs)
Research training groups support PhD students within the framework of a thematically focused research programme and a structured training concept. Graduate schools (cf. ibid) also provide structured doctoral training programmes.

Seed phase
Cf. Early stage.

Social innovations
Changes in the way technologies are used, as well as changes in lifestyles, business and financing models, working practices and forms of organisation are called social innovations, and fundamentally represent changes in social practices. Social innovations can be both complementary to and a consequence of a technological innovation – or be completely independent of such an innovation.

Spillover effects
Spillover effects occur in research and innovation in the form of knowledge transfer, e.g. when a company generates economic benefits from the R&D activities of another company.

Start-up phase
Cf. Early stage.

Tenure track
A tenure track is a term that describes scientific careers which offer young scientists a permanent (tenured) professorship after a successful evaluation.

Third-party funds/funding
Third-party funding is funding for universities or other research institutions raised from public or private sources in addition to the regular budget (basic or institutional funding).

Transnational patents

Transnational patent applications are applications in the form of patent families that include at least one application filed with the World Intellectual Property Organization (WIPO) via the Patent Cooperation Treaty (PCT) procedure, or one application filed with the European Patent Office. Such patents are particularly important for the export-based German economy, as they secure the protection of inventions beyond the domestic market.

Value added

Value added is the total of all factor income (wages, salaries, interest, rents, lease income, sales profits) generated in a given period that is included in the national accounts. The term is equivalent to national income (national product). In a business sense, value added refers to the production value generated in a given period minus the value of the intermediate inputs received from other companies in the same period.

Venture capital

Venture or risk capital refers to initial capital for start-up entrepreneurs and young enterprises. It also includes funding used to strengthen the equity-capital bases of small and medium-sized enterprises. This enables such companies to roll out activities and to implement innovative, sometimes very risky projects. Venture-capital investments are also associated with a high risk for the capital investors. This is why venture capital is also referred to as risk capital. Venture capital is often provided by special venture-capital companies (capital-investment companies). Venture-capital investment can be divided into the seed phase, the start-up phase, and the later stage (cf. ibid).

Volume-based funding (tax-based R&D funding)

In a volume-based R&D tax-credit scheme, all R&D expenditure is included in the calculation of the amount of funding.

W-professorships, W-remuneration

W-remuneration replaced C-remuneration in 2005. Under the W-remuneration system, professors receive a basic salary irrespective of their age plus variable performance-related payments.

Recent studies on the German innovation system

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The Commission of Experts for Research and Innovation (EFI) regularly commissions studies on topics that are relevant to innovation policy. These studies can be accessed via the EFI website (www.e-fi.de) in the series 'Studien zum deutschen Innovationssystem' ('Studies on the German innovation system'). The findings are integrated into the Report of the Commission of Experts.

1-2017
Gehrke, B.; John, K.; Kerst, C.; Wieck, M (2017): Bildung und Qualifikation als Grundlage der technologischen Leistungsfähigkeit Deutschlands 2017, Studien zum deutschen Innovationssystem, Berlin: EFI.

2-2017
Schasse, U. (2017): Forschung und Entwicklung in Staat und Wirtschaft – Kurzstudie 2017, Studien zum deutschen Innovationssystem, Berlin: EFI.

3-2017
Müller, B.; Bersch, J.; Gottschalk, S. (2017): Unternehmensdynamik in der Wissenswirtschaft in Deutschland 2015, Gründungen und Schließungen von Unternehmen, Gründungsdynamik in den Bundesländern, Internationaler Vergleich, Studien zum deutschen Innovationssystem, Berlin: EFI.

4-2017
Neuhäusler, P.; Rothengatter, O.; Frietsch, R. (2017): Patent Applications – Structures, Trends and Recent Developments 2016, Studien zum deutschen Innovationssystem, Berlin: EFI.

5-2017
Frietsch, R.; Helmich, P.; Neuhäusler, P. (2017): Performance and Structures of the German Science System 2016, Studien zum deutschen Innovationssystem, Berlin: EFI.

6-2017
Gehrke, B.; Schiersch, A. (2017): Die deutsche Wissenswirtschaft im internationalen Vergleich, Studien zum deutschen Innovationssystem, Berlin: EFI.

7-2017
Frietsch, R.; Schubert, T.; Neuhäusler, P. (2017): Secular Trends in Innovation and Technological Change, Studien zum deutschen Innovationssystem, Berlin: EFI.

8-2017
Gehrke, B.; Schasse, U.; Leidmann, M. (2017): Folgen des wirtschaftlichen Strukturwandels für die langfristige Entwicklung der FuE-Intensität im internationalen Vergleich, Studien zum deutschen Innovationssystem, Berlin: EFI.

9-2017
Rammer, C.; Schmitz, F. (2017): Fortentwicklung der EFI-Indikatorik: Förderlandschaft, Studien zum deutschen Innovationssystem, Berlin: EFI.

10-2017
Dehio, J.; Rothgang, M. (2017): Indikatorikstudien – Fortentwicklung und optionale Untersuchungen: Hochschulbildung und -finanzierung, Studien zum deutschen Innovationssystem, Berlin: EFI.

11-2017
Frietsch, R.; Schubert, T.; Rothengatter, O. (2017): An Analysis of the Excellence Initiative and its Effects on the Funded Universities, Studien zum deutschen Innovationssystem, Berlin: EFI.

12-2017
Belitz, H. (2017): Internationalisierung privater Forschung und Entwicklung im Ländervergleich, Studien zum deutschen Innovationssystem, Berlin: EFI.

13-2017
Neuhäusler, P.; Frietsch, R. (2017): Global Innovations – Evidence from Patent Data, Studien zum deutschen Innovationssystem, Berlin: EFI.

14-2017
Fichtl, A.; Piopiunik, M. (2017): Absolventen von Fachhochschulen und Universitäten im Vergleich: FuE-Tätigkeiten, Arbeitsmarktergebnisse, Kompetenzen und Mobilität, Studien zum deutschen Innovationssystem, Berlin: EFI.

15-2017
Spengel, C.; Rammer, C.; Nicolay, K.; Pfeiffer, O.; Werner, A.-C.; Olbert, M.; Blandinieres, F.; Hud, M.; Peters, B. (2017): Steuerliche FuE-Förderung, Studien zum deutschen Innovationssystem, Berlin: EFI.

D 8 Endnotes

A 0

1 http://www.bundespraesident.de/SharedDocs/Reden/DE/Roman-Herzog/Reden/1997/04/19970426_Rede.html (last accessed on 16 January 2017).

A 2

2 Cf. Wissenschaftsrat (2016).

A 3

3 http://www.europarl.europa.eu/summits/lis1_de.htm#I (last accessed on 16 January 2017).
4 In this regard and in the following, cf. http://cordis.europa.eu/programme/rcn/805_de.html (last accessed on 16 January 2017).
5 Cf. information from SV Gesellschaft für Wissenschaftsstatistik mbH.
6 Cf. information from SV Gesellschaft für Wissenschaftsstatistik mbH.
7 The method of calculating GDP was changed in 2014. GDP is higher than before according to the new calculation method. This in turn influences the level of the R&D ratio – it is slightly lower as a result.
8 In 2013, the private sector financed 65.4 percent of gross domestic expenditure on internal R&D in Germany. The data for 2015 are not yet available.
9 Cf. https://www.stifterverband.org/pressemitteilungen/2016_12_12_forschung_und_entwicklung (last accessed on 16 January 2017).
10 Cf. also EFI (2013: Chapter B 2).

A 6

11 The Commission of Experts' criticism on the introduction of an ancillary copyright law for press publishing houses. Cf. EFI (2015: Chapter B 3).
12 The Commission of Experts made proposals on this in its 2015 and 2016 Reports. Cf. EFI (2016: Chapter B 3-4) and EFI (2015: Chapter B 3).

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13 The Joint Task of 'University Construction', which had been enshrined in Article 91a, para. 1 of the Basic Law until 2006, was abolished under the Federalism Reform I. Before the Federalism Reform I, the Federal Government co-financed 50 percent of university construction via the Joint Task of 'University Construction'. To offset the additional financial burden on the Länder caused by the loss of this joint task, they will receive the Federal Government's share of financing for university construction up to and including 2019 – up until 2013 this share had been strictly ring-fenced. The Standing Conference of the Länder Ministers of Education and Cultural Affairs (KMK 2016) has calculated that there will be a financing gap for university building maintenance (excluding university hospitals) of 8 billion euros by 2025. If a planned expansion of the available space at universities of 1.2 percent per year is also taken into account, the financing deficit will increase to 35 billion euros by 2025, according to KMK. The KMK also points out that the Association of the University Clinics (Verband der Universitätsklinika, VUK) in Germany has calculated a further financing gap of 12 billion euros for the period from 2016 to 2025.
14 Cf. EFI (2012: 57), EFI (2013: 21) and EFI (2014: 21).
15 Cf. in the following EFI (2015: 20).
16 Cf. https://www.destatis.de/DE/ZahlenFakten/GesellschaftStaat/BildungForschungKultur/Hochschulen/Tabellen/HochschulenHochschularten.html (last accessed on 16 January 2017). The 104 other tertiary education institutions include six teacher training colleges, 16 theological colleges, 52 art colleges and 30 administrative colleges.
17 Cf. Statistisches Bundesamt, Fachserie 11 Reihe 4.4, Tabellenblatt TAB-09.
18 Cf. Statistisches Bundesamt (2016a: 22).
19 Own calculations based on Statistisches Bundesamt, Fachserie 11 Reihe 4.4, Tabellenblatt TAB-9 and Statistisches Bundesamt, Fachserie 11 Reihe 4.1, Tabellenblatt ZUS-01.
20 Meanwhile, the Federal Statistical Office (Statistisches Bundesamt) uses the term 'sponsor funds' (Trägermittel) and has changed the calculation method slightly. The Commission of Experts continues to use the term 'basic funds' here because it is currently more common than 'sponsor funds'.
21 Cf. Statistisches Bundesamt, Fachserie 11 Reihe 4.5, Tabellenblatt 1.2.4. In addition, the comparable figure for 2005 was provided by the Federal Statistical Office on request.
22 Own calculations based on Statistisches Bundesamt, Fachserie 11 Reihe 4.5, Tabellenblatt 1.2.4 and written information provided by Statistisches Bundesamt.
23 According to information provided by the Federal Statistical Office by phone on 26 September 2016, one exception here is the funding of the Quality Pact for Teaching, which is allocated to third-party funds.
24 The term overhead costs refers to costs incurred in addition to the direct project costs during the implementation of third-party-funded projects; they include e.g. adminis-

trative services or the use of rooms. In this regard, cf. also EFI (2014: 20) and EFI (2015: 21).

25 In this regard and in the following, cf. Statistisches Bundesamt, Fachserie 11 Reihe 4.3.2, Tabellenblatt 4.2.1.

26 In this regard and in the following, cf. Statistisches Bundesamt, Fachserie 11 Reihe 4.3.2, Tabellenblatt 4.1.1.

27 Cf. Rammer and Schmitz (2017).

28 In this regard and in the following, cf. EFI (2012: 44).

29 As stated by Prognos, KPMG and Joanneum Research in a study carried out on behalf of the BMBF and published in 2014, in most cases the BMBF project allowance only partially offsets the overhead costs caused by third-party-funded research: "A figure of 20% overhead costs in BMBF projects is likely to be the lower limit of the overall direct and indirect variable costs caused by third-party-funded research. The survey figures cover a wide range, depending on both the discipline and the type of tertiary education institution involved. They range from below 20% in individual cases to figures amounting to several times the allowance, particularly in the technical and experimental disciplines of natural science" (Prognos et al. 2014: 112). However, the programme allowances are the same for all disciplines.

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30 Cf. unknown author (2005) and unknown author (2009a).

31 31 Cf. unknown author (2005).

32 32 In this regard and in the following, cf. unknown author (2009a).

33 In this regard and in the following, cf. http://cordis.europa.eu/programme/rcn/805_de.html (last accessed on 16 January 2017). Overall, funding was provided to 51 graduate schools at 35 universities during the first two funding phases. Cf. DFG and WR (2015: 31).

34 In this regard and in the following, cf. http://www.dfg.de/foerderung/programme/exzellenzinitiative/exzellenzcluster/index.html (last accessed on 16 January 2017). In total, 49 clusters of excellence at 35 tertiary education institutions received funding during the first two funding phases. Cf. DFG and WR (2015: 55).

35 In this regard and in the following, cf. http://www.dfg.de/foerderung/programme/exzellenzinitiative/zukunftskonzepte/index.html (last accessed on 16 January 2017) and unknown author (2005 and 2009a). Overall, the institutional strategies of 14 universities were included in the funding during the first two funding phases. Cf. DFG and WR (2015: 83).

36 Cf. unknown author (2009a). In the first funding phase, the funding of at least one cluster of excellence and at least one graduate school was a prerequisite for the funding of an institutional strategy (c.f. unknown author 2005).

37 In this regard and in the following, cf. Hetze and Mostovova (2016: 18).

38 Journal publications are used in the calculation of the 10 percent most cited publications worldwide. In this context, a separate citation threshold is calculated for each subject (with the exception of the humanities and social sciences) of the Web of Science and for each type of document (article or review); this threshold must be exceeded for a publication to be counted among the 10 percent most cited publications. In this regard, cf. Hornbostel and Möller (2015: 30).

39 Cf. Hornbostel and Möller (2015: 47f.).

40 Cf. Hornbostel and Möller (2015: 48) and IEKE (2016: 19).

41 IEKE (2016: 19).

42 Cf. IEKE (2016: 34).

43 Cf. unknown author (2014a).

44 In this regard and in the following, cf. unknown author (2016a).

45 Cf. unknown author (2016a).

46 Cf. unknown author (2016a).

47 Cf. unknown author (2016a).

48 Cf. IEKE (2016).

49 In this regard and in the following, cf. unknown author (2016a).

50 In order to be granted a university allowance, the university must present its strategic goals. These are checked for plausibility. The cluster of excellence does not receive a university allowance if the presentation receives a negative evaluation. Cf. unknown author (2016a).

51 Cf. EFI (2016: 27).

52 Cf. GWK (2016b).

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53 Cf. in the following own calculations based on Statistisches Bundesamt, Fachserie 11 Reihe 4.4, Tabellenblatt TAB-09, various years.

54 The figures given here relate to fulltime tenured professors, but do not include any C2 professorships, corresponding grades with temporary contracts, or junior professorships.

55 Young academics are defined here as the staff at tertiary education institutions who can be classified as young scientists. These include the following personnel categories: temporary professorships remunerated according to the C2 scale (or equivalent grades), junior professorships, lecturers, assistants, academic and artistic staff.

56 Furthermore, the programme is to "foster the cultural change related to the establishment of tenure-track professorships and to develop the staff structure of the academic personnel throughout the university in such a way that they optimally complement the new career path and show career paths outside the professorship" (unknown author 2016b).

57 The share of the total funding available to the universities of a federal state is calculated as follows: 50 percent according to the Königstein formula and 50 percent according to the respective state's share of the professorships at universities and equivalent tertiary education institutions.

58 This involves increasing the total number of professorships during the term of the programme to the same extent as the tenure-track professorships are promoted under the programme; increasing the total number of tenure-track professorships during the term of the programme by the number of tenure-track professorships funded by the programme and maintaining the number of tenure-track pro-

fessorships achieved with the programme after the end of the programme; increasing the number of tenured full professorships after the end of the programme by the number of tenure-track professorships created by the programme. Cf. unknown author (2016a).

59 The growth rate among staff attributed to young academics is also partly due to the fact that the DFG, in its funding of young scientists, has increasingly financed posts instead of scholarships. In 2006, for example, only 7 percent of the doctoral students funded within the framework of research training groups were financed via posts, compared to 69 percent in 2015, according to written information provided by the DFG on 2 December 2016.

60 Between 2017 to 2024, about 11,770 tenured full professors will retire due to age. In this regard and in the following, cf. Statistisches Bundesamt, Fachserie 11 Reihe 4.4 Tabellenblatt TAB-11 and own calculations.

61 The German University Association of Advanced Graduate Training (GUAT/UniWiND), which serves its member universities as an exchange forum on the topic of promoting young academics, has already formed a working group on non-university careers for postdocs. Cf. http://www.uniwind.org/aktivitaeten/arbeitsgruppen/ausseruniversitaere-karrierewege/ (last on accessed 16 January 2017).

62 This happens essentially via the curricular standard values (Curricularnormwerte, CNW). A CNW refers to the course-specific teaching workload required for the education of a student within the standard period of study. The CNW is specified in the capacity regulations (KapVO) of the Länder. The number of study places is calculated from the teaching capacity (which is essentially determined by the number of posts) divided by the CNW.

63 In this regard and in the following, cf. EFI (2016: 28).

64 In this regard and in the following, cf. unknown author (2016b) and http://www.gwk-bonn.de/themen/vorhaben-an-hochschulen/foerderung-des-wissenschaftlichen-nachwuchses/ (last accessed on 16 January 2017).

65 Cf. EFI (2012: 50f.) and EFI (2016: 28).

66 Cf. EFI (2012: Chapter B 1) and EFI (2016: 27ff.).

67 In this regard, cf. also Allianz der Wissenschaftsorganisationen (2016).

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68 Cf. GWK (2014).

69 Special factors – e.g. start-ups or the switch of institutions to a different form of funding – were taken into account separately in individual cases. Over and above the joint financing under the PFI, both the Federal Government and the Länder have made significant, additional, earmarked resources available via project and special financing. Cf. GWK (2016c: 94f.).

70 Cf. Frietsch et al. (2016: 4).

71 Cf. Frietsch et al. (2016: 4).

72 Full-time equivalent.

73 HGW: from 0.28 (2001-2005) to 0.25 (2011-2014); WGL: from 0.49 (2001-2005) to 0.48 (2011-2014). Cf. Frietsch et al. (2016: 5).

74 Cf. Frietsch et al. (2016: 6).

75 Cf. GWK (2016c: 57).

76 Between 2011 and 2015, the Karlsruhe Institute of Technology, for example, recorded 61 spin-offs, the Freie Universität Berlin 60, and the Technische Universität München 47. There were 71 spin-offs at the ETH Zurich between 2013 and 2015.

77 The HTGF is a fund created as a public-private partnership by the BMWi, the KfW and several major German companies for early-phase investments. The HTGF has been investing venture capital since 2005 in technology-oriented start-ups without any restrictions to specific industries. Cf. http://high-tech-gruenderfonds.de/de/#tools-events (last accessed on 16 January 2017).

78 Pursuant to information provided by High-Tech Gründerfonds Management GmbH.

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79 Emigration or immigration in this context means permanent employment in a new country, but not shorter, temporary stays as a guest or trips abroad for conferences or international cooperation projects (in this regard, cf. also Noorden (2012).

80 In addition to the direct effects of immigration and emigration on scientific and innovation activity, indirect effects of mobility must also always be taken into account. For example, indirect effects can include positive network effects and greater involvement in the international circulation of knowledge, which can strengthen national research to some extent. Although indirect effects are difficult to quantify, they tend to counteract the direct effects. Cf. EFI (2014: B 2).

81 Cf. EFI (2014: B 2) and Franzoni et al. (2014).

82 In the case of researchers, their institute membership, as specified on a publication, can generally be used as a starting point for the formation of a mobility indicator in order to determine whether or not an international change of institution might have occurred over time. The OECD analysis includes researchers with at least two scientific publications in the database, making it possible to check whether these publications were reported from the same or a different country. If an author's country remains identical between two publications, they are characterised as 'non-mobile researchers'; if the country changes, they are called 'movers'. In the case of researchers with at least three publications, 'movers' can be further broken down into 'returnees', i.e. those who return to a country where they had been previously, and 'new arrivals', i.e. those who move to a country for the first time. Cf. OECD (2015a: 128).

83 The goals of the European Research Area, to which the Federal Government is also committed, include increasing the mobility of scientific personnel and establishing a common labour market for science. These overarching objectives counteract migration problems to a limited extent, provided that the researchers choose locations within Europe and the balances are evened out in the longer term.

84 Cf. OECD (2015a: 129). The bibliometric calculations carried out at OECD are based on Scopus Custom Data, Elsevier.

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85 Between 1996 and 2011, the statistics showed a less positive picture for Germany. At that time, the researchers who were the most prolific publishers on average left Germany, and at the same time the returnees to Germany and new arrivals were slightly less prolific on average. Cf. EFI (2014: Chapter B 2).

86 For example, the average impact (number of citations) of publications in these two groups (returnees and new arrivals) was significantly greater than among 'leavers' and 'non-mobile' researchers.

87 ERC grants include 'starting grants', 'advanced grants' and 'consolidator grants'. Under the different funding lines, top scientists receive funds amounting to between €1.5m and €2.5m for a period of five years. The ERC subsidies database includes, inter alia, information on the nationality of the top scientists and the country of location of their research institution. If their nationality and country of location differ, they are assumed to be mobile top scientists.

88 Cf. Noorden (2012), Geuna (2015) and Franzoni et al. (2012). The study by Franzoni et al. (2012) documents a survey of more than 15,000 researchers from 16 countries in 2011. They were interviewed in four different disciplines (biology, chemistry, materials and environmental sciences). Cf. also EFI (2014: B 2).

89 On the other hand, successful recruitment or a return from abroad was hampered by rigid organisational structures, incompatible social security systems, and excessively complex and user-unfriendly visa procedures. Cf. EFI (2014: Chapter B 2) and DFG (2013).

90 In 2013, about 37 percent of the funded doctoral students at graduate schools came from foreign institutions. In the clusters of excellence, 48 percent of professors were recruited abroad; in the case of junior research group leaders the figure was 33 percent, among doctoral students 20 percent. In the case of institutional strategies, a total of 30 percent of the funded researchers had previously been employed abroad. The increased recruitment of foreign personnel in the context of the Excellence Initiative was thus significantly higher than the average level of foreign personnel at German universities. Cf. IEKE (2016).

91 Positive effects could also stem from the international reputation and 'lighthouse' function related to the Excellence Initiative. Furthermore, the introduction of simplified residence permits at the EU level, based on the so-called blue card (which Germany in particular makes considerable use of), could have had a positive influence on the recently observed increased immigration of researchers to Germany. Cf. http://www.bamf.de/DE/Migration/Arbeiten/BuergerDrittstaat/BlaueKarte/blaue-karte-node.html (last accessed on 16 January 2017).

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92 Cf. Stephan (1996) and for a discussion on the concept of knowledge transfer inter alia https://juser.fz-juelich.de/record/ 136212/files/PTJ_Schriftenreihe_01.pdf (last accessed on 16 January 2017).

93 The following section looks at selected programmes at the federal level; there are also further programmes at the Länder level (e.g. 'Transfer. NRW' in North Rhine-Westphalia) and programmes at the EU level (e.g. within the 'Horizon 2020' framework or the 'European Institute of Innovation & Technology (EIT)').

94 The programme plans to organize a selection procedure until the end of 2017. The funding begins in 2018 and will be granted in two rounds of five years each.

95 Thus, departments and formats within the non-university research organisations that are relevant to start-ups – such as 'Fraunhofer Venture' or 'Helmholtz Enterprise' – support the financing efforts and the professionalisation of the institutes' own spin-offs.

96 Cf. the objectives of the Pact for Research and Innovation, including inter alia "enhancing research collaborations and cooperation with industry" and "strengthening exchange between science and the economy and society". Cf. https://www.bundestag.de/dokumente/textarchiv/2015/kw13_pa_bildung_forschung_technikfolgenabschaetzung/364770 and http://www.pakt-fuer-forschung.de/index.php?id=298 (both last accessed on 16 January 2017).

97 For a detailed analysis, cf. Koschatzky et al. (2008), also Correa and Zuniga (2013).

98 The measure consists of three pillars: EXIST Start-Up Culture (since 1998), EXIST Start-Up Grant (since 2007, preceded by EXIST SEED), and EXIST Research Transfer (since 2008); it is supported by the European Social Fund (ESF).

99 Three measures 'SIGNO – Protection of Ideas for Commercial Use', 'Transfer of R&D Results through Standardisation (TNS)' and 'INS – Innovations with Norms and Standards' were merged into WIPANO.

100 Cf. EPO Economic and Scientific Advisory Board (2015).

101 In addition, a relatively small additional volume of patenting is to be expected at the patent offices. Cf. http://documents.epo.org/projects/babylon/eponet.nsf/0/A3EB2FE2F8A5AD71C1257E6D0057194A/$File/b+sub-group_non-prejudicial_disclosures_grace_period_en.pdf (last accessed on 16 January 2017).

102 Cf. https://www.bmbf.de/pub/Open_Access_in_Deutschland.pdf (last accessed on 16 January 2017). Research results are either to be published directly under an open access model, or, after the expiry of an embargo period, posted on a public, freely accessible document server (so-called Golden and Green Paths). Cf. also EFI (2013: A 2).

103 Cf. EFI (2015: B 3).

104 Cf. inter alia Daimer et al. (2014), Kulicke et al. (2015), Becker et al. (2011), Schleinkofer and Kulicke (2010), and Egeln et al. (2010).

105 Cf. IIT (2016). The evaluation shows that initiatives that are not funded also have positive effects. However, research does not usually take place under one roof in these initiatives.

106 There is evidence to back this in various scientific studies, not only in the case of Germany. For example, this also applies for comparable legislative changes in Norway, which also led to a quantitative and qualitative decline in academic patenting and spin-offs. Cf. Czarnitzki et al. (2015), Hvide and Jones (2016), also von Proff et al. (2012).

107 Only a few measures were not continued (in a modified form), for example 'ForMaT', the programme initiated by

the BMBF in 2007 (cf. Lehmann et al. 2016). There was a consolidation by WIPANO, for example.

108 Cf. Lehmann et al. (2016: 185ff.).

109 Cf. Lehmann et al. (2016).

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110 Cf. Porter (1998: 78).

111 These are referred to as agglomeration effects. A further distinction can be made between cluster and urbanisation effects. The former arise when a growing industry in a region is accompanied by an increase in productivity, the latter when the growing size of a city leads to an increase in productivity.

112 These so-called positive local knowledge externalities are especially effective when companies belong to interlinked or related industries. In such cases, they are called Marshall-Arrow-Romer (MAR) externalities. When companies belong to different industries, they are called Jacobs externalities.

113 Cf. EFI (2015: 40ff) and BMBF (2016) on the following comments. The 'Cluster Platform Germany', provided by the BMBF and the BMWi, is an information platform for cluster actors in Germany and abroad about the cluster landscape and policies at the federal and regional levels. The platform provides information in particular on current invitations to tender and programmes on the various levels – Länder, federal and EU. Via a search function featuring different selection criteria – e.g. excellence measure, technological focus, federal state – it is possible to search specifically for clusters according to fields of technology and locations. Cf. BMBF (2016: 209).

114 There is also the 'Federal-Länder Joint Task for the Improvement of the Regional Economic Structure (GRW)'. Cf. BMBF (2016: 233).

115 Cf. EFI (2015: 46).

116 Cf. the BMBF website: https://www.bmbf.de/de/der-spitzencluster-wettbewerb-537.html (last accessed on 16 January 2017).

117 'Go-cluster' continues the previous measure 'Kompetenznetze Deutschland' (Competence Network Germany).

118 Another goal of 'go-cluster' is to increase international visibility. Cf. BMBF (2016: 25f.).

119 At present, 'go-cluster' brings together about 100 innovation clusters in 16 technological fields. In total, the measure reaches almost 15,000 companies and institutions, including over 7,000 SMEs. Approximately 1.8 million euros is spent on direct project funding and almost 1.5 million euros on cluster-related advisory services, operating the 'cluster platform', excellence stimuli and further-training schemes, as well as funding for high-risk model projects. Cf. BMBF (2016: 25f.) and Ekert et al. (2016: 7ff, 71f.).

120 For an overview of the justifications for cluster policy in relation to market and system failure, cf. Fornahl et al. (2015: 54ff). While market failure concentrates on unintended knowledge spillovers, system failure focuses on deliberate (local) knowledge spillover.

121 However, if an existing cluster has already reached a stage of maturity, arguments for subsidies and other interventions quickly lose their justification. There is only an economic argument for further political intervention in the final phase of cluster development, i.e. if a renewal process can be supported. Cf. Klein Woolthuis et al. (2005).

122 More specifically, distinctions are made in the case of system failure between the dimensions of intermediation problems, complementarity problems and reciprocity problems. Cf. OECD (1997), Cantner and Graf (2003), also Klein Woolthuis et al. (2005).

123 The effects of a technological lock-in in a cluster were described for the first time by Grabher (1993) in relation to the Ruhr area. Possible solutions to overcome a lock-in are explained by Hassink (2005).

124 Cf. BMBF (2016: 215f.).

125 The cluster-funding initiatives within the 'Entrepreneurial Regions' initiative include the so-called 'Innovation Forums' (more than 170 innovation forums have received up to 85,000 euros since 2001); 'Innovative Regional Growth Cores' (more than 50 growth cores have been supported since 2001; a total of approx. 350 million euros has been approved up to 31 December 2015); 'Growth Cores Potential' (approx. 40 collaborative projects have been supported to date with a total of over 60 million euros); and 'InnoProfile Transfer' (under which the BMBF is providing a total of 123 million euros up to 2019 to fund 23 market-oriented collaborative projects, 7 junior research groups, and 21 research groups managed by company-funded endowment professorships). Cf. BMBF (2016: 231f.).

126 Cf. BMBF (2016: 232).

127 The funding initiatives mentioned under 'Entrepreneurial Regions' and its predecessor 'InnoRegio' distributed more than one billion euros between 1999 and 2024. Cf. EFI (2015: 39).

128 Cf. EFI (2015: 44).

129 Cf. Rothgang et al. (2014).

130 The evaluation study was carried out by INTERVAL GmbH. The final report is available since February 2016. Cf. Ekert et al. (2016).

131 Go-cluster led to a noticeable reputation gain among the funded clusters. However, this effect was smaller than expected. Positive effects were also noted in terms of transparency and visibility. Cf. Ekert et al. (2016).

132 To this purpose, the starting position of the participating clusters, future projects and networks and their internationalisation strategies will be assessed and proposals submitted to support the funded actors. The funding will be accompanied by ongoing monitoring of the internationalisation goals and the implementation activities of the funded actors.

133 Cf. http://www.crie.uni-bremen.de/files/fornahl/data_store/Projektbeschreibung%20InterSpiN.pdf (last accessed on 16 January 2017).

134 On the basis of interviews of the beneficiary companies, positive effects on different target variables such as network development, R&D results and the development of employment have been identified in relation to the predecessor programme 'InnoRegio' and its subsumed funding instruments 'InnoProfile' and 'Innovation Forums'. Cf. EFI (2015: 45) and BMBF (2005, 2012a, 2012b).

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135 Cf. EFI (2014).
136 Cf. EFI (2012: 60).
137 Cf. EFI (2012: 60).
138 In the next few years, the shortage of skilled personnel will be aggravated by the fact that the baby-boom cohorts will be reaching retirement age. However, this effect is substantially dependent on the de-facto retirement age, which has risen again in recent years, and from this perspective has developed advantageously. While it was still 60.9 for men and 60.8 years for women in 2011, by 2014 it had risen to 61.8 for men and 61.7 for women. Cf. http://www.deutschlandinzahlen.de/tab/deutschland/soziales/gesetzliche-rentenversicherung/renteneintrittsalter (last accessed on 16 January 2017).
139 Cf. EFI (2014: 31).
140 Cf. Fuchs et al. (2016: 8).
141 Cf. Böhm et al. (2011: 4).
142 Cf. EFI (2013: 104ff.).
143 Analyses conducted by the Hans Böckler Foundation for the period 2008 to 2015 show a positive trend at the latter part of this period, particularly in the case of supervisory board positions, whereas the development has been rather slow in the case of boards of management: the proportion of women in supervisory boards rose from 9.3 percent (2008) to 22 percent (2015). At the same time, it also rose in the case of management boards, but only from 2.5 percent (2008) to 5.4 percent (2015). Cf. http://www.boeckler.de/51389.htm (last accessed on 16 January 2017). A recent analysis by the consulting firm EY shows that there were only 45 female members on the management boards of the 160 companies listed on the Dax, MDax, SDax and TecDax indices (compared to 630 male members) on 1 January 2017. The proportion of women is thus 6.7 percent; at the beginning of 2016 it was 5.9 percent, at the beginning of 2015 5.2 percent. About 76 percent of the management boards are still exclusively male. Cf. http://www.ey.com/de/de/newsroom/news-releases/ey-20170109-immer-mehr-frauen-in-deutschen-vorstanden-dax-konzerne-vorreiter (last accessed on 16 January 2017).
144 Cf. EFI (2013: 100).
145 In general, empirical studies suggest that a more balanced ratio of men and women has a positive impact on various corporate indicators. Organisations with mixed teams and with women in management positions achieve better results in terms of unit sales, turnover, customers and profits, cf. e.g. Hoogendoorn et al. (2013), Smith et al. (2006) or Herring (2009). They contribute specific functional expertise that would otherwise be lacking in leadership positions and boards, and thus increase productivity, cf. Kim and Starks (2016). There is also evidence to suggest that women in management are especially valuable in the case of corporate strategies geared towards innovations in particular – cf. Dezsö and Ross (2012) – and they have a positive effect on innovative activities and the start-up success of companies; cf. Parotta and Smith (2013), also Weber and Zulehner (2010). In addition, the greater involvement of women in the innovation process leads to new types of innovation. A group of experts deployed by the European Commission has coined the term 'gendered innovation' in this context. For more details, cf. EFI (2014: 123f.).
146 Cf. EFI (2012: 64).
147 Cf. Veen and Backes-Gellner (2009).
148 For up-to-date information on this, cf. Sachverständigenrat (2016: 288ff.).
149 The already practised suspension of the priority review for professions in which there is a shortage of qualified staff, and the lowering of the income limits point in the right direction. Since autumn 2016 there has also been a model project (PuMa) on the criteria-based immigration of skilled personnel; it is conducted jointly in Baden-Württemberg by the Federal Ministry of Labour and Social Affairs (BMAS) and the Federal Employment Agency (BA). This will offer criteria-based immigration for a limited number of professionally qualified personnel from third countries over a three-year period under a points system. This practical trial of a control mechanism for labour migration can help gain valuable information for controlling the future immigration of skilled personnel; cf. https://www3.arbeitsagentur.de/web/content/DE/service/Ueberuns/Regionaldirektionen/BadenWuerttemberg/Regionalinformationen/PuMAModellprojekt/index.html (last accessed on 16 January 2017).
150 Empirical studies show a positive correlation between immigration and innovation by boosting the pool of people with higher formal qualifications, cf. e.g. Hunt and Gauthier-Loiselle (2010). The same applies to migrants with lower formal qualifications. For example, Jahn and Steinhardt (2016) study the immigration of German repatriates into Germany and find no evidence that this has negative effects on innovation; instead, the results suggest that, if anything, there might even be a positive effect on innovation; cf. Jahn and Steinhardt (2016), also EFI (2014: 123).
151 Cf. EFI (2012: 72).
152 This is helped in particular by good interaction between dual vocational training and academic tertiary education, each of which represents a central pillar of the German innovation system. In this context, foreign education systems that focus solely or too heavily on tertiary education institutions do not represent suitable role models for the further development of the German education system. In Germany it is much more important to strengthen and improve interaction between the two pillars of the education system. Cf. also EFI (2012: 72ff.).
153 In Switzerland, for example, the 'kein Abschluss ohne Anschluss' principle (no dead-ends in education) is regarded as one of the basic principles for the further development of the education system; it points out that in education there should be no educational degree that does not offer subsequent educational career opportunities. All graduates of any educational degree must have an opportunity to continue their education later; cf. in more detail SBFI (2014).
154 Cf. EFI (2014: 35).
155 Cf. EFI (2012: 15).
156 Cf. EFI (2014: 57).
157 Cf. EFI (2014: 13).

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158 Cf. Rammer and Schmitz (2017).

159 Austria: 12.5 percent, United Kingdom: 8.9 percent, France: 8.1 percent, Italy: 6.4 percent, Sweden: 6.1 percent, Finland: 2.8 percent, own calculations on the basis of the OECD, Research and Development Statistics (latest figures for 2013).

160 In this regard and in the following, cf. Rammer and Schmitz (2017).

161 ZIM was topped up for the years 2009 to 2011 with €900m in the context of the Economic Stimulus Package II. In 2011, funding open to all technologies accounted for almost a quarter of total federal funding for R&D in companies. In this regard, cf. Depner et al. (2011) and Günther et al. (2011).

162 Excluding N (Spatial planning and urban development; construction research), T (Funding organisations, restructuring of the research field in the former GDR; construction of universities and primarily university-specific special programmes), U (Large appliances in the basic research field), Y (Non-R&D-relevant education expenditures) and Z (Ministry incl. supplies). Cf. in the following also Rammer and Schmitz (2017).

163 In this regard and in the following, cf. Rammer and Schmitz (2017).

164 In this regard and in the following, cf. Mertens (2009), quoted in Rammer and Schmitz (2017), also Rammer and Schmitz (2017). Cf. also EFI (2016: Chapter B 1).

165 In this regard and in the following, cf. Rammer and Schmitz (2017).

166 At present, projects are currently only assigned to one funding area in the Profi Database. As a result, thematic analyses lack clarity. In the future, this situation could be improved by fractional allocations of the respective projects to several funding areas. This would also raise the precision of ex-post analyses.

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167 Cf. https://www.destatis.de/DE/ZahlenFakten/GesamtwirtschaftUmwelt/ UnternehmenHandwerk/KleineMittlereUnternehmenMittelstand/ Aktuell_.html (last accessed on 16 January 2017).

168 The following countries were included in the comparison: Germany, Finland, France, United Kingdom, Italy, Netherlands, Austria and Sweden.

169 Cf. EFI (2016: 38f.) and Rammer et al. (2016).

170 Cf. EFI (2016: 38f.) and Rammer et al. (2016).

171 The ratio of innovation expenditure to sales is higher among SMEs in Sweden, Finland, France, the Netherlands, Austria and Italy than in Germany. Cf. EFI (2016: 35) and Rammer et al. (2016).

172 Cf. in the following EFI (2016: 36ff.) and Rammer et al. (2016: 53ff.).

173 Cf. in the following EFI (2016: 39ff.) and Rammer et al. (2016: 103ff.).

174 Cf. OECD (2015b).

175 Cf. OECD and Eurostat (2005).

176 Cf. Rammer et al. (2015: 4).

177 Cf. in the following EFI (2016: 40ff.) and Rammer et al. (2016).

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178 When companies secure access to large, fast-growing or strategically important markets, the internationalisation of R&D is said to have market-based motives. In the case of market-based (or home-base-exploiting) motives, the focus is on the economic exploitation of domestic R&D activity abroad. On the other hand, so-called technology-oriented motives of internationalisation seek access to specific knowledge. Technology-oriented (or home-base-augmenting) motives essentially concentrate on gaining access to specific knowledge or highly specialised labour in the target country. Cf. inter alia Ambos (2005). Low wage or capital costs in the target country are less important. Cf. Booz Allen Hamilton and INSEAD (2006), Thursby and Thursby (2006), Kinkel and Maloca (2008), Belderbos et al. (2009), and European Commission (2010).

179 Cf. OECD (2016c).

180 Cf. Ciriaci et al. (2016).

181 Cf. for example the international rules of the World Trade Organisation (WTO).

182 Cf. EFI (2013: 70). These national governments may be aiming to increase the value of their domestic production structures or to secure the transfer of technology and knowledge by promoting or enforcing R&D in their countries. Especially in countries where public procurement plays a key role, preference can be given to companies that are (also) represented with their own R&D in the country.

183 In fact, in this case it is not the development of innovations that is international, but their financing and the trade with intellectual property; the choice of location follows considerations of corporate strategy. While less than 10 percent of all patents with applicants (owners) from the G7 states name inventors abroad, this percentage rises to 30 percent in small, open economies (such as Ireland) and in countries with a high proportion of MNEs (e.g. the Netherlands and Sweden). The percentage is also high in countries with a favourable tax system (e.g. Barbados, Cayman Islands, British Virgin Islands), cf. OECD (2015a: 140). To counteract legal tax avoidance, the OECD is drawing up measures to combat base erosion and profit shifting (BEPS). The aims are to protect national tax bases, to increase security for the taxable population, and to avoid double taxation and restrictions on cross-border economic activities. (http://www.oecd.org/berlin/publikationen/beps-berichte.htm; last accessed on 16 January 2017). In its 2016 Report, the Commission of Experts welcomed on principle the international harmonisation of corporate taxation initiated by the G20 (EFI 2016: Chapter A 2).

184 Cf. OECD (2016c). The study is based on 5,000 greenfield investments; the main motive here is market development.

185 Cf. OECD (2016c).

186 This reshoring is related to the following finding of the Commission of Experts (EFI 2013: 68): “With regard to the structure of the target countries for R&D investments,

emerging changes are more pronounced than changes in the investor countries."

187 Another important indicator for the globalisation of knowledge formation is international co-authorships in top publications. The percentage of international co-authorships has risen sharply worldwide over the last few years, cf. OECD (2015a).

188 Transnational patents comprise applications in the form of patent families that include at least one application filed with the World Intellectual Property Organization (WIPO) via the Patent Cooperation Treaty (PCT) procedure, or one application filed with the European Patent Office, cf. Frietsch and Schmoch (2010: 196). Neuhäusler et al. (2017) provide a comparison for further countries. International co-patents of so-called IP5 applications are an alternative indicator that is used, for example, by the OECD in many studies. They are applications of patent families in at least one of the five largest patent offices: SIPO, JPO, KIPO, USPTO and EPO. Cf. e.g. OECD (2015a).

189 R&D expenditure by foreign companies in Germany can be interpreted as an indicator of the attractiveness of Germany as an R&D location.

190 Cf. Stifterverband (2013: 37f.).

191 Cf. Schasse et al. (2016: 88ff.).

192 Identified according to the European R&D Scoreboard 2013; cf. Stifterverband (2015: 15).

193 The industry definitions are made in accordance with the WZ 2008 classification of economic activities. Other vehicle construction, which is highly international in orientation and comprises ship building, railway construction and aerospace, is included in the automotive industry. Cf. Stifterverband (2015: 14).

194 Internal R&D expenditure is expenditure on research and experimental development that is conducted within the company with its own research personnel, either for its own purposes or under contract for others. By comparison, external R&D expenditure comprises expenditure on R&D services purchased outside the company. This includes e.g. research contracts with other companies, universities or state research institutions. Cf. Stifterverband (2015: 5).

195 The calculations of the shares are based on data from an evaluation by SV Wissenschaftsstatistik. In the analysis of R&D expenditure by foreign companies differentiated by industries, no information is available on their external R&D expenditure. The decline in total foreign R&D in Germany illustrated in Figure B 3-4-2 can – with respect to internal R&D expenditure - also be differentiated according to industries. While vehicle construction, mechanical engineering and (especially) pharmaceuticals recorded a fall between 2011 and 2013, expenditure attracted from abroad rose slightly in the field of electrical engineering.

196 Based on provisional data from SV Wissenschaftsstatistik.

197 The percentage of mobile researchers leaving Germany in recent years was for example in the pharmaceutical and biotechnology industries, as well as in information and communication technologies significantly higher than in mechanical engineering, which is regarded as one of the country's established strong sectors. Cf. EFI (2014: Chapters B 2 and B 3).

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198 Cf. EFI (2012: 76)

199 Cf. EFI (2012: 76) and EFI (2016: 116f.). The knowledge economy comprises knowledge-intensive services and R&D-intensive industries. Knowledge-intensive services are primarily characterized by a workforce with an above-average percentage of employees who have tertiary education qualifications. Cf. EFI (2015: 151). R&D-intensive industries comprise economic sectors with an R&D intensity of between 3 and 9 percent (high-value technologies) and above 9 percent (cutting-edge technologies). Cf. EFI (2014: 210).

200 The closure rate in the knowledge economy was around 5 percent in the period from 2005 to 2015. Cf. Müller et al. (2017b: 17).

201 Cf. http://bmwi.de/DE/Mediathek/publikationen/did=741814.html (last accessed on 16 January 2017).

202 Cf. www.exist.de (last accessed on 16 January 2017).

203 Cf. BMWi (not dated a).

204 Cf. https://www.bmbf.de/de/gruendungsfoerderung-816.html (last accessed on 16 January 2017).

205 Start-ups launched by unemployed people are supported by the Federal Employment Agency with an instrument called the Start-Up Subsidy (Gründungszuschuss). It was introduced on 1 August 2006 and replaced earlier instruments such as Bridge Money and the Ich-AG (the 'I plc'). Various studies have given the subsidy a positive assessment, both because it is a legal entitlement and because of its impact: between 75 to 84 percent of beneficiaries remain self-employed. Abuse and windfall effects are quite rare in this form of funding. Cf. Bernhard and Wolff (2011).

206 Cf. EFI (2012: 78).

207 The proportion of recipients as a percentage of all unemployed (Volume III of the German Social Code) fell from 1.25 percent in 2011 to 0.19 percent in 2012. The figures rose again slightly in 2013 and 2014, albeit at a low level (with figures of 0.23 and 0.27 percent respectively); cf. Bernhard et al. (2015: 2). Not only the number, but also the structure of the recipients has changed. It is shown that the legal precedence of job placement over other active labour-market policies pursuant to section 4 of Volume III of the German Social Code plays a crucial role. The precedence of job placement is not only used as a justification for rejections in discretionary decisions, but also – and especially – as an argument used by job center staff to discourage recipients of Unemployment Benefit I from even applying. The recipients usually accept this argument, or do not even try to apply to the agencies for a start-up subsidy (...)" (Bernhard and Göttingen 2015: 5).

208 Cf. Sternberg et al. (2015: 20f.).

209 Cf. Sternberg et al. (2015: 20f.).

210 Examples: German Business Founder Award for Students, cf. https://www.dgp-schueler.de/top/wettbewerb.html; Junior – Experience Business, cf. https://www.junior-programme.de/de/junior-schueler-erleben-wirtschaft/; Youth Start-Ups, cf. https://www.km.bayern.de/schueler/meldung/57/wettbewerb-foerdert-unternehmerisches-denk-

en-an-den-schulen.html (both last accessed on 16 January 2017).

211 One reason given for the difficulty of establishing entrepreneurial thinking in schools is the fear of excessive business influence on the curriculum. Cf. Sternberg et al. (2015: 24f.).

212 Cf. Kulicke and Seus (2016: 112).

213 Cf. BMWi (2015a: 6ff.).

214 Cf. Kulicke and Seus (2016: 115).

215 Cf. Kulicke and Seus (2016: 112ff.).

216 Cf. Ripsas and Tröger (2015: 3) and http://www.faz.net/aktuell/wirtschaft/cebit/code-n/wenn-startups-scheiternaufstehen-mund-abputzen-weitergruenden-13491341.html; http://www.spiegel.de/karriere/fuckup-night-unternehmer-erzaehlen-vom-scheitern-a-1034303.html; http://gruender.wiwo.de/lernen-aus-dem-scheitern-steh-auf-mann/ (last accessed on 16 January 2017).

217 Cf. Sternberg et al. (2015: 20f.) and Kollmann et al. (2016: 77).

218 Cf. http://www.doingbusiness.org/rankings (last accessed on 16 January 2017).

219 Germany is 17th in terms of ease of doing business', but 114th when it comes to 'starting a business'. A total of 41 indicators are considered for the 'ease of doing business' ranking, and four of these are used for the 'starting a business' sub-indicator: procedures (number); time (days); cost (as a percentage of income per capita); minimum capital (percentage of income per capita). Cf. World Bank Group (2016).

220 Cf. Kollmann et al. (2016).

221 The Point of Single Contact system is based on the EU Services Directive, according to which the public administration is to offer companies and start-ups cross-border and bundled access to all information and processes. BMWi (not dated b) and http://www.bmwi.de/DE/Presse/pressemitteilungen,did=731008.html (last accessed on 16 January 2017).

222 Cf. European Commission (2015).

223 Cf. Wirtschaftsministerkonferenz (2015).

224 Cf. http://www.egovernment-computing.de/der-einheitliche-ansprechpartner-20-a-567301/ (last accessed on 16 January 2017).

225 Workshop on 16 November 2016 as well as information provided by the BMBF by phone on 20 December 2016.

226 Financing business activities counts as a subsidy.

227 Cf. EFI (2012: 79f.)

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228 Cf. EFI (2015: 33).

229 Cf. EFI (2012: 84f.).

230 Cf. EFI (2012: 85).

231 Cf. BMF (2015).

232 Cf. OECD (2016c).

233 The data relate to 2015. Cf. EFI (2017: Chapter C 4).

234 Number of unicorns in 2016: United Kingdom: 18; Sweden: 7; Germany: 6. Cf. Madhvani et al. (2016).

235 Cf. BMF (2015: 2).

236 The INVEST funding programme was given a positive evaluation in 2016. According to the evaluation study, although it has only been running for a short amount of time, INVEST has already contributed to an upturn on the equity investment market, albeit only to a small extent. For example, 30 percent of the investors promoted by INVEST invested in a young company for the first time. Cf. Gottschalk et al. (2016: 232ff.).

237 Private individuals or corporations receive a 20 percent subsidy on investments in venture capital. The cap on the subsidy has been doubled to €500,000. Furthermore, INVEST 2.0 includes an exit subsidy amounting to 25 percent of the capital gains from INVEST holdings. This exit subsidy represents a flat-rate reimbursement of the capital gains tax payable by the investor. Cf. http://www.exist.de/SharedDocs/Kurzmeldungen/DE/Startschuss-fuer-INVEST.html (last accessed on 16 January 2017).

238 Cf. BMF (2015: 2).

239 The KfW withdrew from the market in 2012. With its new ERP venture-capital fund investment/investments, the KfW, together with the BMWi, aims to improve the funding of technology-oriented start-ups and young, innovative companies. The KfW participates in selected venture-capital funds in Germany and Europe. It hopes to provide an important stimulus to encouraging further domestic and foreign institutional investors. Cf. https://www.kfw.de/KfW-Konzern/Newsroom/Aktuelles/Pressemitteilungen/Pressemitteilungen-Details_274688.html (last accessed on 16 January 2017).

240 Cf. BMWi (2016a).

241 The Coparion Fund participates in the financing of a company on condition that a private lead investor provides at least the same amount of capital on the same economic conditions (maximum: €10m per company). The fund volume amounts to €225m. In this way, about €450m of capital can be made available to innovative young companies. Cf. BMWi (2016a: 3) and BMWi (2016d), also http://www.foerderdatenbank.de/Foerder-DB/Navigation/foerderrecherche.html (last accessed on 16 January 2017).

242 Eligible to apply are venture-capital funds that invest mainly in Germany and whose investment policy focuses in particular on technology companies in their early development phase or on follow-up financing for technology companies in their early phase, development phase or growth phase. Cf. http://www.foerderdatenbank.de/Foerder-DB/Navigation/foerderrecherche.html (last accessed on 16 January 2017).

243 The fund of funds, which is financed jointly by the European Investment Fund (EIF) and the ERP Special Fund (administered by the BMWi) participates in venture-capital funds that invest mostly in Germany. Its capital resources are raised in equal amounts by the European Investment Fund (EIF) and the ERP Special Fund and are administered by the European Investment Fund (EIF), which has its head office in Luxembourg. Cf. http://www.bmwi.de/DE/Themen/Mittelstand/Mittelstandsfinanzierung/innovationsfinanzierung.html (last accessed on 16 January 2017) and BMWi (2016c).

244 Cf. http://www.bmwi.de/DE/Themen/Mittelstand/Mittelstandsfinanzierung/innovationsfinanzierung.html (last accessed on 16 January 2017).

245 The company founders must repay the loan with interest, but do not need to assign any company shares. According to reports, the federal budget will cover any losses of the fund from loan defaults. Cf. https://www.boersen-zeitung.de/index.php?li=1&artid=2016141007&titel=Milliarden-fuer-Wagniskapital (last accessed on 16 January 2017). It is still unclear when the Tech Growth Fund will be launched and what funding conditions it will have. Cf. Deutscher Bundestag (2016e).
246 Cf. http://germanaccelerator.com/life-sciences/program/ and http://www.exist.de/DE/Netzwerk/German-Accelerator/inhalt.html (last accessed on 16 January 2017).
247 Cf. Bundesregierung (2016).
248 Loss carryforwards (carried-over losses) are the total losses incurred in previous business years that could not be offset against positive income. These losses can be carried forward and then be netted against profits in subsequent business years, thus reducing the tax burden in these years. Cf. EFI (2015: 140).
249 Cf. EFI (2015), EFI (2012), EFI (2011) and EFI (2009), also BMWi (2015b).
250 Cf. EFI (2015: 34).
251 Bundesregierung (2016).
252 Cf. Hessisches Ministerium der Finanzen (Hessian Ministry of Finance) (2014).
253 Cf. EFI (2015: 34).
254 Cf. Deutscher Bundestag (2014: 9).
255 Cf. EFI (2015: 35).
256 E.g., Finland, France, United Kingdom, Italy, Luxembourg, Netherlands, and Spain. Cf. EVCA (2016).
257 Cf. EFI (2015: 35).
258 The KfW's activities as an anchor investor on the venture-capital market involves a budget of 400 million euros within the framework of ERP venture-capital fund investments. Cf. KfW (2015).
259 Cf. EFI (2012: 88) and BMWi (2015b).
260 Cf. BMWi (2016b).
261 Participants in the dialogue included representatives of start-ups, venture-capital firms, investors, syndicate banks, investor-protection bodies and Deutsche Börse. Cf. BMWi (2015b) and BMWi (2016b).
262 Cf. BMWi (2016b) and http://www.venture-network.com/dbvn-de/ (last accessed on 16 January 2017).
263 Cf. BMWi (2016b) and Deutsche Börse (2016).
264 Cf. http://www.handelsblatt.com/finanzen/maerkte/boerse-inside/boerse-fuer-wachstumsunternehmen-bloss-kein-neuer-markt-2-0/14873538-all.html (last accessed on 16 January 2017).

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265 In this regard and in the following, cf. Fier and Harhoff (2002), also Gassler et al. (2006).
266 In this regard and in the following, cf. EFI (2015: 25) and BMBF (2006). Medical engineering and innovative manufacturing technology, for example, were named as lead markets. Examples of key technologies are ICT, new materials and mechatronics.
267 Cf. BMBF (2010).
268 Cf. EFI (2015: 25) and BMBF (2014: 11).
269 Cf. EFI (2015: 4).
270 BMBF (2014: 5).
271 Cf. Dachs et al. (2015) and EFI (2015: 25).
272 Cf. BMBF (2014).
273 BMBF (2014: 36). The Federal Government mentions the integration of digitisation into production processes (termed Industry 4.0), microelectronics, battery technologies and biotechnology as examples of key technologies in the new High-Tech Strategy. Cf. BMBF (2014: 36).
274 In this regard and in the following, cf. EFI (2015: 36).
275 Cf. BMBF (2014: 30ff. and 37ff.).
276 Cf. BMBF (2014: 40ff.) and EFI (2015: 26).
277 In this regard and in the following, cf. EFI (2015: 25).
278 Cf. BMBF (2014: 14ff.).
279 Cf. EFI (2015: 28).
280 Cf. EFI (2015: 26).
281 Cf. BMBF (2015).
282 Cf. BMBF (2016: 246f.).
283 Cf. EFI (2015: 25).
284 Cf. EFI (2016: 18).
285 In this regard and in the following, cf. EFI (2016: 18).
286 Cf. EFI (2016: 19).
287 In this regard and in the following, cf. EFI (2016: 18).
288 The BMBF integrates societal issues into some of its specialised programmes. According to written information provided by the BMBF on 20 December 2016, examples include the following programmes: The research programme 'Bringing Technology to the People' studies how technology can be used to maximise the benefit for people. The programme entitled 'Research for Sustainable Development' looks for ways to encourage the participation of citizens in the Energy Transition. 'Bioeconomy as Societal Change' links social and humanities research with research in the natural and engineering sciences. The 'Innovative University' funding initiative aims to advance the research-based transfer of ideas, knowledge and technology at German tertiary education institutions. The funding measure 'Validation of the Technological and Societal Innovation Potential of Scientific Research' (VIP+) focuses equally on technological and social innovations. In the funding initiative 'Innovation Programme for SMEs', SMEs collaborate with actors from academia and society in about 50 forums to jointly develop ideas and new business models. The BMBF has published a policy paper on 'Participation', stating its position on the importance of civil society's involvement in research and research policy.
289 Cf. BMBF (2016). The BMBF plans to provide a total of 400 million euros for the framework programme between 2016 and 2020 (BMBF 2016:21).

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290 In this context, the state's function is increasingly being seen as that of the entrepreneur playing a central role as the initiator of innovations. Demand-side innovation policy is therefore interpreted as a permanent state task. Cf. Mazzucato (2013).
291 Cf. EFI (2013: 87).

292 To this purpose, the state can, on the one hand, have recourse to innovative inputs that are available on the market. On the other hand, the public sector must itself initiate innovation processes if the required products and services are not yet available on the market and must first be developed. Cf. EFI (2013: 87ff.).
293 Cf. EFI (2013: 90).
294 Cf. https://www.destatis.de/DE/PresseService/Presse/Pressemitteilungen/2016/11/PD16_413_811.html;jsessionid=B3D532D3D7487628BF5235CFAB01E514.cae3 (last accessed on 16 January 2017).
295 Cf. Berger et al. (2016: 10).
296 Cf. EFI (2013: 90).
297 Cf. Falck and Wiederhold (2013: 32).
298 Cf. Falck and Wiederhold (2013: 75ff.).
299 Cf. Essig and Schaupp (2016: 25).
300 PCP refers to inviting tenders for R&D services in the pre-commercial phase. The PCP instrument is supposed to make it possible to initiate the development of technologically innovative solutions within the framework of public procurement. PCP usually involves the (further) development of a product or service which is taken forward in several stages by two or more companies. Cf. Falck and Wiederhold (2013: 75). In the case of PPI, a public procurement agency operates as a (first) user of innovative products, services or system solutions that are at an early market stage. Cf. Berger et al. (2016: 10f.).
301 Cf. http://de.koinno-bmwi.de/innovation/innovationspreis (last accessed on 16 January 2017).
302 Cf. Essig and Schaupp (2016: 8).
303 The competence centre was evaluated in 2016 on behalf of the BMWi. The appraisal of KOINNO's work is mixed. Although the evaluators recommend the continuation of the competence centre, they criticise the fact that KOINNO's impact has remained restricted to a rather small group of procurement managers. There was no indication that KOINNO's work led to a comprehensive change of mentality among the procurement managers. Nor did KOINNO succeed in establishing new procurement procedures such as pre-commercial procurement (PCP) to any a great extent in Germany. Only one of the three PCP projects originally planned has been implemented to date. Cf. Berger et al. (2016: 49ff.).
304 Cf. Falck and Wiederhold (2013: 7).
305 SBIR is attractive for the participating companies not only because of the financial incentives, but also because they retain their intellectual property rights created in the context of SBIR-funded R&D activities. Cf. OECD (2010: 2).
306 Only a few federal agencies, such as the US Ministry of Defense, use the SBIR programme directly as an instrument for procuring innovative products generated by funded R&D activity. Cf. Falck and Wiederhold (2013: 7)
307 Cf. OECD (2010: 2).

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308 Cf. EFI (2013: Chapter A 6).
309 For a detailed and topical discussion, cf. the works of Rothstein and von Wachter (2016), as well as Deaton and Cartwright (2016).
310 Cf. IAB (2011) and Steinke et al. (2012).
311 This is different in Austria, for example, where there are stringent standards on evaluations in research and technology policy. Cf. Projektträger Jülich (2010).
312 Cf. https://www.socialpolitik.de/docs/VfS-Leitlinien_Ex_post-Wirkungsanalysen.pdf (last accessed on 16 January 2017).
313 Cf. written information provided by BMBF and BMWi.
314 Cf. for the USA: http://clear.dol.gov/topic-area (last accessed on 16 January 2017).
315 Cf. Deutscher Bundestag (2016f).
316 Examples from different political fields in the USA show how the design of economic- and social-policy measures can be improved by the use of government data. For example, the Department of Housing & Urban Development has revised its rules on the design of rent subsidies in the light of research on social mobility conducted by Chetty, Hendren and Katz (2016).
317 "The 15-member Commission is charged with examining all aspects of how to increase the availability and use of government data to build evidence and inform program design, while protecting privacy and confidentiality of those data. Specifically, the Commission is charged with: determining how to integrate administrative and survey data and to make those data available to facilitate research, evaluation, analysis, and continuous improvement while protecting privacy and confidentiality; recommending how data infrastructure, database security, and statistical protocols should be modified to best fulfill the integration and increased availability of data as described above; recommending how best to incorporate rigorous evaluation into program design; and considering whether a Federal clearinghouse should be created for government survey and administrative data." https://www.digitalgov.gov/2016/09/21/the-data-briefing-should-u-s-federal-employees-become-data-science-literate/ (last accessed on 16 January 2017).

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318 Cloud computing is defined as offering, using, and invoicing of IT services via the internet in a way that dynamically adapts to needs. Cf. BSI (2015).
319 According to the definition of the Federal Ministry for Economic Affairs and Energy (BMWi), the digital economy includes both the ICT sector – with its hard- and software manufacturers and service providers – and the internet economy. Cf. BMWi (2014b: 13).
320 Information on the definition and delimitation of the terms can be found in EFI (2016: Chapter B 4). For information on categorizing the two sectors by means of different industry classifications, and on the analysis of market capitalisation cf. Müller et al. (2016)
321 Cf. BMWi (2014b).
322 Cf. EFI (2016: 73). These new areas of application, which lead to a further expansion of the digital economy, include sectors such as the smart home, the Internet of Things, new forms of communication, robotics, augmented and virtual reality, mobility and security, among others.

323 Including German companies. Cf. Müller et al. (2016).
324 Cf. EFI (2013: Chapter A 4). The supposed locational weakness even has advantages because the young companies in the local labour market do not have to compete intensively with established actors.
325 Companies with a large number of users are therefore especially attractive for many investors. The Commission of Experts has already referred to the growing importance of 'user capital' for the value of internet-based companies in the past. Cf. EFI (2015: Chapter B 3).
326 Cf. EFI (2016: 66, Table B 3-5).
327 Cf. EFI (2016: 67, Box B 3-6).
328 Cf. Bloching et al. (2015). For example, banks in the USA are confronted with new competitors in the field of innovative mobile payment systems, where payments are increasingly being handled via smartphones. Similar developments are also taking place in Europe. Banks are being subjected to considerable competitive pressure both by start-ups in the so-called FinTech (financial technology) field and by global internet companies such as Apple, Alphabet, PayPal, and Amazon.
329 Cf. Jetter (2011).
330 Cf. Bain & Company (2012).
331 Cf. D'Emidio et al. (2014).
332 Cf. Müller et al. (2016: 47).
333 Cf. GfK (2014: 7).
334 Cf. EFI (2016: 75, Fig. B 3-12).
335 Cf. Rebholz (2016) and https://www.iwkoeln.de/presse/pressemitteilungen/beitrag/autonomes-fahren-deutsche-starten-von-guter-basis-286200 (last accessed on 16 January 2017).
336 Cf. Sadowski et al. (2016).
337 In this regard and in the following, cf. EFI (2015: 29f).
338 Cf. http://www.oecd.org/sti/broadband/oecdbroadbandportal.htm (last accessed on 16 January 2017).
339 This assessment stems from BREKO, an association of fibre-optic companies with a membership of 148 network operators.

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340 Cf. EFI (2016: 82).
341 The Fraunhofer Institute for Open Communication Systems estimates that the creation of efficient e-government would generate a wave of investment worth around 1.7 billion euros for development and the subsequent five years of operation. Cf. Fromm et al. (2015: 5).
342 Cf. Edler (2006: 78ff.) and Kim (2014).
343 Cf. EFI (2016: 88).
344 "The Survey examines emerging e-government issues and trends, and innovative practices that are relevant to the international community. By studying broad patterns of e-government around the world, the Survey assesses the e-government development status of the 193 United Nations Member States."(…) "Mathematically, the EGDI is a weighted average of three normalized scores on three most important dimensions of e-government, namely: scope and quality of online services (Online Service Index, OSI), development status of telecommunication infrastructure (Telecommunication Infrastructure Index, TII) and inherent human capital (Human Capital Index, HCI). Each of these sets of indices is in itself a composite measure that can be extracted and analysed independently." Cf. UN DESA (2016: 2 and 219).
345 Cf. EFI (2016: 81 and 84).
346 Cf. UN DESA (2016).
347 Cf. EFI (2016: 87).
348 Cf. EFI (2016: 87).
349 Germany's federal structures are the biggest obstacle to the development and expansion of e-government. The Länder are responsible for the organisation of administration in Germany, although Federal and Länder governments can work together on the basis of Article 91c of the Basic Law in the field of information technology, which also includes e-government. Cooperation between the Federal and Länder governments is therefore required in order to implement strategies and legislation on nationwide e-government. Cf. EFI (2016: 88).
350 Cf. EFI (2016: 88).
351 Cf. https://www.bundesregierung.de/Content/DE/Pressemitteilungen/BPA/2016/10/2016-10-14-beschluss-bund-laender.html (last accessed on 16 January 2017).
352 Cooperation between the Federal and Länder governments is ensured by the need for approval by the Bundesrat. Cf. https://www.bmi.bund.de/SharedDocs/Pressemitteilungen/DE/2016/12/buergerportal.html (last accessed on 16 January 2017).
353 Section 4 – Electronic handling of administrative procedures: For the electronic handling of administrative procedures that serve the implementation of federal laws, the Federal Government is authorised to make the use of certain IT components obligatory by statutory ordinance with the approval of the Bundesrat. The use of IT components provided by the competent federal ministry can also be regulated in the statutory ordinance. The Länder can deviate from the regulations stipulated in the statutory ordinance by federal-state law, insofar as they provide IT components suitable for operation of the portal network. Section 6 – Communication standards: For the communication between the IT systems used in the portal network, the Federal Ministry of the Interior lays down the technical communication standards in consultation with the IT Planning Council by statutory ordinance with the approval of the Bundesrat. Cf. BMF (2016: 30f.).
354 Cf. https://www.normenkontrollrat.bund.de/Webs/NKR/Content/DE/Pressemitteilungen/2016-12-14-nkr-durchbruch-digitale-verwaltung.html?nn=1669400 (last accessed on 16 January 2017).
355 Cf. EFI (2016: 83).
356 Cf. BMI (2014: 4ff.).
357 In 2015, Germany ranked last-but-one ahead of Russia in the implementation of the five principles of the G8 Open Data Charter. Criticism focused on the small number of data sets published on GovData and the large number of licenses used. Cf. Castro and Korte (2015: 4ff). The lack of important data sets on GovData (e.g. on public expenditure, invitations to tender, contracts awarded, and economic data) was also criticised. Cf. Zum Felde et al. (2015: 8f.).

358 Cf. https://www.govdata.de/web/guest/datenbereitsteller (last accessed on 16 January 2017).

359 Cf. https://www.govdata.de/web/guest/datenbereitsteller (last accessed on 16 January 2017).

360 Only with a central portal involving all Länder is it possible to ensure that data are clearly structured and mutually compatible, thus avoiding transaction costs and potential multiple investments. Cf. EFI (2016: 87).

361 Cf. Bundesregierung: Draft initial bill to amend the E-Government Act, cf. http://www.stiftung-nv.de/sites/default/files/gesetzentwurf_egovg12a_open_data.pdf (last accessed on 16 January 2017).

362 CDU; CSU; SPD (2013: 107).

363 The draft law is criticised by some civil-society actors because it contains numerous exceptions, and some formulations are open to interpretation. Another criticism is that it is not well aligned with existing legislation on information access and does not weigh up open data against data protection. Cf. Stiftung Neue Verantwortung (2016: 3ff.). Parallel to the submission of the draft law, in December 2016 the Federal Government announced Germany's participation in the Open Government Partnership, thus committing itself to open government and administration. Cf. https://www.bmi.bund.de/SharedDocs/Pressemitteilungen/DE/2016/12/bekanntgabe-der-teilnahme-an-open-government-partnership.html (last accessed on 16 January 2017).

364 Cf. http://www.behoerden-spiegel.de/icc/Internet/sub/2bf/2bf376e3-670e-751b-91a0-4c67b988f2ee,,,aaaaaaaa-aaaa-aaaa-bbbb-000000000003&uMen=1f75009de07d-f011-4e64-494f59a5fb42.htm (last accessed on 16 January 2017).

365 Cf. Zum Felde et al. (2015: 10).

366 Cf. https://transparenzgesetz.rlp.de/transparenzrlp/de/home/file/fileId/112 (last accessed on 16 January 2017).

367 Cf. https://opendata.bonn.de/page/bonner-ogd-vorgehensmodell; https://transparenz.karlsruhe.de/; https://www.moers.de/de/rathaus/offene-daten-moers/ and http://www.kommune21.de/meldung_22737_ Her+mit+den+-Daten.html (last accessed on 16 January 2017).

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368 Cf. Arrow (1962) and Nelson (1959).

369 In this regard and in the following, cf. EFI (2012: 95ff.).

370 Fundamental articles on this form of market failure can be found in Simon (1959) and Akerlof (1970).Cf. in the following also Spengel and Wiegard (2011: 11f.).

371 Fundamental articles on this form of market failure can be found in Myers and Majluff (1984) and Myers (1977, 1984).

372 Cf., e.g., OECD (2016a).

373 This procedure always applies to direct project funding under the Federal Government's specialized programs, to the funding of the BMWi's ZIM and IGF programs, to the Länder funding programs, to funding by the EU, and to R&D funding under the KfW's ERP Innovation program. Cf. Rammer and Schmitz (2017).

374 In 2010, the Federal Chancellery calculated the bureaucratic costs of project funding for applicants on the basis of the applicable law on grants. The monetized cost per application averaged just under €2,500. On the basis of a survey of SMEs to evaluate the 'KMU-innovativ' funding initiative, Rammer et al. (2016:140f.) put the average costs of application as high as approximately €5,000 – for approved and rejected applications alike. At the same time, SMEs with experience of different funding programs stated that these costs do not differ significantly between the individual programs.

375 Technology-unspecific funding measures such as ZIM also have this advantage.

376 Cf. Geyer and Tiefenthaler (2011: 13), also EFI (2012: 98).

377 Cf. EFI (2013: 21) and EFI (2015: 24).

378 The OECD countries that do not use tax-based R&D funding are Germany, Estonia, Mexico, New Zealand, Sweden, and Switzerland. No information is available for Israel. Deviating from the OECD statistics, Slovakia is listed among the countries that use tax-based R&D funding because it offers additional deductions from the tax base. Among the non-OECD countries, Brazil, China, Russia, and South Africa offer tax incentives for private R&D activities. Cf. OECD (2016a: 8). Latvia has also been an OECD member since 1 July 2016.

379 The presentation of different design variants focuses on the EU member states, as well as Australia, Japan, Canada, Liechtenstein, Norway, Switzerland, and the USA.

380 In this regard and in the following, cf. European Commission (2014a) and Spengel et al. (2017: 13ff.).

381 The study also mentions programs in the EU member states Denmark, Croatia, and Spain, as well as Canada.

382 Apart from the programs mentioned here, the European Commission also recommends a further program that offers an increased deduction from the tax base – the Croatian Enhanced Allowance for R&D Expenses. Cf. European Commission (2014a).

383 When personnel costs make up 50 percent of total expenditure on R&D, the WBSO subsidy rate of 50 percent corresponds approximately to a 25 percent subsidy rate in the case of a credit incorporating all R&D expenditure.

384 In addition, concessions can also be granted on consumption taxes such as VAT, if the latter is levied on R&D investment. This arrangement is very rare in practice. Cf. Belitz (2015).

385 In this regard and in the following, cf. Spengel et al. (2017: 11ff.).

386 In this case, R&D activities that (in economic terms) aim to build up net worth (knowledge) are treated differently from investment in physical capital goods, which initially do not represent a tax-relevant operating expense. Only the depreciation on the assets resulting from investment is recognized as a tax-deductible expense.

387 Specifically, design variants in Australia, Japan, Canada, Liechtenstein, Norway, Switzerland, and the USA are examined.

388 Cf. OECD (2015a).

389 In the case of SkatteFUNN, the subsidy rate for SMEs is 20 percent, 2 percentage points higher than for large companies.
390 Cf. European Commission (2003).
391 Only Ireland's R&D Tax Credit program also allows the deduction of R&D overhead costs.
392 The CII program in France uses a definition of qualifying R&D expenditure that goes beyond the Frascati stipulations in order to specifically strengthen prototype development. In the case of the United Kingdom's R&D Tax Relief and SkatteFUNN in Norway, certain expenses are eligible that go beyond the Frascati definition.
393 Cf. Netherlands Enterprise Agency (2016: 7).
394 However, contract research must not account for more than ten percent or €100,000 of R&D spending (15 percent for educational institutions) in the case of the R&D Tax Credit program in Ireland.
395 Within the French and Irish programs, eligible contract research is limited to R&D that is conducted within the European Economic Area. In Norway, outsourced R&D services can be deducted without geographical limitations. However, an assurance must be given in the application to the effect that the expected income from the R&D activities will accrue to a company that pays its taxes in Norway. In Ireland, there is a provision stating that R&D expenditure incurred abroad must not be subject to any additional tax incentives under the respective foreign tax law. For these and other comments, cf. Spengel et al. (2017: 16f.).
396 Up until recently, the only exception was the British R&D Tax Relief program, where double funding was excluded for SMEs, but permitted for large companies on certain conditions.
397 Under the CII program in France it is possible to have eligibility confirmed by special certification authorities. Their decision is binding for the tax authorities.
398 Under the SkatteFUNN program it is also possible to have eligibility confirmed in advance by the authorities, although the tax directorate makes the final decision on the amount of the credit.
399 Cf. EIM (2012: 8).
400 For example, many studies have problems with the exogeneity of regressors, selection effects, and other weaknesses. Wilson (2009), for instance, studies the extent to which the observable positive effects of tax incentives on R&D expenditure are simply caused by R&D being shifted from other regions. However, the study does not take into account the fact that countries with less R&D have a greater incentive to use R&D tax credit instruments (endogeneity problem). Similarly, the estimated coefficients cannot be interpreted as effects of the tax incentives on the allocation of R&D expenditure. Finally, it is impossible to distinguish between the shifting of R&D shares and the development of the overall level of R&D expenditure.
401 In this regard and in the following, cf. Spengel et al. (2017: 65ff). Other studies that do not directly evaluate the effects of lowering R&D user costs or the incentive effect also mention positive effects of R&D tax credits on the attractiveness of a tax system for investment in R&D. Formally, these analyses detect a significantly negative impact of the so-called B-index on R&D expenditure; cf., e.g., Falk (2006), Corchuelo and Martínez-Ros (2010) or Westmore (2013). The B-index measures the attractiveness of a tax system for investment in R&D and declines as its attractiveness increases.
402 The listed studies were selected by the Centre for European Economic Research (ZEW). The Commission of Experts agrees with their choice.
403 Cf. Spengel et al. (2017: 65ff.). For a definition of R&D user costs, cf. Jorgenson (1963: 249), also Hall and Jorgenson (1967). A frequently used formal definition can be found in Bloom et al. (1997).
404 The studies referred to calculate increases in R&D expenditure of between 0.07 and 5.47 percent when the R&D user costs are cut by 1 percent. The ZEW uses the arithmetic mean of the figures determined in the listed studies to calculate the average. There are no significant deviations from this average when the studies are additionally weighted according to their quality. To weight the studies, the ZEW assesses their quality in terms of the methodology used, the available data pool, and the robustness of the results; it varies the weighting factors within certain limits.
405 Here, too, there are no significant deviations from these average figures when the studies are additionally weighted according to their quality (see above).
406 The spread of the determined incentive effects ranges here from 0.19 to 2.80. The ZEW uses the arithmetic mean of the figures determined in the listed studies to calculate the average (see above).
407 Cf. Spengel et al. (2017: 65ff.) for a comparative analysis of 74 econometric studies on input additionality (published between 1980 and 2016) from 14 countries. 58 studies contain information on the impact of the R&D user costs and determine increases in R&D expenditure of between 0.16 and 5.47 percent. On average, a reduction in the R&D user costs of around 1 percent led to a 1.09 percent increase in R&D expenditure. Where the short-term and long-term effects in the studies differ from this larger group, the mean of the examined studies shows that the short-term effects are around 0.44 percent, the long term effects around 1.15 percent. Studies that examined volume-based funding arrive at a mean factor of 1.6 for the increase in R&D expenditure, while studies on incremental funding show a factor of 0.8. The incentive effect was determined in 39 of the 74 studies examined – with a range of 0.05 to 2.8. Studies relating to a more recent period (1990s, 2000s), tend to show a higher incentive effect. Studies that examined incremental R&D tax credits tend to estimate a slightly higher incentive effect (1.3) than studies on volume-based funding measures (1.2).
408 In the short term, SMEs increased their R&D expenditure by 5.7 percent, large companies by 1.5 percent. Cf. Lokshin and Mohnen (2012).
409 Cf. Agrawal et al. (2016). Numerous other studies also found that SMEs react more strongly to the tax credits than large companies. Cf. Kobayashi (2014), Rao (2016), Banghana and Mohnen (2009), Corchuelo and Martínez-Ros (2009), Dechezleprêtre et al. (2015), Guceri (2015), also Lester and Warda (2014).
410 Cf. Lokshin and Mohnen (2013).

411 Cf. CDU, CSU, and FDP (2009: 15).
412 Cf. motion proposed by the Bündnis 90/Die Grünen parliamentary group, Deutscher Bundestag (2016a), 15 March 2016.
413 Spengel et al. (2017: 51) calculate an annual tax revenue shortfall amounting to €794.11 million for the model proposed by the Bündnis 90/Die Grünen parliamentary group. However, this forecast does not take into account the cap of 15 or 7.5 million euros proposed by the Bündnis 90/Die Grünen parliamentary group.
414 Cf. http://www.bundestag.de/presse/hib/201609/-/459976 (last accessed on 16 January 2017).
415 Cf. motion tabled by the states of Bavaria and Lower Saxony: Deutscher Bundestag (2016b), 4 May 2016.
416 Cf. Bundesrat resolution: Deutscher Bundesrat (2016), 17 May 2016.
417 Cf. European Commission (2016). The idea is that this proposal should be the first step in a phased approach; it concentrates on the components of a joint tax base – i.e. the rules for calculating the corporation tax base, including certain provisions against tax avoidance – and the international dimension of the proposed tax system.
418 In this regard and in the following, cf. Spengel (2009: 98ff.).
419 For example, the possibility cannot be excluded that companies report R&D activities which are not in line with the Frascati Manual's usual definitions of R&D.
420 Cf. Guceri (2016).
421 Cf. Neicu et al. (2016).
422 Cf. EFI (2016: 37f.). Cf. Box B 3-3-2 in this report on the delimitation between R&D and innovation expenditure.
423 Cf. EFI (2009: 18), EFI (2010: 26f.), EFI (2011: 19), EFI (2012: 97f.) and EFI (2016: 46).
424 Various studies assume that the direct tax revenue shortfalls caused by tax-based R&D funding will be more than offset by higher revenue in the longer term. Cf. inter alia Spengel (2009), Spengel and Wiegard (2011), also BDI and ZVEI (2017).
425 Figure B 7-5 is based on data from SV Wissenschaftsstatistik's R&D survey that were reported, collected and adjusted up to the cut-off date 30 November 2016.
426 Initial projections by SV Wissenschaftsstatistik in January 2017 indicate that this figure is even higher: if the funding is designed as a volume-based tax credit with a 10 percent subsidy rate and a credit cap of €2 million per company, as many as 97.6 percent of companies engaging in R&D would be able to benefit fully from the funding. This means that 20.7 percent of total private internal R&D expenditure could potentially be covered by tax-based funding.
427 It is based on the microsimulation model ZEW TaxComm, which uses the balance sheet data of the DAFNE database, data of the Mannheim Innovation Panel (MIP), data from the European patent database REGPAT, and manually selected business reports. Case-based simulations taking into account institutional and regulatory framework conditions make it possible to deduce the periodically fixed trade and corporation tax liability of individual companies. Cf. Spengel et al. (2017), also Spengel and Wiegard (2011).
428 Furthermore, the study by Spengel et al. (2017) determines differentiated estimates of expected tax revenue shortfalls using regressive subsidy rates (i.e. subsidy rates that decrease as R&D expenditure increases), and by designing incremental instead of volume-based funding (cf. explanatory Box B 7-1).
429 Cf. Spengel et al. (2017) on this and all following results. To calculate the effect on revenue, the eligible R&D expenditure is multiplied by the respective rate of the tax credit.
430 Cf. European Commission (2003).
431 The SMEs' share of tax revenue shortfalls would have corresponded to about 5.5 percent of state R&D funding and 0.05 percent of the total German tax revenue (not including the notional tax incentives).
432 Using lower participation rates reflects the probability that not all companies with qualifying R&D expenditure actually make use of the R&D tax incentives. Studies on R&D incentives in other countries reveal participation rates of between 23 and 87 percent of all companies. The empirical findings indicate that companies with discontinuous R&D activity take part more rarely. Furthermore, there are indications that smaller companies and companies with a low R&D intensity also take part more rarely.
433 This is based on the assumption that R&D personnel expenditure account for 48 percent of total R&D expenditure. This figure stems from Spengel and Wiegard (2011) and relates to measurements made in 2007. Cf. Spengel et al. (2017: 56f.).
434 Cf. http://www.ifm-bonn.org/definitionen/kmu-definition-des-ifm-bonn/ (last accessed on 16 January 2017).
435 The extrapolation of the revenue loss is also based on the 2007 figure for R&D personnel expenditure as a percentage of total R&D expenditure. Cf. Spengel et al. (2017: 61).
436 Spengel et al. (2017) make further differentiated estimates of tax revenue shortfalls, limiting calculations to R&D personnel expenditure, e.g.,by varying the subsidy rates for non-SMEs/SMEs (4 percent/12 percent or 4 percent/25 percent) and by varying the caps (between one and ten million euro per company).
437 Cf. Rammer et al. (2016) and EFI (2016: 39ff.).
438 The lack of external sources of financing is also a major obstacle to innovation: 22 percent of German SMEs lamented this lack of external funding in the period from 2012 to 2014. Cf. EFI (2016: 41) and Rammer et al. (2016: 105ff.).
439 Most recently, Germany funded only about 14 percent of total R&D expenditure by SMEs in this way. In France, by contrast, more than half of SMEs' R&D costs were financed by more than 206 state funding measures. In the Netherlands and the United Kingdom, the most recent average total funding quotas were 38 and 32 percent respectively. Cf. EFI (2016: 36ff., 41).
440 In Italy and Finland, 64 percent of state-funded R&D in SMEs was financed via indirect tax incentives; in Austria the most recent figure was 41 percent. Own calculations, cf. EFI (2016: Fig. B 1-12).
441 Cf. OECD (2016b).
442 However, the Commission of Experts has no information from other countries relating to tax-based R&D funding

on whether any deviation from the European Commission's definition of SMEs has led to conflicts with state aid rules.
443 Cf. OECD (2015b: 29, 43ff.).
444 Cf. in particular Spengel et al. (2017: 29) on the treatment of contract research.
445 The deadline for submitting a tax declaration does not end until 31 December of the following year if a tax consultant is hired (Section 149 (2) of the German Tax Code [AO]). Furthermore, preparing the tax assessment notice takes additional time.
446 The reduction in payable wage tax would be of no consequence for the R&D employees because the attested wage tax could be deducted in full from the pay scale income tax – i.e. irrespective of the tax credit.
447 Income tax and corporation tax are divided between the Federal Government and the Länder, and the municipalities are entitled to a share of income tax. The Federal and Länder governments each receive 42.5 percent of the income tax and 50 percent of the corporation tax. The municipalities receive 15 percent of the income tax. The distribution of the tax revenue shortfall among the Federal Government and the Länder is thus not dependent on whether the funding is linked to corporation tax, income tax or wage tax, since wage tax represents an advance payment on income tax. Cf. https://www.bundesfinanzministerium.de/Content/DE/Standardartikel/Themen/Oeffentliche_Finanzen/Foederale_Finanzbeziehungen/Laenderfinanzausgleich/DEr-Bundestaatliche-FAG.pdf?__blob=publicationFile&v=4 (last accessed on 16 January 2017).

C

448 The systematic selection of international reference countries is based inter alia on the size of the economies and the national R&D intensity in the OECD and BRICS countries.

C 1

449 Cf. Gehrke et al. (2017).

C 2

450 Cf. Schasse (2017).

C 3

451 In this regard and in the following, cf. Rammer and Hünermund (2013).
452 In this regard, cf. also Rammer et al. (2017).
453 Cf. Blind (2002).

C 5

454 Chapter C 5 is based on a study prepared for the Commission of Experts by the ZEW. Cf. Müller et al. (2017b).
455 However, the data from the individual countries are not fully comparable. For more details on this, cf. Müller et al. (2014).
456 In this regard and on individual points, cf. Müller et al. (2013).
457 An original, newly formed company is created when a business activity not exercized before is begun and provides at least one person with their main source of income. A company closure is when a company no longer exercizes any business activity and no longer offers products on the market.
458 The MUP has a much narrower definition of economically active companies, market entries, and market exits, so that relatively small entrepreneurial activities are not covered in the MUP.

C 7

459 Cf. Frietsch et al. (2017a).
460 Cf. Frietsch et al. (2017a: 18ff.).

C 8

461 This section and the following figures are based on Gehrke and Schiersch (2017).
462 Cf. Gehrke and Schiersch (2017: 74) for a methodological explanation of the RCA indicator.

D

463 Cf. Gehrke et al. (2013).

D

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