RESEARCH, INNOVATION
AND TECHNOLOGICAL
PERFORMANCE IN GERMANY

COMMISSION OF EXPERTS
FOR RESEARCH
AND INNOVATION

EFI

REPORT

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REPORT 2016

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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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C STRUCTURE AND TRENDS

Foreword

In its analyses and recommendations the 2016 Report of the Commission of Experts for Research and Innovation addresses current developments (A chapters), presents a series of detailed studies (B chapters), and documents the development of Germany's research and innovation system on the basis of eight groups of indicators (C chapters).

Not only technological, but also social innovations can help solve societal challenges. These are at the focus of Chapter A 1. Yet, although social innovations have not been sufficiently taken into consideration in German R&I policy up to now, bringing about a change here will not require a paradigm shift in R&I policy: as in other fields, public intervention should only be forthcoming if markets fail.

Patent boxes, which have been introduced in a number of European countries, are considered in Chapter A 2. These schemes grant a reduced tax rate on income from intangible assets such as patents. Patent box regimes cannot be regarded as an equivalent alternative to R&D tax credits. The Commission of Experts maintains its position that the introduction of R&D tax credits is necessary to fund R&D in Germany.

The debate on higher-education policy is currently dominated by the planned continuation of the Excellence Initiative, which is discussed in Chapter A 3. The first rounds of the Excellence Initiative have improved the performance of German science and enhanced its international visibility. German universities that perform particularly well should continue to receive institutional funding in the future. Career prospects for young scientists must be improved. Tertiary education institutions and political decision-makers should work together to ensure that refugees with the appropriate qualifications can gain swift and unbureaucratic access to the German higher-education system.

In Chapter B 1, the Commission of Experts presents its study on innovation in small and medium-sized enterprises (SMEs) in Germany, having announced its intention to do so last year. SMEs are a very heterogeneous group when it comes to their innovation performance. On average, the innovation intensity and innovation expenditure of German SMEs are low by international comparison. Patent activities and innovation successes present a mixed picture. As documented last year, innovation and research activities among SMEs have been declining over the last ten years. Public funding for research by SMEs is very low by international comparison. The most widespread obstacles to innovation are excessive innovation costs and economic risks. Further factors include a dearth of skilled personnel and a lack of internal sources of finance. The Commission of Experts presents a raft of measures to reinvigorate the innovative strength of German SMEs, e.g. by introducing R&D tax credits – paying special attention to the needs of SMEs – and taking measures to increase the number of start-ups and improve the supply of skilled personnel.

Three of the four B chapters complement the studies on the role of digitisation and connectedness submitted in the previous year. In Chapter B 2, the Commission of Experts initially turns to another important key technology: robotics. Germany is currently well positioned by international comparison in the industrial use of robots, but there are research and innovation deficits in the rapidly growing field of service robotics. The Commission of Experts is of the opinion that the Federal Government should develop an explicit robotics strategy that pays particular attention to the growing importance of service robotics. Robotics should play a more significant role than in the past at tertiary education institutions, in the dual system of vocational training, and in all further-training schemes.

In many areas of life, the internet makes itself felt not directly as a new technology, but rather as the basis for new ‘digital business models’ (Chapter B 3), which have increased considerably in economic importance. New intermediaries are increasingly dominating the strategically important access to end customers and threatening the positions of incumbent firms. Software- and internet-based technologies, such as cloud computing and big data, can generate disruptive innovations with far-reaching consequences. The Commission of Experts recommends that the Federal Government should further develop the Digital Agenda into an ambitious strategy focusing on new sources of value creation. There is still a need for legal clarification in the general field of digital business models. Despite all the controversy, the Commission welcomes the new EU General Data Protection Regulation. In many cases, start-ups are the engine driving the development of new forms of value creation. The Commission of Experts reiterates its recommendation to work towards improving the framework conditions for venture capital and setting up a stock-exchange segment for high-growth companies. Computer science should be understood as a new key discipline; skills development in handling digital technologies and business models should be supported in all education and training segments.

In Chapter B 4, the Commission of Experts examines the status quo and prospects of e-government (electronic government) in Germany. In e-government, IT and communication technologies based on electronic media are used to run governmental and administrative processes. E-government represents an innovation in the public sector that is spreading only hesitatingly in Germany. The goal of making Germany’s e-government the international standard for effective and efficient administration by 2015 – formulated by the Federal Government, the Länder and the municipalities in their 2010 national e-government strategy – has not been reached. Germany is a long way behind in this field by international comparison, thus letting important potential for innovation and value creation go to waste: citizens are being deprived of quality improvements in public services, companies are being denied important demand stimuli. The Commission of Experts submits proposals for measures aimed at quickly making up this deficit.

The Commission of Experts reiterates its assessment that digitisation, connectedness and the introduction of new internet-based business models cause disruptive changes. In the light of the experience gained in the 1980s, it is confident that Germany can do well when it comes to making the necessary adjustments to the labour market. Overall, however, German political decision-makers are currently too intent on defending established German strengths. The creative possibilities of digitisation are not being given sufficient consideration. In future, Germany needs to be more involved in opening up new sources of value creation and jobs – this will also require some rethinking among political decision-makers.

Berlin, 17 February 2016

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EXECUTIVE SUMMARY

Executive Summary

A Current Developments and Challenges

A 1 Social innovations – no paradigm shift in R&I policy

Not only technological but also social innovations can help solve societal challenges. However, social innovations are not sufficiently taken into consideration in German R&I policy, which has thus far been dominated by a technological understanding of innovation. The Commission of Experts therefore calls on the Federal Government to focus its attention more on social innovations and to experiment with new forms of participation and with suitable funding instruments, such as inducement prizes.

However, in the view of the Commission of Experts, taking greater account of social innovations does not require a fundamental paradigm shift in the current R&I policy. There is no need for specific criteria in the funding concept that distinguish between social and technological innovations. As in other fields, public funding should only be invested if markets fail. Public funding for social innovations should primarily support the development, research and testing of new ideas for changing social practices. Furthermore, social innovations should also only be supported if they show sufficient potential for economic sustainability. This assessment by the Commission of Experts should not be misunderstood as advocating permanent subsidies for social innovations.

In a similar way to the support and funding that is dedicated to technological innovations, support and funding for social innovations should in principle be systematically and scientifically assessed, supervised and subsequently evaluated.

A 2 Patent boxes – no substitute for R&D tax credits

A number of European countries have introduced tax schemes, known as patent boxes, that grant a reduced tax rate on income from intangible assets like patents. The arguments given to justify this policy are that it promotes innovative activities that create jobs for highly qualified people and generate knowledge. However, empirical evidence does not suggest that a low level of taxation on income from patents leads to an increase in domestic R&D activities.

A patent box scheme is not an equivalent alternative to R&D tax credits. Patent boxes are a fundamentally less suitable instrument for domestically promoting R&D, since they apply to the income from patents, not directly to the R&D activities themselves. Although the Commission of Experts welcomes the international harmonisation of corporate taxation (base erosion and profit shifting – BEPS) launched by the G20 group, it is sceptical about the design of the Nexus Approach. In general, the Commission of Experts recommends that the Federal Government should work in the international context towards the complete abolition of patent box schemes. The Commission of Experts considers the introduction of tax credits to fund R&D to be urgently necessary in order to promote R&D in Germany.

A 3 Current challenges for tertiary education policy

The differentiation of the tertiary education sector should be further intensified under the planned continuation of the Excellence Initiative. Universities that perform particularly well should continue to receive institutional funding in the future. Furthermore, regarding the continuation of the Excellence Initiative, support should be guaranteed for outstanding research structures that are particularly focused on specific issues or disciplines and are internationally recognised. The institutions to be funded should be selected within the framework of a scientific competition procedure.

In order to be able to attract the best talent also in the context of international competition young scientists must be offered attractive working conditions and career prospects. Additional W2 and W3 professorships and more tenure-track career positions should be created over the next few years.

Tertiary education institutions must develop strategies to make better use of the opportunities offered by digitisation. In this context they should be supported by identifying and promoting examples of best practice. The Federal Government could furthermore provide institutional funding for individual institutions to encourage the implementation of particularly ambitious digitisation strategies.

Tertiary education institutions and political decision-makers must also work together to ensure that potential students among refugees gain quick and unbureaucratic access to the German tertiary education system.

B Core Topics 2016

B 1 The contribution of SMEs to research and innovation in Germany

Small and medium-sized enterprises (SMEs) are considered one of the strengths of the German economy. In this context, emphasis is placed primarily on their great importance for employment and innovation. However, SMEs are a heterogeneous group when it comes to their innovation performance.

The innovation intensity and innovation expenditure of German SMEs are low by international comparison. By contrast, patent activities and innovation successes reveal a mixed picture. While German SMEs are leaders in terms of the frequency of product or process innovations, their ranking is only average by European comparison when it comes to patent intensity and the share of revenues that is generated with new products.

The most widespread obstacles to innovation are excessive innovation costs and excessive economic risks followed by the lack of skilled personnel and the lack of internal sources of finance.

In most comparable countries, there exists not only direct funding but also R&D tax credits. In these countries, the percentage of R&D expenditure by SMEs financed from public sources is significantly higher than in Germany, where R&D tax credits do not exist.

The Commission of Experts recommends the following measures:

- The current funding instruments should be supplemented by the introduction of R&D tax credits, paying special attention to the needs of SMEs.
- Germany must make major efforts to counteract the decline in start-up rates – also by attracting foreign entrepreneurs.
- In order to improve the framework conditions for venture capital and thus to create more financing options for innovative companies, the legal foundations announced in the coalition treaty must finally be laid. This should include facilitating the private financing of business start-ups.
- The supply of skilled personnel should be increased overall. Political decision-makers, chambers of commerce, and associations should intensify their support measures for SMEs that recruit foreigners for skilled jobs, and launch a corresponding information campaign.
- The structure of the funding programs at the federal level should be regularly reviewed – and simplified if there is excessive complexity or duplication in the range of funding options.
- The SME funding programs must be evaluated according to current scientific standards. The results of the evaluation should be published and the collected data should be made accessible for further scientific analyses.

B 2 Robotics in transition

Robots have been in use in industrial production for more than 50 years. Initially they performed monotonous, dangerous or physically strenuous tasks within production processes. Nowadays, in many sectors of the economy, potential applications of modern robots also exist beyond the industrial production, namely in the provision of services by so-called service robots. By international comparison, Germany is currently still well positioned in the use of robots in industrial production, particularly in vehicle construction. However, competition is growing in robotics nations such as the USA, Japan, South Korea and China. In addition, service robotics is gaining economic importance: Forecasts predict that it will even overtake the importance of industrial robotics in the near future. Germany is currently not well positioned in this field.

The Commission of Experts recommends the following:

- The Federal Government should develop an explicit robotics strategy, like the ones other countries already have. This strategy should provide appropriate public support that takes the growing importance of service robotics into account.
- A critical view must be taken of the very high concentration of robot use in the German automotive industry. Funding programs should give more consideration to the potential of modern robots in sectors outside of the automotive industry.
- Tertiary education institutions must place greater emphasis on robotics research. Spin-offs from research should be given stronger support than in the past.
- The requirements and opportunities of an increased use of robots must be taught in the dual system of vocational training. It is important not only to target the application of robots in the industrial sector, but also to increasingly focus on the use of service robots.
- Life-long learning, and with it further-training courses in robotics applications and development should be systematically expanded for graduates of both vocational training and tertiary education. Massive Open Online Courses (MOOCs) represent a great opportunity in this context.
- In higher education there should be more interaction between engineering and IT training study programs. At the same time, course elements focusing specifically on robotics should be strengthened.

B 3 Business models of the digital economy

Digitisation and connectedness are creating new opportunities for action and are confronting businesses, policy-makers and society with major challenges. The economic importance of data-driven services and business models for value creation has increased considerably over the last years. New intermediaries are increasingly dominating the strategically important access to end customers and threatening the positions of incumbent firms. Software- and internet-based technologies, such as cloud computing and big data, enable disruptive innovations that have far-reaching consequences. Up to now, Germany has not been able to build up capabilities either in the classical ICT industry or in the new, internet-based sectors of the digital economy. Policy-makers in Germany have failed to create sound framework conditions for new business models; rather, they have tended to trust in incumbent structures and models.

Against this background, the Commission of Experts states the following:
- The Federal Government's strong focus on a relatively small area of digitisation is unlikely to yield the intended results. For example, Industry 4.0 one-sidedly targets efficiency gains in the field of manufacturing technology. Similarly, other industry- or application-specific initiatives such as Smart Service Welt or eHealth are limited in their ability to generate positive funding effects across the broad range of digital applications. There is an urgent need for a convincing overall strategy. The 'Digital Agenda' does not meet this requirement, despite the fact that it delivers a helpful collection of analyses and necessary actions.
- Currently, start-ups that are developing new sources of value creation with ambitious business-model innovations have insufficient access to venture capital and growth finance in Germany. The Commission of Experts reiterates its recommendation to work towards improving the framework conditions for venture capital and setting up a stock-exchange segment for high-growth companies.
- Skill development in handling digital technologies and business models should be supported across the board – in all education and training segments.

B 4 E-Government in Germany: much room for improvement

E-government (electronic government) stands for using information and communication technologies based on electronic media to run governmental and administrative processes. E-government represents an innovation in the public sector. Consistently implemented, it provides significant potential for value creation and can greatly improve the quality of services provided for citizens by public authorities.

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. Various studies show, however, that Germany's e-government is clearly lagging behind by international comparison.

This deficit primarily reflects a limited and not very user-friendly range of e-government services. Germany is thus letting important potential for innovation and value creation untapped.

The Commission of Experts therefore recommends the following:
- The Federal Government should significantly intensify activities to create and develop a central e-government portal as well as an open-data portal for the provision of open government and administration data.

- The e-government portal should offer as many services as possible from the Federal Government, Länder and municipalities in concentrated form, arranged according to the concerns they address, and in the form of a one-stop shop for citizens and businesses. The existing data portal for Germany, GovData, should be developed into an open data portal that makes available the topical data of the Federal Government, Länder and municipalities in machine-readable format for further use.
- The mere provision of e-government offerings and large amounts of data is not enough, and this applies both to the e-government portal and to the data portal. Rather, the expansion of services offered by e-government must go hand in hand with an improvement in user friendliness.
- The development of a comprehensive, digitally integrated e-government service requires the introduction of binding milestones for the Federal Government, Länder and municipalities. The Federal Government should create a central coordination office for e-government in the Chancellery. This should be supported by the IT Planning Council, which must be equipped with the corresponding authority to ensure the constructive cooperation of all stakeholders.

CURRENT DEVELOPMENTS AND CHALLENGES

A

A

A 1 Social innovations – no paradigm shift in R&I policy

Social innovations are becoming more important in R&I policy

In the past, German research and innovation (R&I) funding has been primarily technology oriented. This has led to a growing debate on the role of social innovations in recent years.[1] It is pointed out that although social innovations are important for solving societal challenges, they have not been given sufficient consideration in R&I policy, which is dominated by a technological notion of innovation. Against this background, the Commission of Experts had already advocated a broader definition of the concept of innovation in its 2008 Report.[2]

In innovation policy, the topic of social innovations has been explicitly addressed at the EU level since 2010 within the framework of the Innovation Union initiative.[3] In Germany, different projects on social innovations have been funded by ministries and foundations over the last few years.[4] In its new High-Tech Strategy (HTS), which targets a 'comprehensive interministerial innovation strategy', the Federal Government explicitly refers to the relevance of social innovations. However, neither the concept of social innovation nor how social innovations should be funded has been precisely defined.[5]

Box A 1-1

Examples of social innovation in the context of 'grand challenges'

- Scarce resources: conservation and improved use of resources ('sharing economy')
  - New ways of organising mobility (e.g. Uber)
  - New forms of consumption and living together (e.g. CouchSurfing or Airbnb)
- Climate change: emissions mitigation
  - Cutting energy consumption by means of new forms of consumption and living together (e.g. Prosumetime or Eaternity as specialised coaching services for climate-friendly production and consumption)
- Lifestyle diseases: health sector
  - New concepts of healthcare and prevention (e.g. Discovering Hands: tactile diagnosis by the visually impaired in the early detection of breast cancer)
- Demographics, shortage of skilled labour: integration into education systems and labour market (especially women, older people and migrants)
  - New concepts facilitating access to education, on educational success and access to the labour market for marginalised groups (e.g. coaching initiatives)

What are social innovations?

In the discourse on the role of social innovations in various scientific disciplines there are many different definitions and considerable heterogeneity as regards the concrete understanding of the term. Nevertheless, there is at least a consensus that social innovations can make an important contribution to tackling major societal challenges. Meeting what are known as 'grand challenges' – e.g. climate change – requires not only novel technological developments, but also changes in the way technologies are used, as well as changes in lifestyles, business and financing models, working practices and forms of organisation (cf. Box A 1-1). Such changes are called social innovations and, in principle, represent all changes in social practices. Social innovations can be both complementary to, and a consequence of, a technological change – or be completely independent of technological innovation. According to this general definition, social innovations do not necessarily lead to an improvement in societal conditions and can certainly also be commercially successful.

Policy-makers face the challenge of operationalising social innovations for the purpose of public R&I funding. The heterogeneity of the concept makes it very difficult for public R&I policy to lay down specific funding and success criteria. In the view of the Commission of Experts, however, there is no need for specific criteria distinguishing between social and technological innovations in the concept of funding. Basically, a case can be made for funding eligibility when innovations that are desirable from a welfare perspective cannot be sufficiently developed without public support. In order to determine the types of innovation that are desirable in terms of improving social welfare, greater emphasis should be placed on societal participation – e.g. through internet-based forms of civil dialogue – which in turn is itself a social innovation in the field of governance ('good governance').[6] In past reports, the Commission of Experts had already called for a greater involvement of citizens in setting priorities in R&I funding.[7] The Federal Government has taken up this point in its new High-Tech Strategy and already gathered experience in various dialogue formats.[8]

With regard to social innovations, there should be a clear division of tasks between R&I policy on the one hand and social policy on the other hand. Although, for example, the development, research and testing of new ideas for changing social practices can be eligible for funding, the final implementation of such measures remains the task of social policies. The implementation of policy reforms that essentially mirror social policy should not be seen as social 'innovations' from the point of view of R&I policy, and should not be covered by public R&I funding for this reason.

Tab. A 1-2

Download data

Examples of market failure relating to social innovations and examples of instruments in an extended R&I policy framework

Incidences of market failure	Problems
Social innovation as a public good; diffusion or imitation of ideas by other players ('spillover').	Social innovators do not privatise all social returns on the idea; this leads to underinvestment. Lack of monetary incentives are partly offset by altruistic behaviour.
Information asymmetries on financing markets for social innovations, especially for high-risk start-up activities.	Social and economic returns on social innovation are only partly assessable by investor(s) in advance; this leads to underprovision of funds.
Adoption externalities	Other stakeholders benefit from the initial investments or experiences of social innovators without paying for them; here again the result is underinvestment.
Demand is insufficient or market too poor, e.g. in the case of rare diseases	No incentives for innovators; no investment takes place at all.
Risk aversion and a limited time horizon among players in public or partly privatised sectors such as health or education prevent long-term investment in, and experiments with, innovative services.	Innovative competition is too weak and there are few incentives to improve the quality and preventive orientation of services.

Exemplary instruments of R&I policy

- Direct R&D subsidies: competitive support programmes, inducement prizes for social innovations or real-life laboratories.
- Development of new policy instruments, offering (also) non-monetary incentives and supporting non-profit orientation.
- Demand-side policies or support of diffusion.
- Investment-friendly regulation of financial markets, e.g. rules on crowd funding.
- Extension of entrepreneurial funding framework to include social entrepreneurship.

Source: Own diagram.

How can social innovations be funded?

There is very little funding for the development of social innovations in R&I policy at present. The task of R&I policy is to create positive incentives for innovation where market failure hinders innovation processes that are desirable in terms of solving societal challenges.[9] Table A 1-2 shows different forms of market failure and possible R&I-policy instruments targeting social innovations. For example, patents that create incentives for innovation through temporary property rights have little incentive effect in the field of social innovations because they primarily aim to protect technical inventions.

Competitions for prize money – or 'inducement prize contests' (IPCs) – can be a flexible instrument for promoting social innovations.[10] Such competitions are linked to a clearly defined problem or objective. To this extent, IPCs are a good way to generate target-oriented R&I activities, as well as social and technical solutions for specific societal challenges (cf. Box 1-1).[11] Furthermore, IPCs can provide important incentives for creating business models in the digital economy and encourage the opening and use of open (government) data (cf. Box A 1-3; cf. Chapters B 3 and B 4).

A relatively new funding instrument is the setting up of so-called real-life laboratories in the context of social innovation and regional development.[12]Scientists initiate innovative changes in pilot projects – in close dialogue with representatives of municipalities, businesses and citizens. Real-life laboratories are already being implemented today as instruments of R&I policy at the Länder level. For example, Baden-Württemberg's Science Ministry has selected several real-life laboratories in a competitive bidding process and is providing about eight million euros in funding over the next three years.[13] One specific project is the development of a needs-oriented, digitally based, local public-transport concept that does not require fixed bus stops etc., thus adapting transport services better to the individual needs of users. As in other cases, it is important to ensure that such policy measures are strictly evaluated on a regular basis.

In situations where different departments of government participate in the funding of social innovations, there will be a need for coordination to ensure a coherent and effective use of funds across all departments.

Box A 1-3

Open Data Challenge in the UK

The Open Data Challenge Series (ODCS) is running a series of prize contests on various societal challenges, e.g. in the areas of education, energy and the environment, the labour market, and food, which were launched in 2013 for the first time. Entrepreneurial teams are given support in developing products and services, as well as in founding their ventures in these target areas, in a multi-stage procedure. The process supports the development of ideas and start-ups – in a way comparable to the activities of an accelerator and incubator – and concludes with a prize contest.[14] Only teams that build their internet-based business models on open (government) data can take part in the competition.

The ODCS is supervised and run by the Open Data Institute and the research-oriented Nesta Trust; it is financed by ministries and funding agencies. An evaluation has confirmed the success of the prize contest: Every £1 spent on the ODCS is likely to return between £5-10 to the economy in the first three years.[15]

Recommendations

- Against the background of major societal challenges, the Commission of Experts calls on the Federal Government to focus its attention more on social innovations. Courageous steps will be necessary in the coming years to experiment with new formats of participation and new funding instruments. These steps should be systematically and scientifically assessed, supervised and subsequently evaluated from the outset.
- More efforts should be made to try out new funding instruments like competitions, prizes or real-life laboratories.
- With regard to social innovations there should be a clear division of tasks between R&I policy on the one hand and social policy on the other. Policy reforms that essentially implement social policy should not be covered by public R&I funding. Although the development, research and testing of new ideas for changing social practices can be supported by public R&I funding, ministries in the field of social policy should be in charge of the final implementation of such concepts.

- Support should only be provided for social innovations that demonstrably show sufficient potential for economic sustainability after the expiry of the initial public financing phase for the project. This assessment by the Commission of Experts should not be misunderstood as advocating the provision of public subsidies for social innovations.
- In cases where social innovations are funded by different government departments, there is a need for interministerial coordination of these activities involving the most important stakeholders in the fields of policy, businesses and society. This is especially true in times of grand coalitions in which party-political logic leads to strong and sometimes dysfunctional rivalry between ministries.

A 2 Patent boxes – no substitute for R&D tax credits

Distribution and design of patent boxes

Over the last fifteen years, a number of European countries have introduced schemes granting a reduced tax rate on income from intangible assets such as patents. The term patent box for these schemes derives from the box that is ticked in the tax declaration to indicate income from patents. The reasons given by the various countries that have introduced patent boxes are many and varied: to create incentives for companies to invest more in innovative activities; to attract mobile investment, thereby creating jobs for highly qualified personnel and generating knowledge; and to increase tax revenues from mobile income flows.[16]

Patent box schemes currently apply in twelve European countries. They first attracted widespread public attention when introduced in the Netherlands and Luxembourg in 2007. France and Hungary had already introduced such schemes in 2000 and 2003 respectively.[17] Other countries followed suit in subsequent years (cf. Table A 2-1).

The design of patent box schemes varies from country to country – particularly as regards the level of the tax rate, the definition of eligible intellectual property (IP) rights and the resulting income, and what expenditures on research and development (R&D) related to the intellectual property right qualify under the scheme.[18]

All twelve existing patent box schemes grant a reduced tax rate on income from patents. In Belgium, France and the United Kingdom (UK), the scheme applies not only to patents, but also to supplementary protection certificates.[19] The scope of the schemes in Cyprus, Hungary and the Swiss canton of Nidwalden is much wider. There, the reduced tax rate applies not only to patent income, but also to income from software, trademarks, designs and models, secret formulas and processes, know-how and copyrights.[20]

In all twelve countries, reduced tax rates apply to royalties under the patent box schemes. With the exception of Belgium and Malta, all the countries also grant reduced tax rates on profits from the sale of intellectual property rights. In Belgium, Liechtenstein, Luxembourg, the Netherlands and the UK, notional royalties[21] and sales income from products based on intellectual property assets also qualify. With the exception of the UK, sales income only qualifies if the level of income that is directly connected with intellectual property is calculated. Under the UK's current patent box scheme, all income from products containing a patented invention qualifies for the reduced tax rate.[22]

A further distinguishing feature of patent box schemes is whether only self-developed intellectual property is deemed eligible, or whether acquired intellectual property also qualifies. In the majority of countries with patent boxes, income from acquired intellectual property rights is also subject to the reduced tax rate.[23]

The empirical studies conducted to date suggest that the level of taxation on patent income influences the decision as to where patent applications are filed.[24] A recent study[25] specifically on patent box schemes shows that patent boxes have a positive effect on patent applications. This applies especially to applications for patents of high quality[26] that are expected to generate high levels of income. However, the tax incentive has a negative impact on local innovation activities. This negative effect is weakened if a company is required to engage in R&D locally. This indicates that a low level of taxation on income from patents does not automatically lead to an increase in domestic R&D activities.

In order to create incentives for companies to engage in R&D, a patent box scheme should be selected that makes the tax relief dependent on the company itself carrying out the R&D that leads to the patent (nexus approach). Even more effective would be tax

Tab. A 2-1

Download data

A

Design of existing patent box schemes

Country	Year of introduction	Reduced tax rate under patent box schemes	Nominal corporate income tax rate[1)]	Acquired intellectual property rights promoted?	Type of promoted intellectual property rights	Type of tax-privileged income from intellectual property rights
Belgium	2007	6.8 %	34.0 %	No	Patents, supplementary protection certificates	Royalties, sales income, notional royalties
Cyprus	2012	2.5 %	12.5 %	Yes	Patents, software, copyrights, trademarks, designs, secret formulas and processes, know-how	Royalties, income from the sale of the right
France	2000	16.8 %	35.4 %	Yes	Patents, supplementary protection certificates	Royalties, income from the sale of the right
Hungary	2003	9.5 %	19 %	Yes	Patents, software, copyrights, trademarks, designs, secret formulas and processes, know-how	Royalties, income from the sale of the right
Liechtenstein	2011	2.5 %	12.5 %	Yes	Patents, software, copyrights, trademarks, designs, models	Royalties, income from the sale of the right, sales income, notional royalties
Luxembourg	2008	5.8 %	29.2 %	Yes	Patents, supplementary protection certificates, software, trademarks, designs, models	Royalties, income from the sale of the right, sales income, notional royalties
Malta	2010	0 %	35 %	Yes	Patents, software, copyrights, trademarks	Royalties
Netherlands	2007	5 %	25 %	No	Patents, software, designs	Royalties, income from the sale of the right, sales income, notional royalties
Portugal	2014	15 %	30 %	No	Patents, designs	Royalties, income from the sale of the right
Spain	2008	12 %	30 %	No	Patents, designs, secret formulas and processes	Royalties, income from the sale of the right
Switzerland (only Nidwalden canton)	2011	8.8 %	12.7 %	Yes	Patents, software, copyrights, trademarks, designs, secret formulas and processes, know-how	Royalties, income from the sale of the right
United Kingdom	2013	10 %	21 %	Yes	Patents, supplementary protection certificates	Royalties, income from the sale of the right, sales income, notional royalties

[1)] Includes, where applicable, surcharges (Belgium, France, Luxembourg and Portugal), local taxes (Luxembourg and Nidwalden canton) and other income taxes (France). The maximum rate is assumed in each case. Source: own diagram based on Evers et al. (2015).

A

credits on these R&D activities. The advantages and disadvantages of these two options are discussed in the next section.

Effect of R&D tax credits and patent boxes: a comparison

The provision of public support for investment in R&D is generally justified by the existence of externalities. This means that innovators are unable to appropriate the full social returns of their product or process developments and therefore invest too little in the production of knowledge from a societal point of view. Other firms often also benefit from a company's innovation by finding out about the newly created knowledge – e.g. via conversations among employees, by employees moving to another company, by product re-engineering or other forms of knowledge flows.

The tax system can be used in different ways to promote innovation. The most common forms are R&D tax credits and tax credits under a patent box scheme.[27] The key difference between these two measures is that, in the case of R&D tax credits, the innovation input, i.e. R&D, is favoured via the incurred costs. In the case of patent box schemes, by contrast, it is the output, i.e. the patent, that is favoured via the income it generates.

One advantage of promoting the innovation output by means of a patent box scheme is that successful inventors are rewarded, thus creating incentives to pursue promising projects. On the other hand, not all innovations are patentable, so that patent boxes only support a certain proportion of eligible R&D results.

Moreover, there is much evidence to suggest that the knowledge externalities are greatest when knowledge is generated, i.e. at the R&D stage.[28] It has been proved that the better innovations are protected by patents, the harder it is for other companies to build on this knowledge. A study[29] with American patent data shows that the externalities that are generated by companies financed with venture capital are lower in industries where patents offer particularly effective protection. Patent boxes thus primarily promote innovations that can be well protected by patents and which offer the companies particularly good opportunities to appropriate the returns of the innovation. But this means that in such cases the innovations being promoted are not those which exhibit particularly high externalities.[30]

One advantage of patent box schemes could be that they increase the incentive to license patents to third parties. Lower taxation on income from the sale or licensing of patents might make this profitable for a company. The dissemination and use of knowledge and technologies could be increased by other companies integrating them into their products. The extent to which patent box schemes have actually contributed to more licensing, or to a broader use of new technologies, and how strong this effect might be, has not yet been examined empirically.

At the same time, R&D tax credits have a more targeted effect when it comes to increasing domestic R&D expenditures and creating jobs in the R&D field. Since the tax credit is granted in the country where the R&D expenditure is incurred, it promotes domestic R&D and jobs. In a patent box scheme, however, this is only the case if it includes the requirement that the R&D relating to a patent must be carried out within the country. Without such a requirement, the R&D can also be carried out in another country, so that there are no employment effects on the domestic labour market for R&D personnel.

When considering the financing aspect, it should be borne in mind that it sometimes takes a long time before a company's R&D translates into a patent and the patent generates income. The financial support provided by a patent box therefore involves a much longer waiting period for a company than R&D tax credits; it therefore requires a longer period of financing from other sources.

When the two funding options – R&D tax credits and patent boxes – are compared in terms of the positive externalities and the related financing effects that are generated, the result is largely in favour of R&D tax credits. The use of a patent box in addition to R&D tax credits seems to make little sense if the primary objective is to encourage R&D. The fact that most of the countries that have introduced a patent box scheme also offer R&D tax credits suggests that the main aim of patent boxes is to attract internationally mobile companies or their patent portfolios.

Box A 2-2

Design of the nexus approach – actions agreed on under the BEPS Action Plan

The nexus approach determines the substantial business activity via expenditures. However, it is not the absolute amount of expenditures that is decisive, but the proportion of qualifying expenditures relative to overall expenditures on the development of intellectual property. This proportion determines how much of the overall income resulting from the intellectual property right is subject to the reduced tax rate (cf. Figure A 2-3).[31]

The qualifying expenditures for the development of the intellectual property must be incurred directly by the taxpayer. They comprise only expenditures necessary for the R&D activities that are actually carried out. Expenditures with no direct connection to specific intellectual property rights cannot be deducted (e.g. interest payments, building costs, acquisition costs). The exact definition of these expenditures is the responsibility of the individual countries.

In order to take into account the fact that both the acquisition of intellectual property rights and contract research play an important role for companies, it is possible to increase the qualifying expenditures by also including such expenditures. To ensure that the principle of the substantial business activity is maintained, the increase is limited to 30 percent of the qualifying expenditures.[32]

The total expenditures are made up of the qualifying expenditures, acquisition costs for intellectual property, and expenditures on contract research.[33]

Under the nexus approach, only income from patents and intellectual property rights that are functionally equivalent to patents – i.e. are legally protected and subject to similar approval and registration processes – are to be taken into account.[34]

Only income directly derived from intellectual property rights should receive preferential tax treatment, i.e. royalties, capital gains and income from the sale of products directly related to the intellectual property assets (embedded IP income). Countries that decide to give preferential treatment to embedded IP income must implement a consistent and coherent method to distinguish from other income that part of the income that is attributable to intellectual property.[35]

Fig. A 2-3

Download data

Calculation of tax-privileged income under the nexus approach

Qualified expenditures for the development of intellectual property / Total spending on the development of intellectual property X Total income resulting from the intellectual property right = Tax-privileged income

Source: own diagram based on OECD (2015a).

International harmonisation of patent boxes

In November 2012 the G20 group asked the OECD to draw up measures to combat so-called base erosion and profit shifting (BEPS), the aim being to ensure that corporate profits are taxed in the country where economic activities take place and value is created. The project included an Action Plan with several points, including the issue of patent boxes, or the granting of tax advantages for income generated by intellectual property. One core topic was to draw up a definition of the substantial business activity, on which special tax schemes are to depend in the future. It was decided to pursue the nexus approach.[36] The results were endorsed at the meeting of the G20 finance ministers in October 2015.

The nexus approach is based on the principle of an expenditure-oriented tax regime, in which expenditures and tax benefits are directly linked to each other, as, for example, in the case of R&D tax credits. The nexus approach extends this principle to income-oriented tax regimes. It allows countries to grant not only tax advantages on expenditures incurred in the creation of intellectual property, but also on the income resulting from the intellectual property right. In the case of the latter, however, there must be a direct relationship, a nexus, between tax-privileged income and the expenditures contributing to this income.[37] In order to prove the nexus between expenditures on intellectual property and income from intellectual property, companies that want to benefit from patent box schemes must comprehensively track and document their expenditures and income in relation to the intellectual property.[38]

Cf. Box A 2-2 for a detailed description of the nexus approach.

In its previous annual reports, the Commission of Experts has repeatedly expressed the concern that the introduction of patent box schemes in Europe has triggered a race for the most favourable tax conditions for income from intellectual property.[39] For this reason the Commission of Experts considers the nexus approach a step in the right direction, in order to achieve at least a partial relation between R&D investment and tax relief and to counteract purely tax-induced transfers of profits. However, the Commission of Experts points out that the present design proposals make very high demands and would involve a considerable amount of work for companies in tracking their income and expenditure. Furthermore, often it is difficult or even impossible to allocate expenditures and income to a specific intellectual property right.

Recommendations

Patent boxes are a fundamentally less suitable instrument for promoting domestic R&D, since they apply to the income from patents, not directly to the R&D activities themselves. There is the risk of putting non-patentable research results and commercially unsuccessful R&D projects at a disadvantage, even though they can also contribute towards raising the level of knowledge and enhancing the capacity for innovation.

- The patent box is not an equivalent alternative to R&D tax credits and must not be depicted and pursued as such by political decision-makers.
- The Commission of Experts welcomes the international harmonisation of corporate taxation (base erosion and profit shifting, BEPS) initiated by the G20 group, but is sceptical about the design of the nexus approach. The current proposal for the concrete implementation of the nexus approach involves a disproportionate amount of red tape for the companies concerned. Simpler rules need to be found here.
- It would be preferable to abolish patent box schemes completely. The Commission of Experts recommends that the Federal Government should work towards this aim in the international context.
- The Commission of Experts considers the introduction of R&D tax credits to be urgently necessary in order to promote R&D in Germany. Germany is one of the few countries offering no R&D tax credits to date. The Commission of Experts therefore continues to see the need to support innovation financing by means of R&D tax credits.

Current challenges for tertiary education policy

A 3

The German innovation system requires efficient and internationally competitive tertiary education institutions conducting basic research, applied research and teaching at a high and the highest level. In addition, universities and colleges should give society and the business sector access to their results and at the same time take on new problems and insights. Against this background, Germany's tertiary education institutions – and government tertiary education policy in general – face a wide range of challenges. These include, among many others, further differentiating Germany's tertiary-education system, creating attractive conditions for young scientists, taking the opportunities offered by digital change, and integrating refugees.

Further differentiating Germany's tertiary-education system

On several occasions, the Commission of Experts has advocated a further differentiation of the German tertiary-education system.[40] This could sustainably reinforce not only its own international competitiveness, but also the competitiveness of Germany as a whole.

Ten years ago, the Excellence Initiative set a differentiation process in motion. The Excellence universities have succeeded in enhancing their international visibility.[41] The promotion of graduate schools and clusters of excellence helped set scientific priorities at the supported universities,[42] thus initiating a process of differentiation between tertiary education institutions.

In December 2014, the Federal and Länder governments took a fundamental decision on a new initiative to follow the Excellence Initiative, which expires in 2017.[43] A concept detailing specific elements of the follow-up programme will be submitted by the Joint Science Conference (Gemeinsame Wissenschaftskonferenz, GWK) in June 2016. This is to be developed on the basis of the Imboden Commission's evaluation of the Excellence Initiative and launched at the end of 2016.

The Commission of Experts recommends using the planned continuation of the Excellence Initiative to further intensify the differentiation of tertiary education institutions. German universities that are performing particularly well at the time when the decision on funding is taken should continue to receive institutional funding in the future – in a similar way to the third line of funding of the current Excellence Initiative – to ensure a high level of visibility for the German science system. The term 'excellence' should be defined more precisely in future. A University of Excellence should not only conduct outstanding research, but must simultaneously make a successful contribution to the knowledge transfer of research results to business and society. Furthermore, regarding the continuation of the Excellence Initiative, support should also be given for outstanding research structures that are particularly focused on specific issues or disciplines and are internationally recognised.

Using science-driven competitions to choose the institutions to be funded has proved a successful procedure in the past.[44] The standards that have already been reached in the assessment of scientific projects must definitely be maintained and further enhanced.

The two rounds of applications for the Excellence Initiative have shown that the task of meticulously filing and evaluating applications involves a lot of work for the scientists involved. The duration of funding should therefore in future be significantly longer than five years,[45] to make it possible to implement long-term research programmes and to reduce the workload involved in the application process relative to the duration of funding.

When it comes to the differentiation of the tertiary-education system, other performance dimensions of universities and colleges in addition to research are also of importance: e.g. teaching, further education, knowledge transfer and research infrastructure. Tertiary education institutions are invited to identify their comparative advantages and to raise their profiles on that basis.

Creating attractive conditions for young scientists

The tertiary education institutions have the task of training young scientists, and that is a great responsibility. Universities and colleges must enable doctoral and post-doctoral researchers to become as well qualified as possible for their subsequent activities both inside and outside the science system. Attractive working conditions and career prospects must be offered in order to attract the best talents – also in the context of international competition.

Most young scientists at universities and colleges have fixed-term contracts.[46] When such fixed-term contracts are concluded between state tertiary education institutions and academic staff, the relevant law is the Law on Fixed-Term Employment Contracts in Science (WissZeitVG), which came into force in 2007. The core of the special fixed terms agreed here is the unfounded maximum fixed term, which amounts to six years both before and after PhD graduation (section 2, subsection 1, sentences 1 and 2 of the WissZeitVG). The Law on Fixed-Term Employment Contracts in Science is also the basis for fixed-term options when posts are funded by third parties (section 2, subsection 2 of the WissZeitVG). An evaluation of the law conducted in 2011 showed, inter alia, that the terms of more than half of the contracts concluded at tertiary education institutions amounted to less than one year.[47] The evaluation also revealed ambiguity with regard to the relevance of the scientific qualification for the unfounded fixed term. Further ambiguity was identified regarding the extent to which periods of temporary employment before graduation count towards the maximum fixed term.[48]

The Bundestag passed an amendment to the Law on Fixed-Term Employment Contracts in Science on 17 December 2015 which touched on the above-mentioned points, among other things.[49] In future, unfounded fixed terms will only be allowed in connection with an academic or artistic qualification; the period of the fixed term must be appropriate in view of the targeted qualification. In cases of third-party financing, the period of the fixed term is to correspond to the duration of the project. Furthermore, the amendment of the Law on Fixed-Term Employment Contracts in Science clarifies the extent to which fixed-term employment contracts are permitted before graduation.

The Commission of Experts is aware that there were shortcomings in the field of tertiary education under the old legal framework, and that these may have been favoured by the earlier version of the Law on Fixed-Term Employment Contracts in Science. Some of these shortcomings will be eliminated with the revised version of the law.[50]At the same time, the Commission is sceptical as to 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 being burdened with a lot of bureaucracy, and the trend seems to be towards limiting their flexibility.

Structured doctoral study programmes in the form of research training groups and graduate schools have grown in importance[51] and the quality of training for PhD students has improved. In the view of the Commission of Experts, there is now a further need for action to improve the career prospects of post-doctoral students. Since the percentage of permanently employed professors is very low in Germany by international comparison,[52] post-doctoral students can expect little chance of a permanent position.[53] Furthermore, German universities rarely offer tenure-track careers and therefore often have little to offer to attract and keep talented young scientists in the face of international competition.[54]

At the Joint Science Conference (GWK) held in April 2015, the Federal and Länder governments agreed to implement an initiative for young scientists aimed at helping tertiary education institutions to make young scientists' future career prospects more reliable and easier to plan.[55] The negotiations to flesh out the details of the initiative have not yet been completed.

The Commission of Experts advocates a change in the personnel structure at the universities. It sees this as a key starting point for improving the situation of young scientists. Over the next few years additional W2 and W3 professorships should be created and the curricular standard values concurrently raised. This would have the advantage of reducing the teaching workload of professors and bringing the student-to-professor ratio into line with international standards. This could improve not only young scientists' career prospects, but also the quality of teaching, and increase the time resources available for research.[56]

In addition to the creation of additional W2 and W3 professorships, the Commission of Experts recommends creating more independent research and teaching positions for post-doctoral students. The growth in the establishment of junior research groups that can already be observed should continue.[57] An increasing number of tenure-track careers should be offered instead of the usual form of junior professorships, which do not provide for a continuation of employment even after a successful probationary period. This would offer the job holders permanent employment after successful evaluation – which should be carried out according to transparent criteria.

Forms of faculty organisation within universities are also an important issue if there is to be a change in the personnel structures at universities.[58] For example, universities in the USA and the United Kingdom have departmental structures, as opposed to the German system, which follows the 'professorship principle'. There should be more experimentation with such models.

Taking the opportunities offered by digital change

Tertiary education institutions should make better use of the opportunities offered by digital change.

An adequate digital infrastructure is a prerequisite for excellent research and teaching. This applies not only to the STEM subject group, but increasingly also for the social sciences and humanities.[59] The focus here is on the development, expansion and networking of information infrastructures. In the social sciences, it is essential to build up and have access to data stocks, which make empirical analyses possible.[60] In the humanities, the digitisation of texts and artefacts in particular opens up new avenues of research.[61]

The priority in teaching is to pass on to students skills with which they can exploit the potential of digitisation in research and practice – for example techniques such as programming, data mining and text mining. Computer science education should be more interdisciplinary and application-oriented that it is today. Furthermore, greater use should be made of digital technologies for teaching skills and knowledge; one instrument, for instance, could be Massive Open Online Courses (MOOCs).[62]

Digital solutions can also be used to further optimise administrative processes in tertiary education institutions and make them more transparent. In addition, digitisation offers opportunities to improve knowledge transfer to business and society,[63] to make more progress with the internationalisation of tertiary education,[64] and to engage in citizen science.[65]

Tertiary education institutions need individual strategies for dealing with the challenges of digitisation. The Commission of Experts has the impression that this topic has been neglected by many education institutions up to now. Such strategies need to be developed against the background of the respective profile-building processes. Issues such as open access and open data must also be taken into consideration.[66] The tertiary education institutions can be supported in their strategy development by identifying and supporting best-practice examples.[67] Furthermore, the Federal Government could provide institutional funding for individual tertiary education institutions to encourage the implementation of sustainable digitisation strategies which promote interdisciplinarity (cf. Chapter B 2), have especially ambitious aims, and can be used to build the profiles of these universities and colleges.

Beyond project-related IT investments, tertiary education institutions need sufficient basic resources to build up, expand and operate an appropriate digital infrastructure.

Giving refugees easier access to the tertiary-education system

Providing refugees with the appropriate qualifications access to the education system – and thus also to the tertiary-education system – is a big challenge both for the tertiary education institutions and for tertiary education policy.[68] It is necessary to tackle this task quickly – both for humanitarian reasons and in the light of the looming shortage of skilled labour. In the meantime there are a large number of programmes and initiatives at German universities and colleges aimed at integrating refugees.[69] Various measures have also been taken at the federal-state level to give qualified refugees access to tertiary education.[70] In addition, on 3 December 2015 the Standing Conference of Education Ministers passed a resolution on procedures for providing access and admission to tertiary education for applicants who no longer have proof of the tertiary education entrance qualification they acquired in their home country as a result of their flight.[71]

The Commission of Experts is in favour of sometimes using unconventional methods to give refugees access to the tertiary-education system. Innovative ways of proving qualifications – and study courses in the form of the English-speaking MOOCs – can be part of the solution. A lack of German language skills, and lost or not recognised documents, must not mean that qualified refugees have to wait a long time for a university education – or be forced to abandon the idea altogether.

The private Kiron University in Berlin, founded as a start-up in 2014, has an interesting concept: its aim is to enable refugees to gain a university degree free of charge.[72] For the first two years of study the programme is made available in the form of MOOCs that can be subtitled in the respective language. Complementary support is also available in the form of language courses and access to IT infrastructure. In the third year, students who have been successful hitherto can attend regular lectures and seminars at the partner tertiary education institutions – these include the RWTH Aachen, the Eberswalde University for Sustainable Development, and Heilbronn University.

Recommendations

- Regarding the continuation of the Excellence Initiative, institutional funding of Germany's best-performing universities should be maintained. In addition, support should be provided for outstanding research structures that are focused on specific issues or disciplines and internationally recognised.
- Tertiary education institutions should further raise their profiles and, in addition to their main research areas, also focus on other performance dimensions such as teaching, further education, knowledge transfer and research infrastructure.
- The personnel structure of tertiary education institutions must be changed in order to create attractive conditions for young scientists. Over the coming years additional W2 and W3 professorships should be set up and the curricular standard values concurrently raised. An increasing number of tenure-track careers should be offered instead of the usual form of junior professorships, which do not provide for a continuation of employment even after a successful probationary period.
- Tertiary education institutions must develop strategies to make better use of the opportunities offered by digitisation. In this context they should be supported by identifying and promoting examples of best practice. Furthermore, the Federal Government could provide institutional funding for individual tertiary education institutions to encourage the implementation of digitisation strategies which promote interdisciplinarity (cf. Chapter B 2), have especially ambitious aims, and can be used to build the profiles of universities and colleges. Sufficient basic resources must be available to build up, expand and operate an appropriate digital infrastructure.
- Tertiary education institutions and political decision-makers must work together to ensure that refugees with the appropriate qualifications gain swift and unbureaucratic access to the German tertiary-education system.

CORE TOPICS
2016

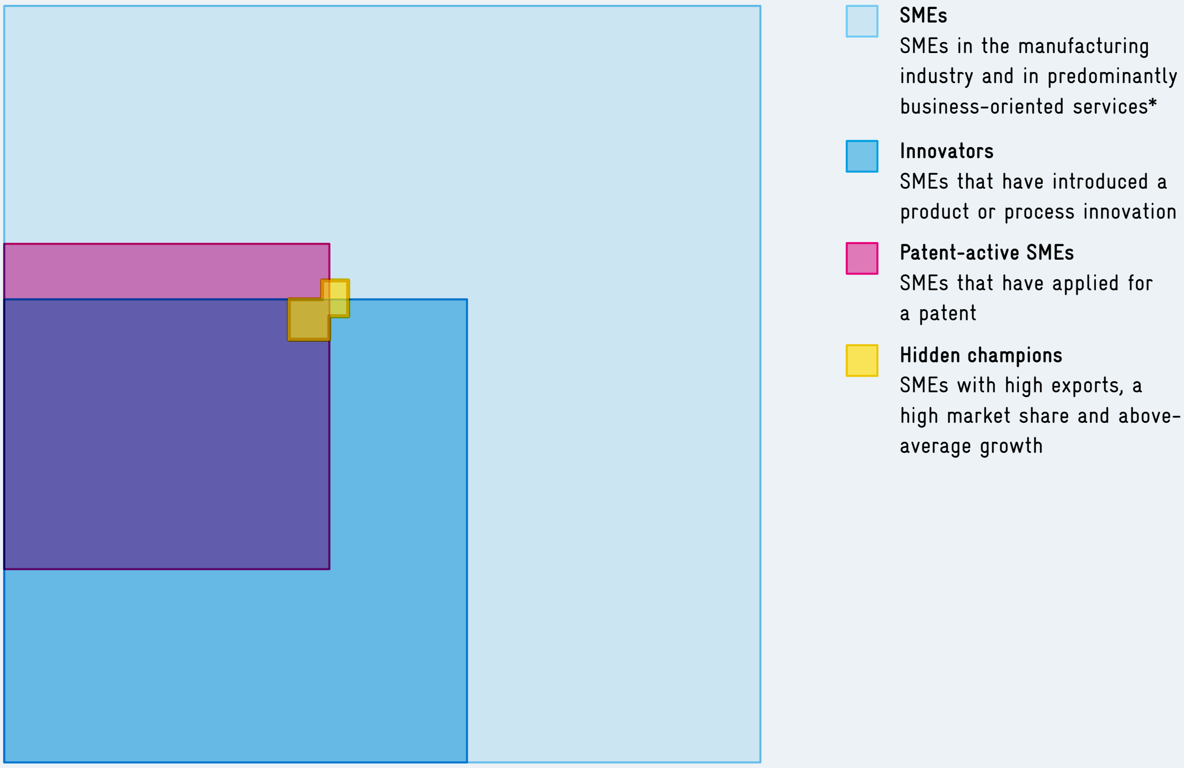
B

The contribution of SMEs to research and innovation in Germany

According to the European Commission's definition, an enterprise is a small or medium-sized enterprise (SME) if it has no more than 249 employees and generates an annual turnover not exceeding 50 million euros or posts a balance sheet total of no more than 43 million euros.

Group of SMEs is heterogeneous

Innovators, patent-active SMEs and hidden champions
as a percentage of all SMEs, 2010–2012



* Manufacturing industry: divisions 5-39 of WZ 2008 classification of economic activities; predominantly business-oriented services: divisions 46, 49-53, 58-66, 69-74 (without 70.1), 78-82 of WZ 2008 classification of economic activities.
Source: Mannheim Innovation Panel. Calculations by ZEW (Centre for European Economic Research).

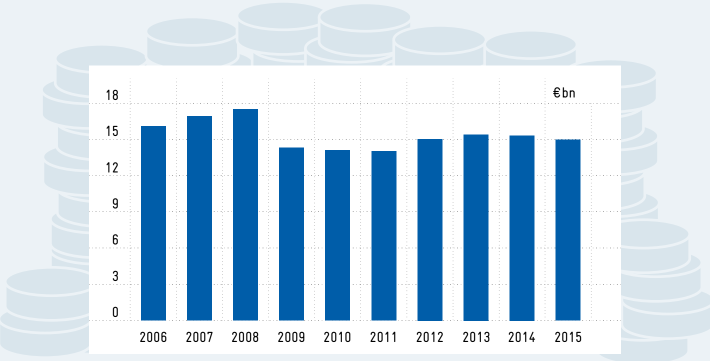
Innovation expenditure by German SMEs is low by international comparison

Innovation expenditure per innovation-active SME; average figures for 2008, 2010 and 2012 (in thousands of euros)

500 France
440 Sweden
400 United Kingdom
210 Germany

Innovation expenditure by German SMEs has stagnated since 2009

Innovation expenditure by German SMEs (in billions of euros)



Lack of skilled personnel and sources of finance as important obstacles to innovation

33% Percentage of innovation-active SMEs that regarded a lack of suitable skilled personnel as an obstacle to innovation in the period 2012 to 2014.

68% Percentage of researching SMEs that experienced difficulties in recruiting new scientific staff due to high salary demands in 2013.

30% Percentage of innovation-active SMEs that regarded a lack of internal sources of finance as an obstacle to innovation in the period 2012 to 2014.

22% Percentage of innovation-active SMEs that regarded a lack of external sources of finance as an obstacle to innovation in the period 2012 to 2014.

23,000 Number of SMES that restricted their innovation activities due to a lack of finance in the period 2010 to 2013.

11,000 Number of SMES that abandoned their innovation activities due to a lack of finance in the period 2010 to 2013.

Public R&D funding of SMEs in Germany is relatively low

Direct and indirect public financing of R&D by SMEs as a percentage of total R&D expenditure by SMEs, 2011/2013

Source: International comparison of innovation expenditure: Community Innovation Surveys. Calculations by ZEW in Rammer et al. (2016). Innovation expenditure by German SMEs and lack of skilled personnel and sources of finance: Mannheim Innovation Panel. Calculations by ZEW in Rammer et al. (2016). Percentage of researching SMEs that experienced difficulties in recruiting new scientific staff: Schneider and Stenke (2015).
For information on direct and indirect public financing of R&D in SMEs as a percentage of total R&D expenditure by SMEs: OECD: Research and Development Statistics, Main Science and Technology Indicators. Calculations by ZEW in Rammer et al. (2016). The study by Rammer et al. (2016: 152) shows that the observed rate in a number of OECD countries is significantly higher than in Germany.

Download data

B 1 The contribution of SMEs to research and innovation in Germany

B 1-1 Introduction

In its 2015 Report, the Commission of Experts drew attention to the fact that the innovation efforts of SMEs have been declining over the long term. This chapter discusses possible reasons and options for action.

The group of small and medium-sized enterprises (SMEs) is generally regarded as one of the special strengths of the German economy. Their importance for employment and innovation is emphasised, and the role of the so-called hidden champions (cf. Box B 1-1) in particular is regularly highlighted.

In Germany the terms Mittelstand and SMEs (in German KMU) are often used synonymously in the public discussion. Indeed, there are overlaps between these groups of companies; here, however, a clear distinction is made between the terms. There is no generally accepted definition of Mittelstand. The Institute for Mittelstand Research (IfM), for example, states that the decisive criterion for a company being a member of the Mittelstand is that ownership and

Box B 1-1

Hidden Champions

The term 'hidden champions' was coined by Hermann Simon in a study published in 1990.[73] It refers to a group of companies, often relatively unknown, most of which are owner-managed and not quoted on the stock exchange. Each company has an annual turnover of less than three billion euros, targets the world market, and is one of the top three companies in its respective market in terms of market share. One characteristic feature of hidden champions is the fact that they are active in narrow niche markets. Almost half of the hidden champions identified by Simon worldwide come from Germany;[74] although a large proportion of these companies are owner-managed, they are not SMEs, but have more than 249 employees.

The following section examines the importance of hidden champions for the group of SMEs in Germany using data from the Mannheim Innovation Panel (MIP).[75] The criteria for hidden champions were operationalised on the basis of these data as follows: (i) Their main sales market is outside of Germany; at the same time a proportion of their exports must also go to countries outside of Europe. (ii) They have a high market share in their main sales market.[76] (iii) Their growth over the last five years was above-average compared to the average growth in their industry.

On the basis of these criteria, about 1,200 SMEs with up to 249 employees were identified as hidden champions for Germany for 2012, plus more than 350 enterprises with a headcount of between 250 to 999 employees. These two groups had just under 300,000 employees and an annual turnover of approximately 93 billion euros in 2012.

The hidden champions among the SMEs (up to 249 employees) are much more innovation-oriented than the overall SME group. In 2012, 77 percent of the hidden champions among the SMEs introduced a product innovation (compared to 29 percent for all SMEs). There are also marked differences when it comes to continuous R&D activities (47 percent vs. 10 percent).

management are in the same hands. The company's size is not, therefore, the decisive factor. However, many SMEs also meet this criterion, so that there are considerable overlaps between the two groups of SMEs and the Mittelstand.[77] The IfM defines the group of SMEs as all companies with fewer than 500 employees and annual sales of less than 50 million euros.[78]

This chapter focuses on the innovation performance of SMEs as defined by the EU, i.e. companies with a staff headcount of up to 249. This group of companies accounts for 10 percent of Germany's total R&D expenditure and 15 percent of the country's innovation expenditure. It is responsible for 24 percent of the transnational patent applications by all German companies.

SMEs are a heterogeneous group in terms of their innovation performance. Between 2010 and 2012, 42 percent of SMEs launched a product or process innovation. 40 percent of SMEs had innovation expenditures in 2012; 22 percent of them had internal research and development (R&D) operations;[79] 18.5 percent applied for a patent in the period from 2010 to 2012.[80]

The contribution of SMEs to research and innovation in Germany – input side

B 1–2

As a first step in drawing a differentiated picture of the SMEs' contribution to innovation, the input side of the innovation process – in the form of innovation expenditure and SMEs' expenditure on R&D by international comparison – is observed.[81] The comparison is made with seven European countries (reference countries) that are especially active in innovation or else comparable to Germany in terms of their structure (Austria, Finland, France, Italy, the Netherlands, Sweden and the United Kingdom (UK)). The differences between expenditure on R&D and expenditure on innovation are explained in Box B 1-3.

Innovation expenditure is low by international comparison

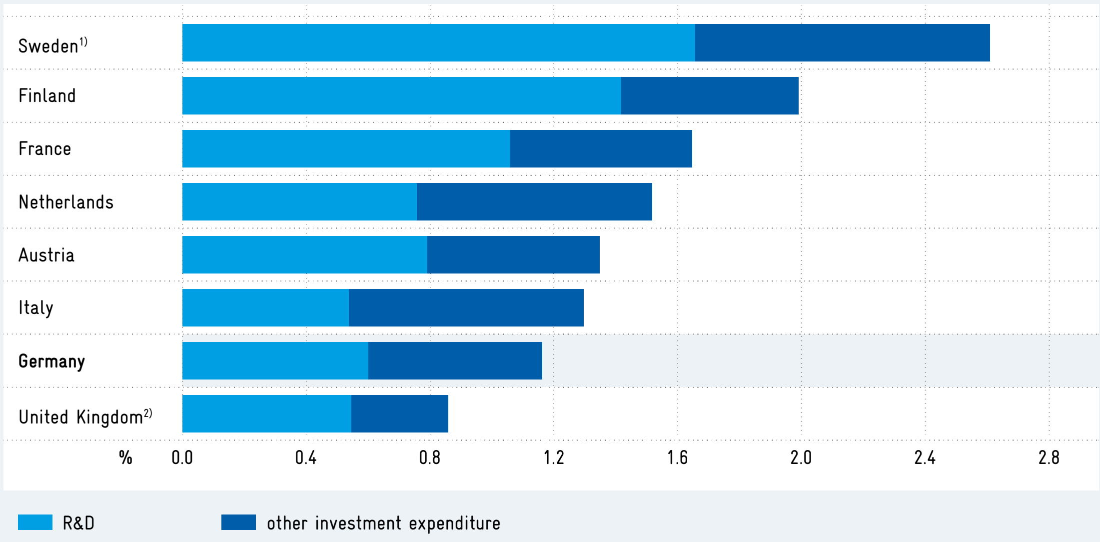
Figure B 1-2 shows the innovation intensity of SMEs, i.e. their expenditure on innovation as a percentage of the total turnover of the group of SMEs. The ratio of innovation expenditure to sales is higher among SMEs in Sweden, Finland, France, the Netherlands,

B

Fig. B 1-2

Download data

Innovation expenditure by SMEs (10 to 249 employees) as a percentage of the turnover of all SMEs; average figures for 2008, 2010 and 2012



[1)] only 2008, [2)] only 2012
Source: Eurostat: Community Innovation Survey. Calculations by ZEW in Rammer et al. (2016)

Box B 1-3

R&D expenditure versus innovation expenditure

The OECD's Frascati Manual[82] defines R&D expenditure as expenditure on creative work undertaken on a systematic basis in order to increase the stock of knowledge – also with the objective of developing new applications. The definition of innovation expenditure in OECD's Oslo Manual[83] 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 design, conceptual design, training and further education, market launches and other preparations for the production and distribution of innovations.[84]

Austria and Italy than in Germany. With regard to R&D expenditure, the picture is very similar; only the UK and Italy have lower figures than Germany.

Another indicator for measuring innovative strength is the average expenditure on innovation per innovation-active[85] SME.[86] According to this indicator, innovation expenditure by German innovation-active SMEs is lower than those of the reference countries (cf. Figure B 1-4). Germany's position is slightly better if the industrial sector is considered alone. Here, innovation expenditure per innovation-active SME is higher than in the UK and Italy. Moreover, innovation expenditure both in small (10 to 49 employees) and in medium-sized enterprises (50 to 249 employees) is lower in Germany than in the reference countries.

Innovation intensity of German SMEs is declining

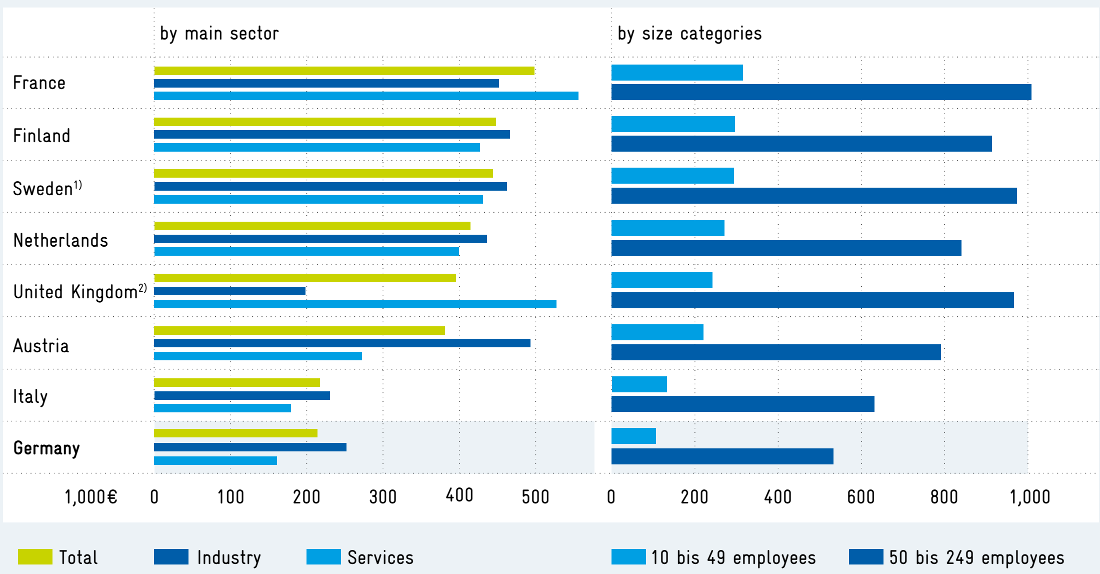
An analysis of the development of innovation intensity among German SMEs shows a downward trend over the last few years. In contrast to innovation intensity, R&D intensity has remained constant at approximately 0.6 percent. The decline in innovation intensity from 1.7 percent (2006) to 1.2 percent (2014) has therefore been caused by a decrease in the part of innovation expenditure that goes beyond R&D expenditure (cf. Figure B 1-5).

Several factors influence the level of SMEs' expenditure on innovation and R&D.[87] First, the group of SMEs changes over time. The MIP data

Fig. B 1-4

Download data

Innovation expenditure per innovation-active SME (10 to 249 employees); average figures for 2008, 2010 and 2012 (in thousands of euros)

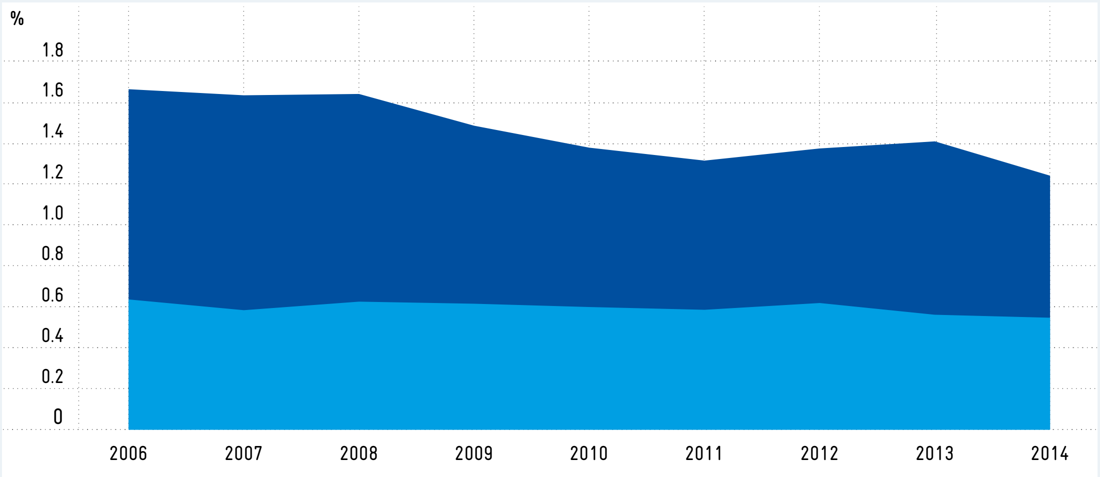


1) only 2008, 2) only 2012.
Source: Eurostat: Community Innovation Survey. Calculations by ZEW in Rammer et al. (2016)

Fig. B 1-5

Download data

Innovation and R&D intensity of SMEs (5 to 249 employees), 2006 to 2014 (figures in percent)



Innovation and R&D expenditure by SMEs as a percentage of the turnover of all SMEs;
Source: Mannheim Innovation Panel. Own diagram based on written information provided by the ZEW.

show that, between 2006 and 2013, start-ups and closures, as well as the movement of companies above the upper and below the lower threshold values of the SME definition, led to a net average loss per annum of 1 percent of total SME innovation expenditure and 1.7 percent of total SME R&D expenditure. The decisive factor for the negative balance is the transition from SMEs to the group of large companies.

Second, the contribution of young SMEs (maximum of five full financial years) to expenditure on innovation and R&D fell markedly. Since 2009 the innovation and R&D expenditure of young SMEs has decreased continuously – innovation expenditure from 2.6 billion euros in 2008 to 1.1 billion euros in 2013, and R&D expenditure from 1.0 billion euros to 0.4 billion euros in the same period. Two factors play a role here. On the one hand, innovation expenditure per young SME fell significantly between 2006 and 2013, while R&D expenditure per young SME remained stable. On the other hand, the number of young SMEs has fallen. This in turn was caused by the decline in start-up activity in Germany since 2004,[88] which could be at least partly a result of demographic change. As shown by a topical study based on the Global Entrepreneurship Monitor, start-up activities are lower in countries with an older population than in countries with a younger population.[89]

In order to describe the development of SME expenditure on innovation and R&D in a more differentiated manner, SMEs with innovation expenditure are categorised in the following into continuously researching SMEs (26 percent), occasionally researching SMEs (22 percent), and SMEs with innovation expenditure but no internal R&D (52 percent).[90]

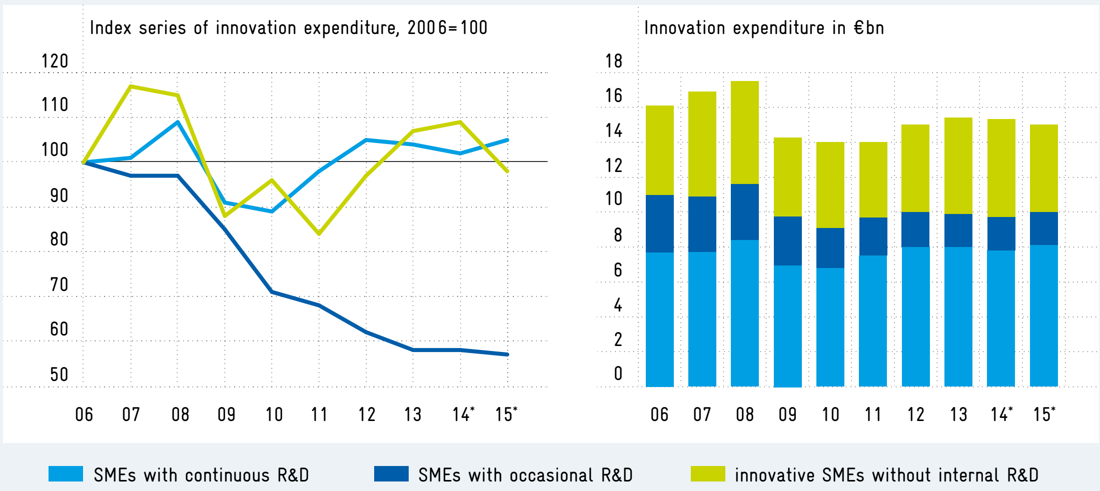
Figure B 1-6 shows how the innovation expenditure of the three different groups developed between 2006 and 2013. Having fallen in all three groups in the crisis year of 2009, innovation expenditure recovered in the subsequent years among SMEs with continuous R&D and SMEs with innovation expenditure but no internal R&D. The innovation expenditure of SMEs with occasional R&D declined further – to less than 60 percent of the 2006 level by 2015 (cf. Figure B 1-6, left side). The innovation expenditure of SMEs with occasional R&D only accounts for a small proportion of SMEs' total expenditure on innovation. It was 20.5 percent in 2006, has fallen continuously since then, and stood at 12.3 percent in 2013.

SMEs with continuous R&D account for 26 percent of all SMEs with innovation expenditure (see above), but in 2013 they were responsible for over 52 percent of the total innovation expenditure of German SMEs

Fig. B 1-6

Download data

Development of innovation expenditure of SMEs (5 to 249 employees) by R&D activity, 2006 to 2015



* Planning figures from spring/summer 2014.
Source: Mannheim Innovation Panel. Calculations by ZEW in Rammer et al. (2016)

(2006: 48 percent). Innovation expenditure per SME in this group is significantly higher than in the other two groups. Innovation expenditure per SME with continuous R&D in 2013 was 3.5 times higher than that of SMEs with occasional R&D and more than 2.5 times higher than that of SMEs with innovation expenditure but no internal R&D.

B 1-3 The contribution of SMEs to research and innovation in Germany – output side

The results of R&D and innovation processes, i.e. the successful launch of new products and processes, are a decisive factor for Germany's innovative and competitive strength. The following section therefore compares the innovation output of SMEs in Germany with that of selected European reference countries.

Innovation success by international comparison – no uniform picture

The innovation output of German SMEs can be measured by various indicators. Since each has specific advantages and disadvantages, the following three indicators are used in order to draw as descriptive a picture as possible: patent applications, product and process innovations, and turnover from product innovations. Table B 1-7 gives an overview of the position of German SMEs according to these indicators.

The patent intensity of SMEs[91] can be expressed by the number of transnational patent applications[92] that are filed by SMEs relative to the population. According to this indicator, Germany is in the middle range of the European reference countries. However, the industrial structure of the countries exerts an influence on this indicator. While some industries use patents a great deal to protect their inventions, secrecy is much more widespread as a protection mechanism in other industries. The innovative strength of German SMEs cannot therefore be assessed solely on the basis of patent intensity.

Another indicator for assessing the innovation performance of SMEs is the number of product and process innovations that are launched. The percentage of SMEs that have launched a product or process innovation within a three-year period is highest in Germany relative to the European reference countries: 42 percent of SMEs introduced a product or process innovation. This puts Germany just ahead of the Netherlands, Finland and Sweden and a long way ahead of France and the UK. However, the percentage of German SMEs that have launched a product or process innovation has declined markedly in the past

Tab. B 1-7

Download data

Patent activities and innovation successes of SMEs, 2010-2012

Patents		Innovations		Revenue	
Transnational patent applications by SMEs (< 500 employees) per million inhabitants		Percentage of SMEs (10 to 249 employees) with product or process innovations		Product innovations' share of turnover of SMEs (10 to 249 employees)	
Sweden	137	**Germany**	**42%**	United Kingdom	18%
Finland	132	Netherlands	41%	France	8%
Austria	104	Finland	40%	Italy	8%
Germany	**87**	Sweden	40%	Netherlands	7%
Netherlands	82	Italy	39%	**Germany**	**6%**
United Kingdom	50	Austria	36%	Austria	6%
France	45	France	32%	Finland	5%
Italy	44	United Kingdom	28%	Sweden	5%

Source: EPA: Patstat, Eurostat: Community Innovation Surveys. Calculations by Fraunhofer ISI and ZEW in Rammer et al. (2016).

few years (by 11 percentage points between 2008 and 2012). In most of the reference countries this percentage has remained relatively constant during the same period.

German SMEs focus their innovation activities particularly on product innovations. Both the percentage of German SMEs that have introduced only product innovations, and the total percentage of product innovators (only product innovation or product and process innovation) are higher than in the reference countries.

How successful the introduced innovations have been can be measured by the turnover generated with product innovations. In 2012 German SMEs generated 6 percent of their turnover with product innovations, compared to 13 percent in 2008. Germany was about in the middle of the rankings of the reference countries in 2012. A downward trend can also be observed for the EU-28 as a whole over this period: the share of turnover generated with product innovations fell from 14 percent in 2008 to 10 percent in 2012.[93]

As already mentioned above, the economic structure must be taken into account when interpreting results from international comparisons. For example, the innovation cycles vary greatly in the different industries. While new products can be launched on the market quickly in some fields – in the ICT industry, for example – thus rapidly generating turnover with new products, the development and market launch of a new car model takes significantly longer. Since Germany's economy is greatly influenced by the automotive industry, longer innovation cycles could contribute to the low sales shares of German SMEs by international comparison.

The picture drawn by the different output indicators is not uniform. While German SMEs are leaders in terms of the frequency of product or process innovations, they rank in mid-table when it comes to patent intensity and the share of turnover that is generated with new products.

Obstacles to innovation B 1–4

High innovation costs and economic risks are the main obstacles to innovation

Companies are regularly questioned in the MIP about obstacles to innovation. 75 percent of the innovation-active SMEs in Germany reported that their innovation activities were hindered by obstacles in the period from 2012 to 2014. Excessive innovation costs and economic risks (at 40 percent respectively) were the most commonly cited innovation obstacles (multiple answers were possible, cf. Figure B 1-8). The most important obstacles after these two factors were a lack of adequately skilled personnel (33 percent) and a lack of internal sources of finance (30 percent). Further highly relevant factors were organisational problems within the company (25 percent), low levels of

Fig. B 1-8

Download data

Percentage distribution of obstacles to innovation in innovation-active SMEs (5 to 249 employees) in Germany, 2012 to 2014

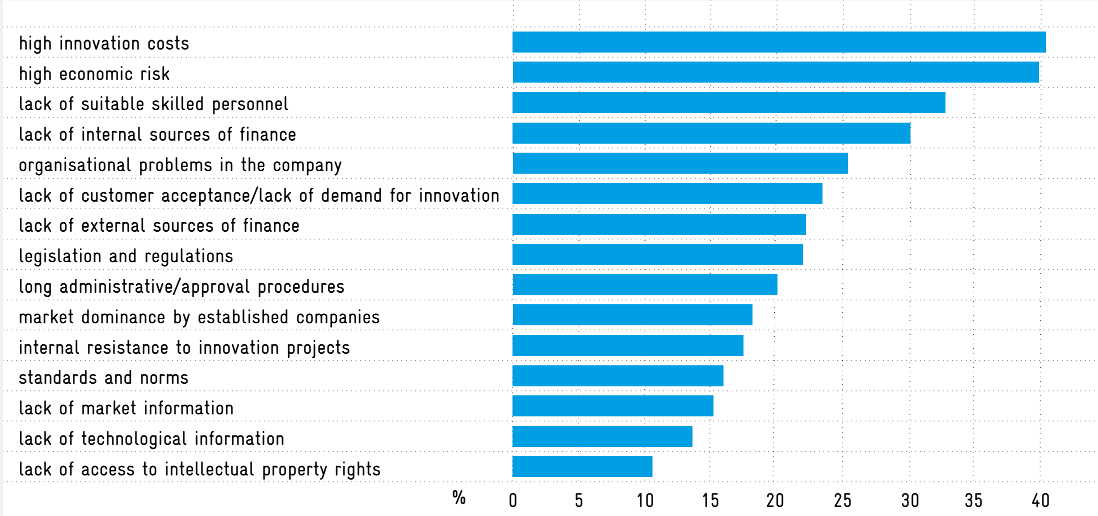


Chart covers obstacles to innovation that have led to delays, the abandonment or the non-implementation of innovation projects.
Source: Mannheim Innovation Panel. Calculations by ZEW in Rammer et al. (2016)

customer acceptance or a lack of demand for innovation (24 percent), and a lack of external sources of finance (22 percent).

Against this background, education, research and innovation policy can primarily target the external factors in order to remove obstacles to innovation for SMEs. These include in particular the areas of skilled personnel and innovation finance.

Growing problems for SMEs in the recruitment of skilled personnel

In the wake of demographic developments and the intensification of knowledge in the economy, the shortage of skilled employees is increasingly threatening to become an obstacle to innovation.[94] In the period from 2004 to 2006, the lack of adequately skilled personnel only represented a barrier to innovation for 16 percent of innovation-active companies. However, this percentage rose considerably both during the financial and economic crisis and after the crisis receded. Between 2008 and 2010 it had already reached 23 percent and rose further to 33 percent in the period from 2012 to 2014.

In 2013 the Stifterverband Wissenschaftsstatistik conducted a special survey specifically on scientific research staff in addition to its R&D survey of research-based companies. Among other things it investigated whether companies still had sufficient numbers of scientific research staff at their disposal.[95]

- The study showed that nine out of ten companies, regardless of corporate size, expected to be able to meet their needs for scientific research staff in the three years following the survey. In this context, there were differences between the sectors: the export-oriented sectors of mechanical and automotive engineering – and the ICT industry – were harder hit by the shortage of skilled personnel than the average of all companies.
- Although the shortage of skilled personnel does not affect all industries to the same extent, in 2013 two out of three companies were experiencing difficulties in recruiting new scientific staff due to a low supply of suitable research staff and high salary demands. In this context, a higher proportion of SMEs than of large corporations stated that they were having difficulties in finding new research staff because of high salary demands.

– The entry-level salaries for scientific research staff among research-oriented companies rose more than the entry-level salaries for staff as a whole in the period from 2011 to 2013. The companies surveyed expected this development to continue in the period from 2014 to 2016. In small, research-based companies with up to 100 employees, entry-level salaries for scientific research staff had already risen in the past by more than they had in medium- and large-scale enterprises. In the future, starting salaries there were also expected to rise faster than in companies of other size categories.

Decline in innovation activities due to financing restrictions

Innovation financing is also of great significance for the participation of SMEs in innovation and for their innovation intensity. As already mentioned above, high innovation costs are the most widespread obstacle to innovation for SMEs. At the same time, the lack of internal and external sources of financing impedes innovation activities in many SMEs. The proportion of innovation-active SMEs whose innovation activities were hindered by a lack of internal sources of finance was 30 percent in the period from 2012 to 2014, i.e. 3 percentage points lower than during the financial and economic crisis (2008-2010), but 9 percentage points higher than between 2004 and 2006.[96] The proportion of SMEs whose innovation activities were hindered by a lack of external sources of finance developed in a similar way: it amounted to 16 percent in the period from 2004 to 2006, rose to 26 percent between 2008 and 2010, and then fell to 22 percent in the period from 2012 to 2014 – but was thus still around 6 percentage points higher than before the financial and economic crisis.[97]

In order to determine the extent to which the availability of additional financial resources leads to additional innovation activities, the companies were asked in the 2014 MIP survey what they would do with a ‘gift' of additional own resources amounting to 10 percent of their previous year's turnover.[98] Such hypothetical questions are a practicable method for determining the effect of financing constraints on innovation activity. The companies were given a choice between five options: general investment, innovation activities, accumulation, distribution to the owners and the repayment of liabilities. Multiple answers were possible. The companies were also asked how they would use an additional low-interest loan worth the same amount.

While 13 percent of SMEs stated that they had refrained from innovation activities in the period from 2011 to 2013 for lack of financial resources,[99] when asked the hypothetical question of what they would do with additional own resources, 22 percent of the SMEs said that they would use these funds – at least partly – for additional innovation activities. The percentage is significantly higher among innovation-active SMEs than among non-innovation-active SMEs.

– In the group of innovation-active SMEs, 37 percent of companies would have carried out additional innovation activities if they had received additional own resources amounting to ten percent of their annual turnover. This figure is almost twice the percentage of innovation-active SMEs that had restricted their innovation activities in the previous three-year period due to a lack of financial resources (19 percent). This result shows that innovation-active SMEs still have considerable untapped innovative potential.[100]
– The proportion of non-innovation-active SMEs that wanted to use the additional own resources for innovation projects was 10 percent, i.e. only slightly higher than the percentage of non-innovative SMEs that stated they had not pursued innovation projects in the previous three-year period because of a lack of financial resources (8 percent).
– When the hypothetical additional resources are offered in the form of loans, they are less frequently used for innovation activities than hypothetical additional own resources: 14 percent of innovation-active SMEs would have used an additional low-interest loan amounting to ten percent of annual turnover for innovation activities. 4 percent of the non-innovation-active SMEs would have undertaken innovation activities if the additional funds had been available.[101]

B

B 1–5 Innovation funding

Wide range of instruments for funding researching and innovative SMEs

Federal and Länder governments, as well as the EU, provide financial support for SMEs with grants and low-interest loans for R&D and innovation projects, and with venture capital for innovative corporate start-ups.[102]

The Federal Government offers a wide range of measures to support SME research and innovation projects (cf. on this also Table B 1-9):

- The Federal Ministry for Economic Affairs and Energy (BMWi) directly subsidises R&D projects of SMEs with the Central Innovation Programme for the Mittelstand (Zentrales Innovationsprogramm Mittelstand, ZIM). The ZIM supports individual and collaborative projects and network activities.[103] Between 2013 and 2015 the ZIM disbursed subsidies to SMEs amounting to an average of 320 million euros a year (cf. Table B 1-9).
- The KMU-innovativ funding initiative (KMU is German for SME) of the Federal Ministry for Education and Research (BMBF) is one of the BMBF's specialised programmes. Its programme types and administrative implementation take account of the specific situation of R&D in SMEs.[104] In the period from 2013 to 2015, the KMU-innovativ scheme disbursed development funds to SMEs amounting to an average of 60 million euros per year (cf. Table B 1-9).
- The ERP Innovation Programme, which is administered by the KfW Bankengruppe, offers long-term loans for SME innovation projects. The support focuses on collaborations with research institutes.[105]
- Innovation processes in SMEs are indirectly supported by two BMWi programmes: Industrial Collective Research (Industrielle Gemeinschaftsforschung, IGF) and Innovation Competence East (INNO-KOM-Ost). IGF promotes scientific-technical R&D projects that are organised by research associations at the pre-competitive stage.[106] With the aim of sustainably boosting the innovative strength of east German companies and offsetting competitive disadvantages, INNO-KOM-Ost supports the R&D activities of not-for-profit external industry research institutions.[107]
- The BMWi offers grants for innovation consulting services in the form of go-Inno innovation vouchers.[108]
- A BMWi programme called SIGNO (continued since 2016 under a new programme called WIPANO) promotes the initial securing of R&D results by industrial property rights.[109]
- Venture-capital investment is promoted directly and indirectly by various measures. KfW provides young technology companies with equity capital via the ERP Start Fund if they have an additional contributor as lead investor.[110] The EIF/ERP Umbrella Fund, financed jointly by the European Investment Fund (EIF) and the ERP Special Fund, contributes to venture-capital funds whose investment policy focuses on technology companies in their early stages or on follow-up financing for technology companies.[111] The High-Tech Gründerfonds (HTGF) – which was initiated as a public-private partnership between the BMWi, KfW Bankengruppe and a number of industrial companies – finances newly established or young technology companies with seed capital and helps them acquire further capital for follow-up rounds.[112] With the INVEST scheme, the BMWi subsidises private investors (business angels) that acquire shares in young innovative companies.[113]
- The BMWi's EXIST programme supports university graduates, scientists and students in their preparations for technology-oriented and knowledge-based start-ups.[114]
- Although funding SMEs is not the primary objective of the Federal Government's specialised programmes, numerous SME research and innovation projects are supported with their assistance.

Numerous Länder have their own programmes for subsidising R&D projects. Some of these are open in terms of what is supported, while others target certain technological fields or clusters and focus mostly on collaborative projects between science and industry. Some Länder promote the use of external R&D from scientific sources or from external innovation consultants. The previously widespread Innovation Assistant Programmes, which provide subsidies for SMEs to recruit graduates, only still exist in a few Länder.

Horizon 2020, the European Union's Framework Programme for Research and Innovation, offers, among other things, grants for collaborative R&D projects.[115] Horizon 2020 not only continues the EU's Seventh Research Framework Programme, but also integrates the European Institute of Innovation and Technology (EIT) and the innovation-related elements

Tab. B 1-9

Download data

Overview of Federal Government R&D funding benefiting SMEs

	Technology-open BMWi measures benefiting SMEs (IGF, INNO-KOM-Ost)*	ZIM	KMU-innovativ	Specialised programmes of the Federal Gov.
Target group	Research institutions or not-for-profit external industry research institutions (economically active SMEs benefit indirectly by using research results)	SMEs according to EU definition (higher headcount threshold: < 500 employees)	SMEs according to EU definition (in individual technology fields: extension to up to 1,000 employees and turnover of €100 million per year)	open (EU definition of SMEs sets framework for funding quotas)
Funding limit	none (IGF) €500,000 (INNO-KOM-Ost)	€209,000 (max. eligible costs: €380,000)	none	none
Number of newly funded projects per year (annual approvals, average figures for 2013–2015)	approx. 420 (IGF) approx. 220 (INNO-KOM-Ost)	approx. 2,900 (only SME projects, total approx. 4,300 projects, i.e. approx. 1,400 sub-projects of cooperating research institutions)	approx. 280 (only SME projects; total of approx. 500 projects – i.e. about 220 sub-projects of the R&D partners, usually research institutions)	approx. 2,600 (only SME projects; total of over 13,000 projects)
Funding paid out for or to SMEs per year (average figures for 2013-2015)	approx. €140m (IGF) approx. €60m (INNO-KOM-Ost)	approx. €320m (plus funds to cooperating research institutions: approx. €190m)	approx. €60m (plus funds to R&D partners in the projects, usually research institutions: €50m)	approx. €480m (EU definition; incl. KMU-innovativ, only funds that go direct to SMEs; funding to R&D partners used for research services for the benefit of SMEs cannot be shown separately)

* Other BMWi programmes benefiting SMEs – such as the ERP Innovation Programme, go-Inno innovation vouchers, the SIGNO or WIPANO programme, the High-Tech Gründerfonds and the EXIST programme – are not included in the calculation here because of their different approaches to funding.
Source: Written information from BMBF and BMWi.

of the previous Competitiveness and Innovation Framework Programme (CIP).[116]

Eurostars is also being continued under Horizon 2020 as Eurostars 2.[117] This programme provides grants for internationally oriented, cooperative projects between researching SMEs. It promotes the market-oriented development of an innovative product, process or service.[118]

17 percent of the innovation-active SMEs in Germany received public financial support for the implementation of innovative projects in the period from 2010 to 2012 (cf. Figure B 1-10).[119] This figure is significantly higher than in the period from 2004 to 2006. While the Federal Government and the EU were continuously expanding their funding activities, the percentage of innovation-active SMEs supported by Länder programmes has recently been declining.[120]

Public R&D funding among German SMEs is low by international comparison

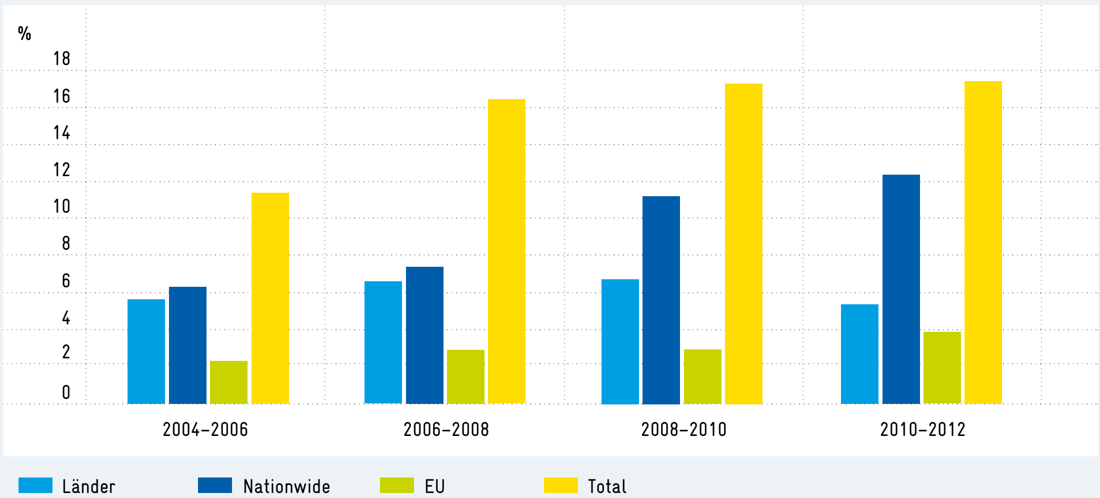
When comparing public R&D funding in Germany with that of important European competitors, it is important to note that many countries use indirect instruments in addition to direct public funding of R&D expenditure.[121] These instruments primarily include fiscal support measures under which tax credits or tax exemptions are granted, depending on the level of R&D spending.[122] Up to now there has not been any such tax-based funding of R&D in Germany.[123]

On average, direct public funding of R&D in SMEs in Germany in 2012 and 2013 was the equivalent of 0.25 per mill of the gross domestic product. This puts Germany in third place behind Austria and Finland in the comparison of eight selected European countries.

Fig. B 1-10

Download data

SMEs receiving public innovation funding as a percentage of all SMEs (5 to 249 employees) in Germany, 2004 to 2012



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

B

Germany slips to seventh place when the indirect R&D funding of SMEs is included in the European comparison (cf. Figure B 1-11).[124]

The contribution of direct public financing to total R&D expenditures by SMEs comes to 14 percent in Germany, according to the latest figures. This percentage is relatively high. However, the picture also changes considerably with regard to this indicator when indirect funding of R&D is considered in addition to direct promotion. Germany is then in seventh position among the reference countries (cf. Figure B 1-12). In France, de facto more than half of SMEs' R&D costs were financed by direct or indirect public support measures during the same period. In the Netherlands, the United Kingdom and Austria, the average total funding quotas were 38, 32 and 30 percent respectively.

The BMBF presented its new ten-point programme called 'Vorfahrt für den Mittelstand' in January 2016.[125] It lists several existing and planned measures aimed at improving R&I funding among SMEs, and announces an increase of 30 percent in the funding available for SMEs – reaching 320 million euros by 2017.[126] The Commission of Experts welcomes the BMBF's plan to increase its funding of R&I in SMEs,but notes that the additional resources then available will at best increase the share of public funds in SMEs' R&D expenditure from 14 to 15 percent.

Recommendations B 1-6

Reduce financing constraints on innovation projects

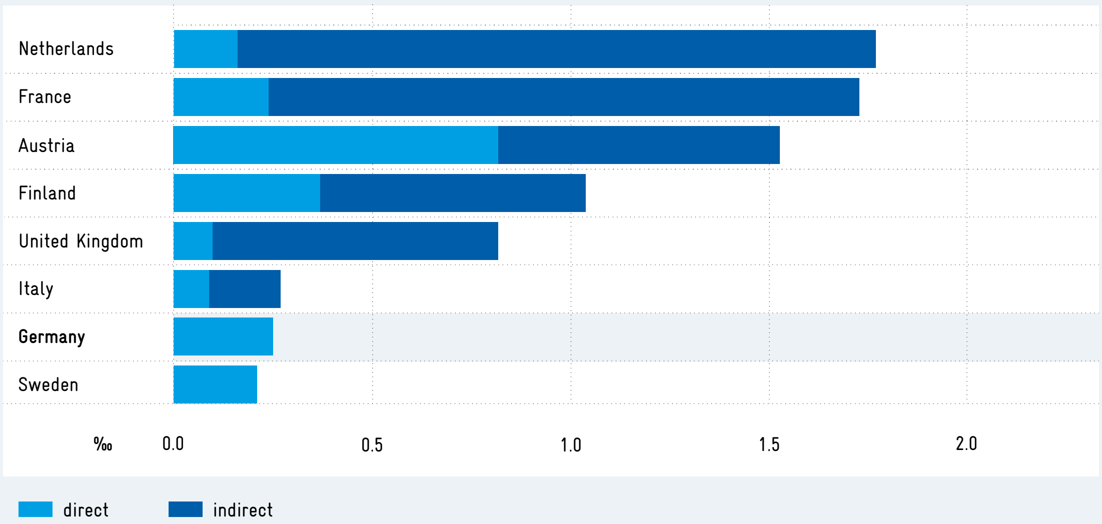
The Commission of Experts continues to regard R&D tax credits, paying special attention to the needs of SMEs, as an important complement to the funding instruments currently in use. The Commission calls on the parties to develop concrete proposals for the design of such a measure over the next few months.

– R&D tax credits are easily predictable for companies and can therefore achieve a broad-based effect. They can be claimed for R&D projects of all kinds without needing to file an application, and represent a legal entitlement. The instrument can be a useful complement to targeted project funding, which should continue to be used in specific problem situations. If, due to budget restrictions, there is only scope in the federal budget for limited tax incentives, the tax credits should initially be introduced primarily for SMEs.[127]

Fig. B 1-11

Download data

Direct and indirect public financing of R&D in SMEs as a proportion of GDP (per mille)

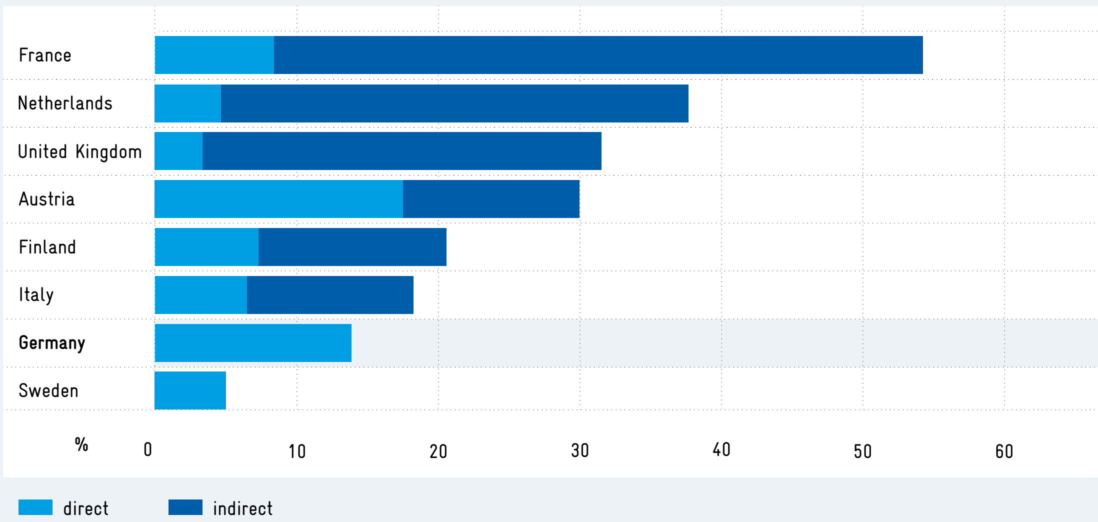


Direct funding: most recent available year = 2013, 2012 or 2011, depending on the country. Indirect funding: mean of indirect funding in 2012 and 2013.
Source: OECD: Research and Development Statistics, Main Science and Technology Indicators. Calculations by ZEW in Rammer et al. (2016).

Fig. B 1-12

Download data

Direct and indirect public financing of R&D in SMEs as a percentage of total R&D expenditure by SMEs



Direct funding: most recent available year = 2013, 2012 or 2011, depending on the country. Indirect funding: mean of indirect funding in 2012 and 2013.
Source: OECD: Research and Development Statistics, Main Science and Technology Indicators. Calculations by ZEW in Rammer et al. (2016).

Improve conditions for the launch and growth of innovative enterprises

Innovative start-ups aim to make use of market opportunities and introduce new products and business models. If entrepreneurs do not have access to sufficient capital, they cannot realise and market their innovative products or business models.

– Germany must urgently make efforts to counteract the decline in start-up rates, which is partly induced by the demographic change.
  Consideration should also be given to attracting foreign entrepreneurs, as already proposed in the 2013 Report.[128] There is great potential for Germany here, especially in the knowledge economy.
– Venture capital is an important source of financing for young innovative companies. However, the market for venture capital in Germany is relatively small – despite some improvements in 2013 and 2014.[129] In order to improve the framework conditions for venture capital and thus create more financing options for innovative companies, the legal basis announced in the coalition treaty must finally be laid.[130] The main focus of political decision-makers should be on facilitating the private financing of business start-ups.

Increase the availability of skilled personnel

The shortage of skilled personnel is increasingly becoming an obstacle to innovation for SMEs.

– The Commission of Experts has already expressed its views in different contexts on the shortage of skilled personnel and formulated recommendations aimed at increasing the overall supply of skilled personnel.[131]
– Given the shortage of skilled personnel, SMEs should consider recruiting more foreign skilled personnel. This should also include hiring qualified refugees. However, since the administrative requirements for hiring foreign skilled personnel represent major hurdles for many SMEs, and existing information and support services are still relatively unknown,[132] political decision-makers, chambers of commerce, and associations should intensify their support measures and launch a corresponding information campaign.

Evaluate innovation funding

The Federal Government offers a wide range of measures to support SME research and innovation projects. In addition, numerous Länder also offer their own programmes for subsidising R&D projects. The current structure of funding is complex and is therefore backed up by advisory offices at the federal and Länder levels.

– The structure of the funding programmes at the federal and Länder levels should be regularly reviewed – and simplified if there is excessive complexity or duplication in the range of funding options on offer.
– Furthermore, SME funding programmes must be evaluated according to current scientific standards. The results of the evaluations should be published and the data collected made accessible for further scientific analyses in a research data centre.

Robotics in transition

The use of robots has expanded systematically over the last few years and offers huge potential for the future. The trend in industrial manufacturing is moving towards collaborative, lightweight robots. New areas of application are increasingly being found beyond industrial manufacturing.

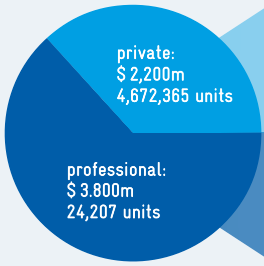
Industrial robotics:
Sales worldwide 2014

$ 10,700m

229,261 units

Service robotics:
Sales worldwide 2014

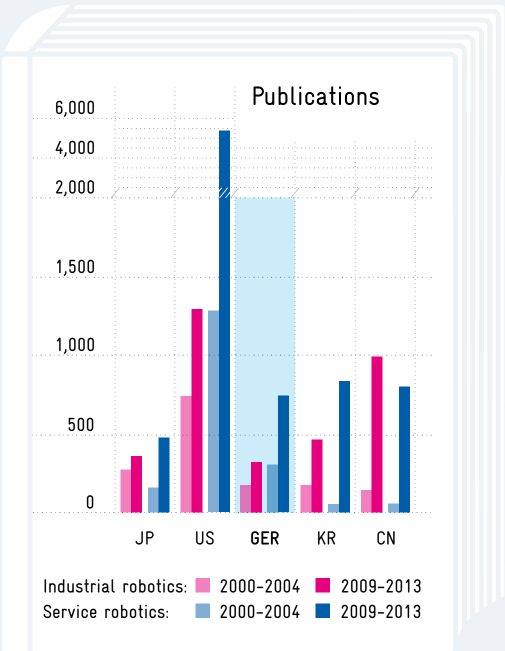
$ 6,000m

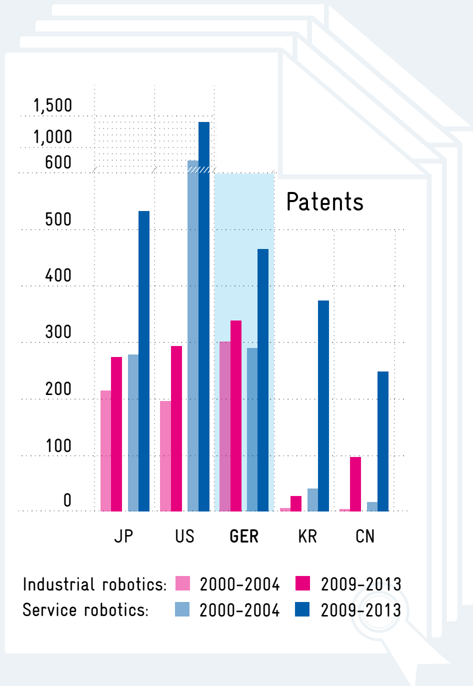


Predicted sales of industrial robots worldwide, 2015 to 2018:

1,283,000 units

Publications and patents in industrial robotics and service robotics, 2000 to 2004 and 2009 to 2013

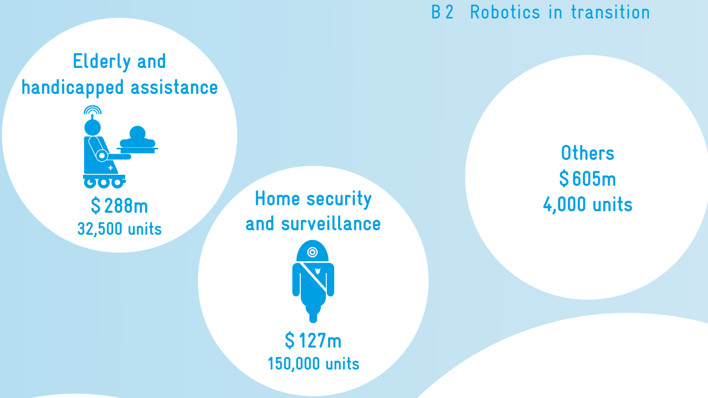




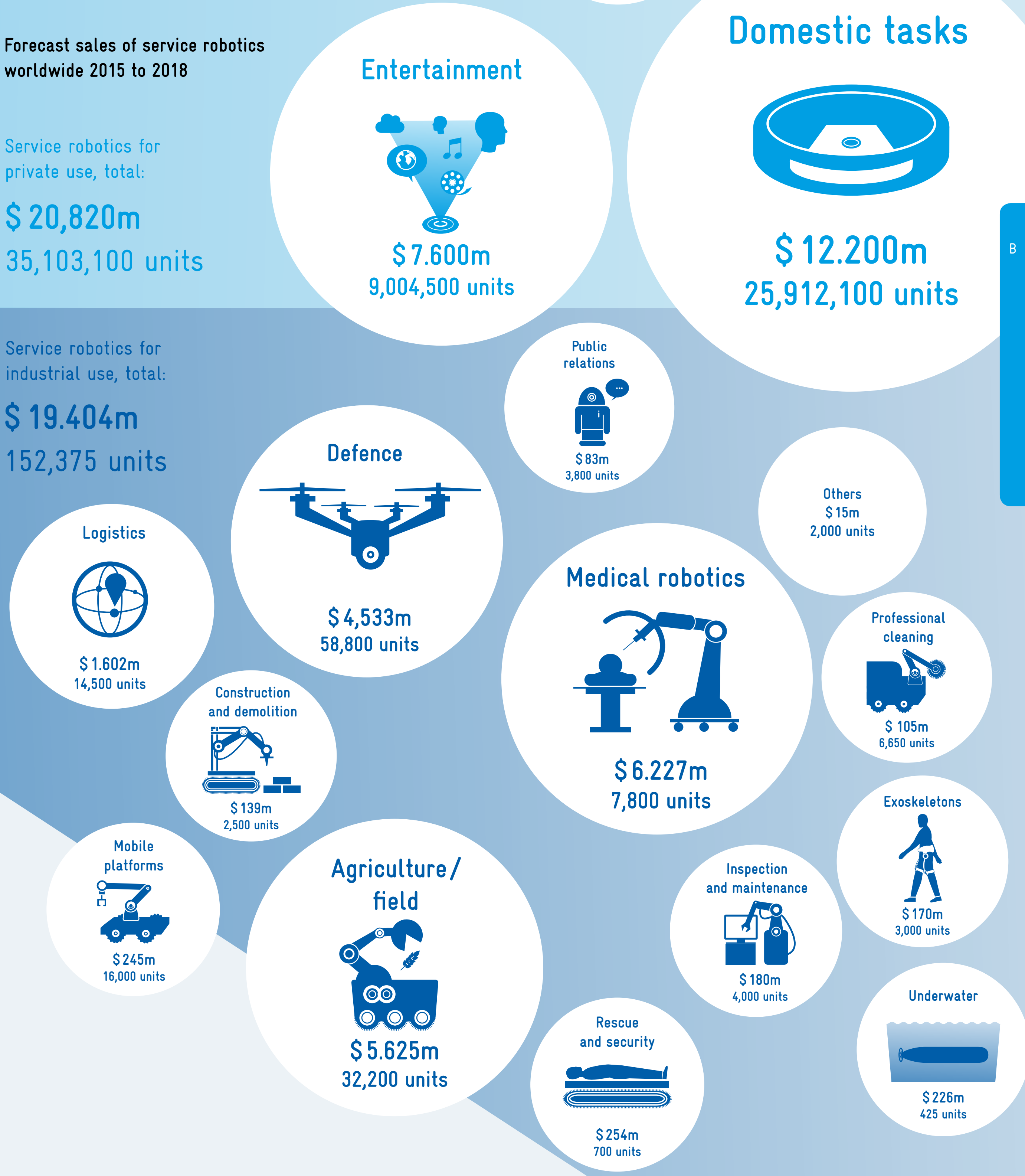
Source: Estimated sales figures and turnover in robotics: World Robotics Report – Industrial Robots/Service Robots, IFR (2015a, 2015b). Publication data: Scisearch Database, Web of Science (WoS). Patent data: World Patents Index database (WPI, STN). Calculations by Fraunhofer ISI.

Prospects of service robotics

Service robots help to automate services. For example, they provide support during surgical procedures, carry out maintenance and servicing work, do domestic work, farm agricultural land.



Forecast sales of service robotics worldwide 2015 to 2018



Source: Estimated sales figures and turnover in service robotics: World Robotics Report – Service Robots, IFR (2015b).

Download data

B

B 2 Robotics in transition

B 2-1 Status quo and prospects for robotics

Robots have been in use in industrial production for over 50 years. Initially they took over monotonous, dangerous or physically strenuous tasks within production processes. In the last decades, however, the range of applications in which robots are used has expanded massively (cf. Box B 2-1). Apart from growing computer processing power, the key drivers of this development are simpler programming methods and the fact that robots are becoming more flexible.

In industrial robotics, the trend is moving towards collaborative, lightweight robots.[133] Compared to conventional industrial robotics they are less expensive to buy, more flexible in their uses and easier to operate.[134] New areas of application are emerging, especially in areas of manufacturing where manual skills have seemed irreplaceable up to now – e.g. in the assembly of small components with low batch sizes. Furthermore, machine learning has considerably expanded the possibilities of man-machine interaction (MMI)[135] in recent years. In industrial production, innovations from MMI research are making it possible to complement human labour with an increasingly efficient, yet easily controllable machine environment ('robotic assistance systems').[136] For example, skilled human operators direct the robots using voice and gesture control. The aim is to make production more flexible and efficient. In some cases, the cost of a robotic working hour has now fallen below one dollar.[137] This cost even undercuts the labour costs of factory workers in low-wage countries.

At the same time, full or partial automation is also gaining a foothold in the service sector. So-called service robots are increasingly being used outside the strictly demarcated security zones that are common in industrial robotics. Robots that clean buildings, roads or vehicles already exist. Monitoring robots improve security in both the private and the public sphere. Semi-automated systems provide support during surgical procedures or in caring for patients. Robots increasingly take on dangerous maintenance and inspection work, and driverless transport systems run errands. It is estimated that almost 80,000 service-robotic systems are already in use today in professional applications world-wide.[138] In addition, millions of private service robots (such as fully automatic vacuum cleaners) are being purchased for domestic use.[139]

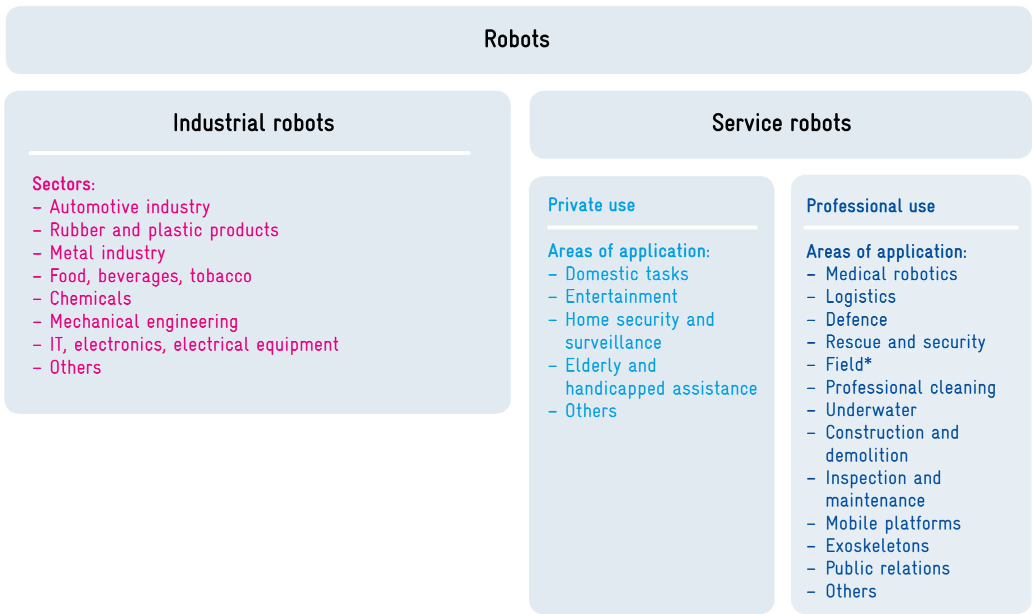
One example of a new generation of service robots is the humanoid robot 'Pepper'.[140] It can analyse facial expressions and gestures and reacts to them.[141] It currently serves primarily as a source of entertainment and is used as a shopping assistant in the retail trade.[142] This service robot, which costs just under €1,500[143] also collects a wide variety of information about the customers who interact with it.[144] The evaluation of these customer data makes it possible to optimise existing business models and develop entirely new ones. The robot is currently being sold at a price that does not cover the production costs. It becomes profitable through additional monthly contributions (around €110) that are charged for periodic upgrades, e.g. cloud-based speech recognition, and through new applications that are sold in app stores. As in the case of smartphones, the range of potential applications can be continuously expanded in this way. Robotics can therefore also be an important element of data-driven business models.[145]

Box B 2-1

Robots and robotic systems

A robot is a mechanically operated piece of equipment that has a certain degree of autonomy, acts physically within a specific environment and carries out tasks as directed.[146] Robots that are used in industrial production processes are called industrial robots. All other robots are categorised as service robots, where another distinction is made between robots for industrial and private use.[147] The figure below illustrates this distinction. Sensors and actuators[148] enable modern service robots in particular to function even in unstructured environments. Robotics research therefore emphasises the importance of artificial intelligence and adaptability, as well as the ability to work together with humans.

This classification should be distinguished from the kind of robotic systems that are the subject of many reports on the economic importance of robotics. Robotic systems comprise not only robots, but also software, peripherals and related plant and systems engineering. However, the technological distinction between robots and robotic systems is not always clear. As a result, unequivocal sales volumes can rarely be calculated, for example. In 2014 the world market for industrial robots was estimated to be worth 10.7 billion US dollars, whereas the market for robotic systems in this field was put at 32 billion US dollars – about three times as high.[149] Statements and interpretations on robotics markets must look very closely at this distinction.[150]



* Also includes space and mining robots.
Source: Own diagram based on WZ 2008 classification of economic activities (for industrial robots) and the IFR's allocation to areas of application (for service robots).

B

Use of industrial robots in Germany is concentrated on vehicle construction

An analysis of the figures for industrial robotics in manufacturing in the world's top five users of robots shows that Japan had the highest number of robots in 2014 (cf. Table B 2-2).[151] In second place, a long way behind, was the USA, followed by Germany, South Korea and China, which were approximately level. The picture has changed since 2011. At that time Japan was also in first place with almost as many industrial robots. However, in the meantime the USA and Germany have swapped places in the ranking order.

Particularly striking are the developments in China and South Korea. Starting at a comparatively low level in 2011, South Korea almost caught up with Germany in 2014 with a growth rate of 59 percent. South Korea shows a similar dynamic to that of the

USA (+58 percent). The development of China is even more impressive. In 2011 China had a stock of 45,697 units, compared to Germany's 142,678 units. China has almost caught up with Germany in just three years with a dramatic growth rate of 218 percent. In terms of total industrial robotic stocks, forecasts predict that in 2016 China will already head the ranking list of the five countries mentioned, with Germany bringing up the rear.[152]

Figure B 2-3 illustrates how robots are distributed across the most important industries in manufacturing.[153] It shows that both vehicle construction and the electrical industry are the dominant user industries in all countries with the exception of Germany. In Germany, vehicle construction is quite clearly the main user. This high concentration of robotics application makes German robotics manufacturers vulnerable to cyclical fluctuations in the automotive industry.

Not only the distribution of robots among the different sectors is interesting, but also the intensity of use of industrial robots in the above-mentioned

B

Tab. B 2-2

Download data

Development of the number of industrial robots in manufacturing in selected countries from 2011 to 2014

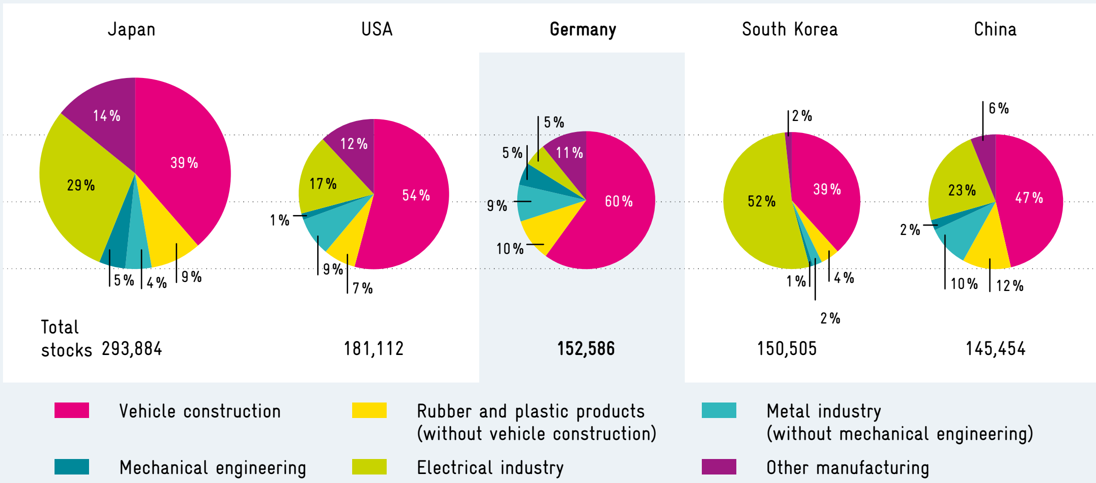
State	Stocks in 2011	Stocks in 2012	Stocks in 2013	Bestand 2014	Growth 2011-2014
Japan	304,432	308,038	301,610	293,884	-3.5%
USA	114,476	134,844	155,998	181,112	58.2%
Germany	**142,678**	**145,174**	**147,390**	**152,586**	**6.9%**
South Korea	94,619	112,674	129,685	150,505	59.1%
China	45,697	63,471	94.,437	145,454	218.3%

Source: Own diagrams based on IFR data.

Fig. B 2-3

Download data

Distribution of the number of industrial robots across important sectors in selected countries, 2014

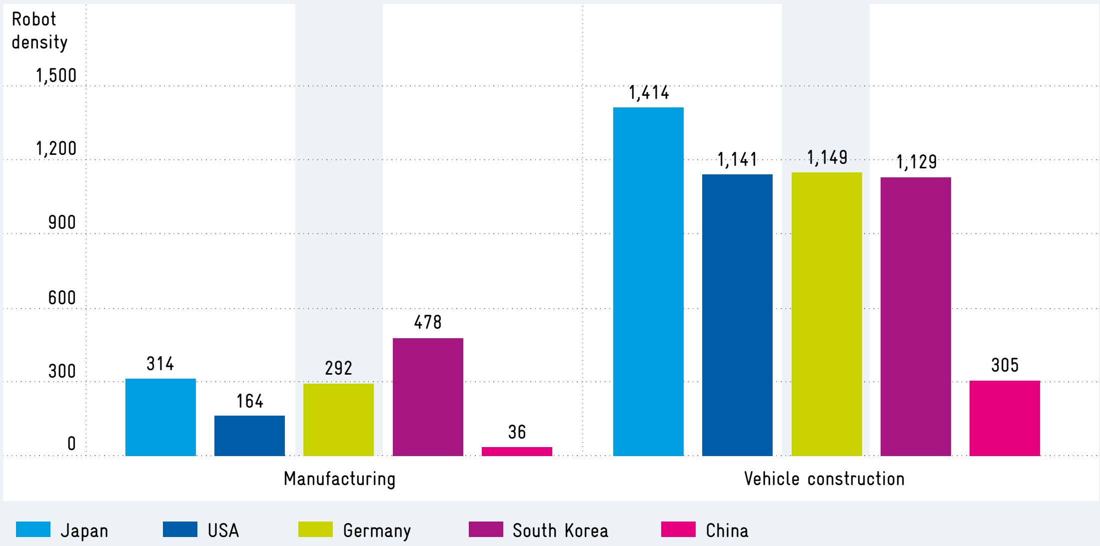


Source: own diagram based on IFR data.

Fig. B 2-4

Download data

Robot density* in manufacturing and vehicle construction in selected countries, 2014



* Robot density = number of industrial robots per 10,000 employees
Source: Own diagram based on IFR data.

industries and countries. The indicator generally used is the density of robots, which is defined as the number of robots for every 10,000 workers in an industrial sector. An international comparison of robot density for 2014 can only be compiled for the whole manufacturing industry and for vehicle construction.[154] Figure B 2-4 shows that the use of robots in vehicle construction was by far the most intensive. In relation to manufacturing as a whole, South Korea (478), Japan (314), Germany (292) and the USA (164) were all still far ahead of China (36).

Service robotics: global growth market

The economic importance of robotics is reflected in the turnover generated by robot sales.[155] In 2014 turnover in industrial robotics totalled 10.7 billion US dollars. For service robotics it amounted to 6.0 billion US dollars (divided into 3.8 billion US dollars for professional use and 2.2 billion US dollars for private use). Turnover in industrial robotics is currently still significantly higher than in service robotics.[156] However, forecasts predict that service robotics will have caught up with industrial robotics in terms of global market volume between 2020 and 2025.[157] The greatest potential is seen in the demand for private systems in households, in entertainment, and in the fields of medicine, agriculture, defence and logistics.[158]

Turnover estimates for the individual areas of application shown in the info chart indicate that over 150,000 new service robots for professional use – with a total value of 19.4 billion US dollars – are likely to be sold between 2015 and 2018 alone.[159] In the private sphere, approximately 35 million units are expected to be sold with a total turnover of 20.8 billion US dollars.

Overall, the indications are that although industrial robots continue to play an important role for the economy,[160] service robotics will appreciably gain in importance – not only in the industrial, but also in the private sphere.[161] For Germany it will be important not to concentrate exclusively on industrial robotics, but also to make the most of the growth potential of service robotics. Other countries like Japan and South Korea are far ahead in this field (cf. Box B 2-5).[162]

Box B 2-5

Robotics strategies in the USA, China, Japan and South Korea

Under the Obama administration in the USA the re-industrialisation of the country is being driven forward primarily through the use of modern, advanced manufacturing technologies.[163] The 'National Robotics Initiative' is playing an important role in this context.[164] Several public institutions are jointly providing funding of up to 70 million US dollars – primarily for the development of robots that directly support and work together with people.[165]

Whereas suppliers from Europe and Asia are world leaders in traditional industrial robotics, the future potential in the US robotics strategy is increasingly seen in the field of service robotics,[166] particularly in the medical sector, in military applications and astronautics.[167]

In 2015 China presented its 'Made in China 2025' plan. China's long-term objective in this context is to become the world's leading nation in production technology. The country's robotics strategy combines the promotion of industrial-robot applications with the further expansion of the domestic robotics industry, which includes the research and development of new generations of robots.[168] As a result, the development of both the amount and the market share of industrial robots made in China has been impressively dynamic in the last few years.[169]

Japan is the world's third-largest economy after the USA and China.[170] Like Germany, Japan, although poor in natural resources, spends a great deal by international comparison on research and development (R&D) in order to assert its position.[171] Together with Germany and the USA, Japan is regarded as a world leader in large sections of the mechanical- and automotive-engineering, electrical and chemical industries.[172]

At the same time, Japan is confronted with the challenges of a rapidly ageing population and a declining number of people capable of being in gainful employment.[173] It is also struggling with the consequences of the reactor accident in Fukushima. Robotics is expected to play a prominent role in tackling these challenges. In 2014, as part of its 'Revitalisation Strategy', Japan propagated a 'New Industrial Revolution Driven by Robots'.[174] This was followed in February 2015 by the 'New Robot Strategy'.[175] The objectives of the strategy are to halt the decline in the competitiveness of the manufacturing sector, to counter the growing shortage of labour and the consequences of natural disasters by further increasing the level of automation,[176] and to open up the service sector – in addition to industry – for robotic applications. To achieve these goals, Japan wants to make robots significantly easier to handle and more flexible. The aim is to make robots easier to use especially for SMEs and private individuals. Furthermore, the new systems are intended as autonomous and networked data collectors to create new business models based on big data.

South Korea was still one of the poorest countries in the world up until the 1960s, but in the space of just 50 years it has risen to become the world market leader in several cutting-edge technologies – such as semiconductors, smartphones and monitors.[177] This success has been primarily based on above-average R&D efforts. Between 2003 and 2013 alone, the proportion of the gross domestic product spent on R&D in the South Korean economy rose from 2.49 to 4.36 percent.[178]

The first five-year plan for the South Korean robotics strategy (the 'Intelligent Robot Development and Dissemination Promotion Law'), which came into force in 2009, was designed to create suitable industrial infrastructures for the development and diffusion of robotic applications. In 2014 the South Korean Ministry of Trade, Industry and Energy submitted the second five-year plan for the national robotics strategy. This plan aims to permeate the entire manufacturing industry, as well as the service sector. By the end of 2018, the target is for the robotics market for South Korean providers to grow by up to 7 billion US dollars a year – with targeted annual exports of 2.5 billion US dollars.[179] Joint investment from the public and private sectors amounting to 2.6 billion US dollars by 2018 initially aims to give the South Korean market players the necessary core competencies. At the same time, the demand for robotic applications is to be boosted in all sectors of the economy.

B 2-2 Research in robotics – patents, publications and funding

To remain competitive in the robotics market in the long-term, key importance must be assigned to R&D. The following section explains how, in the field of robotics, publications and patents developed as indicators of R&D activity between 2000 and 2004 and between 2009 and 2013.[180] The fields of industrial robotics and service robotics are viewed separately (cf. info chart at the beginning of the chapter).[181] The picture that ensues is that Germany is the leader when it comes to patents for industrial robotics, but ranks only in mid-table compared with the other countries when it comes to patents for service robotics. As regards the number of publications, the USA dominates in both industrial and service robotics.

Germany's strong position is put into perspective, however, when patenting activity in industrial robotics is observed over time. In the period from 2009 to 2013, the number of German patent applications was 12 percent higher than in the period from 2000 to 2004. In the same periods, the aggregated patent figures for the reference countries Japan, USA, South Korea and China rose by 64 percent. The picture is similar for publications. The number of publications rose by 86 percent in Germany, compared to 134 percent in the reference countries.

In the field of service robotics, too, the dynamics of publishing and patenting activities is significantly weaker in Germany than in the reference countries, where the number of publications on service robots rose by 390 percent, in Germany, however, by only 143 percent. The number of patents in the reference countries increased by 123 percent, whereas in Germany it increased by only 61 percent.

Overall, Germany's relatively strong position in the patenting of industrial robotics is increasingly under attack by the reference countries. The Commission of Experts regards this as a cause for concern. The situation is even more critical in the field of service robotics. Up to now Germany has not succeeded in improving on its weak starting position with regard to publications and patents.

Little focus on research funding of service robotics

The main recipients of large-scale funding in state-supported projects involving robotics are research institutions and less often private companies.[182] Since 2010, the German Research Centre for Artificial Intelligence (DFKI) has been involved in six of the seven most strongly supported robotics subprojects – some of which have been completed, while others are still ongoing.[183] In terms of the scale of funding, the largest amounts are invested in the fields of astronautics[184] and in cross-section functions that are of relevance for many different applications in both industrial and service robotics.[185]

There is only one funding programme that is specifically oriented towards service robotics: within the framework of 'ICT 2020 – Research for Innovations', the Federal Ministry for Education and Research (BMBF) provides relatively small amounts to support projects concerning service robotics that might be used in everyday life.[186] The prerequisite for such funding is the development of universal standards and system solutions that are as open and interoperable as possible.[187]

In view of the growing importance of service robotics and the low level of publications and patents in Germany by international comparison, it is a matter of concern that so little priority is attached to this aspect of research funding.

Robotics and change in the labour market B 2-3

Public discussion suggests that the increasing use of robotics is expected to cause major changes in the labour market.[188] The question that remains is how well employees in Germany are prepared for these changes: whether they will complement new technologies or be replaced by them. There is particular interest in the effects on wages and employment opportunities. It can be helpful in this context to take a look at technological changes that have happened in the past (cf. Box B 2-6).

Analyses of past technological developments and the adjustment processes associated with them show that employees with an intermediate level of qualification in Germany were well prepared for technological changes and – unlike in other countries – there was no pronounced polarisation of the labour market.

Box B 2-6

Effects of technological changes on labour-market outcomes

Many studies on the effects of technological change on the labour market originated in English-speaking countries. Early studies point primarily towards a growing polarisation of the US labour market, i.e. to sharply increasing inequalities with regard to wages and employment opportunities (polarisation hypothesis).[189] These studies attribute the polarisation to changes in the tasks carried out at the workplace, caused by technological change.[190] For the US these studies hypothesise that jobs in the low-wage sector, which are primarily carried out by low-skilled workers, are characterised by manual tasks, while jobs in the high-wage sector, carried out by highly skilled workers, are mainly characterised by cognitive tasks. On the other hand, they expect jobs requiring intermediate qualifications to involve many routine tasks and that it is precisely these routine tasks that can be replaced by modern technologies. This substitution leads to falling wages and a decline in the number of jobs for employees with intermediate qualifications. The situation is different in the case of low-skilled and highly skilled workers. Low-skilled occupations are not affected at all by technological change; whereas high-skilled occupations are complementary to technology, i.e. they become even more important in order to be able to use the modern technologies efficiently.[191] This hypothesis has been empirically proven for the US and the UK in many studies over the last few years.[192]

The empirical findings are less clear-cut for Germany. While past studies see evidence of a polarisation of wages and employment,[193] more recent studies tend to show that the polarisation hypothesis cannot be easily transferred to Germany.[194] Rather, recent analyses point to stable employment and earnings for workers with an intermediate qualification in Germany.[195]

This stability is primarily due to the qualification structure of the labour force, which differs substantially from what is found in English-speaking countries.[196] Whereas, for example, US workers with an intermediate qualification level are often high-school graduates or people with "some college", the German intermediate level is characterised by workers with a solid dual vocational education and training.[197]

One of the advantages of the dual system of vocational education and training lies in the continuous adaptation of the training content to technological change. This adaptation is achieved by means of established processes for the systematic further development of training curricula in which above all technologically leading firms are involved.[198] As a result, the labour force with intermediate qualifications, especially the younger workers, are not only very well prepared for technological change, in some cases they are even driving it forward. The latter can be illustrated, for example, by an international comparison on the early use of CNC (computer numerical control) machines. Compared to British and French companies, German companies had not only broadly adapted the CNC technology very early on, but, moreover, they had by far the highest share of shopfloor programming as opposed to back-office programming, thus exploiting the special productivity advantages of CNC; they also had the lowest downtimes.[199]

The importance of modernised curricula for the employment effects after the introduction of CNC machines in Germany is also shown by a recent study.[200] Employees who were trained according to the curricula of the reformed metal and electrical occupations (which included the new CNC technology) were paid higher wages than employees who were taught according to the old curriculum. Furthermore, a larger proportion of incumbent workers were able to adapt to the new requirements over time and participate in wage increases. Only a comparatively small percentage of the incumbent workers were unable to master the adjustment process, switched to a different firm or industry, and were thereby affected by a wage loss.

Therefore, employment and wages in Germany have developed differently from what is suggested in US or UK studies. More precisely, the development was more complementary rather than substitutive to the use of new technologies.[201] Process innovations introduced in Germany did not lead directly to layoffs.[202] Furthermore – unlike in the US[203] – recent studies show that the task profiles in Germany are very heterogeneous and not characterised exclusively by routine tasks – also for workers with intermediate qualifications. Rather, occupations with intermediate qualification levels include jobs with a high proportion of manual tasks as well as jobs with a high proportion of cognitive tasks. Over time, wages for manual tasks tended to decrease, while wages for cognitive tasks tended to increase.[204] In contrast to the US, the German occupational profiles are adapted to changing task requirements over time, leading to a much less pronounced polarisation of wages and employment.

In addition, if we examine how quickly the human capital acquired by dual vocational education and training depreciates over time in Germany, and how the depreciation rate depends on the type of job tasks, differentiated patterns emerge.[205] Skills based on the so-called knowledge-intensive tasks, especially those involving specific technological knowledge, lose their value more quickly than those from experience-based tasks such as social skills or leadership skills. Therefore, employees who not only regularly update, but also complement their original know-how through further training, are better protecting themselves against negative consequences of technological change.

The main reason for this development was broad-based dual vocational education and training (VET) and the regular updating of VET curricula in line with current technological developments. The dual vocational education and training system with its regular updating of curricula, in which above all technologically leading companies are involved, has therefore not only contributed to a cushioning of the impact of technological change on the employment opportunities and earnings of employees with an intermediate qualification level, but in some cases even encouraged progress. For the future this means that the system of updating the curricula must be maintained and continuously further developed.

The analyses also show that, in addition to dual vocational education and training, it is essential to regularly update and complement the skills of older employees by offering systematic workplace training and workplaces with evolving tasks. In the future, against the background of anticipated demographic change, greater attention must be paid to further education; there, too, a continuous and systematic updating of skills must be incorporated, just as it is already a matter of course today in the system of dual vocational education and training.

Recommendations B 2–4

The Federal Government regards robotics as an important technology of the future. The Commission of Experts fully agrees with this assessment. Germany is currently still well positioned by international comparison in the use of robots in industrial production – particularly in vehicle construction. Germany is facing growing competition from robotics nations such as the USA, Japan, South Korea and, in the future, China. These reference countries are quickly catching up with regard to publications and patents in industrial robotics. Furthermore, the potential areas of application of modern robots are changing in many industries – not only within the industrial sector, but also in the provision of services. Service robotics is gaining in economic importance; forecasts predict that it will even overtake the importance of industrial robotics in the near future. Germany is currently not well positioned in this field.

Strengthen research and transfer

- Unlike the four reference countries, Germany has no explicit robotics strategy. The Commission of Experts recommends that the Federal Government should develop such a strategy and in particular provide a form of funding that does justice to the growing importance of service robotics.
- Against the background of international competition, a critical view must be taken of the very high concentration of robot use in the automotive industry in Germany. Funding programs should focus more on potential applications of modern robots in sectors outside of the automotive industry.
- Tertiary education institutions must also place greater emphasis on robotics research. At the same time, tertiary education and research institutions must provide more support for research spin-offs than they have done in the past.

Modernise training and support life-long learning

To be prepared on the labour market for a broader dissemination of robots in the industrial and service sectors, it is important to encourage further developments in the dual system of vocational education and training, in tertiary education institutions and regarding life-long learning.

- The requirements and opportunities of an increased use of robots must be taught across all occupations in the relevant curricula in the dual system of vocational education and training. It is important not only to focus on the use of robots in industry, but also increasingly to concentrate on the use of service robots (in both the professional and private spheres). The corresponding educational curricula must be adapted quickly to achieve this goal. The key players in the dual vocational education and training system should step up their tried-and-tested cooperation to integrate new robotics knowledge into all relevant training curricula. This process should be supported by additional financial resources from the Federal Government.
- Furthermore, since in the wake of demographic change it is becoming increasingly important to regularly update the skills of incumbent employees, life-long learning, and with it further-training courses in robotic applications and development, must be systematically expanded for graduates of both dual vocational education and training and tertiary education. In this context, MOOCs – on which the Commission of Experts reported in detail in its 2015 annual report – represent a great opportunity. For example, the Federal Government could fund the development of MOOCs for teaching robot applications and development for different target groups.
- In tertiary education institutions there should be more interaction between classical engineering and IT training courses. At the same time, study programmes focusing specifically on robotics should be fostered in order to boost the human capital that is available for robotics research and development.

Business models of the digital economy

The digital economy is divided into the internet economy and the 'classic' information and communication technology industry. Innovative business models of the digital economy are based on software- and internet-based technologies such as cloud computing or the analysis of large quantities of data (big data). The business models are adopted especially by young enterprises.

B

Market capitalisation of companies on 1 January 2015 in billions of euros and growth since 1 January 2005

Internet economy:

1,159 (+365%)
USA

34 (+166%)
Germany

Information and communication technology:

3,392 (+87%)
USA

297 (+57%)
Germany

Platform operators of the most frequently visited websites come primarily from the USA

Most frequently visited websites, international

1. Google.com (USA)
2. Facebook.com (USA)
3. Youtube.com (USA)
4. Baidu.com (China)
5. Yahoo.com (USA)

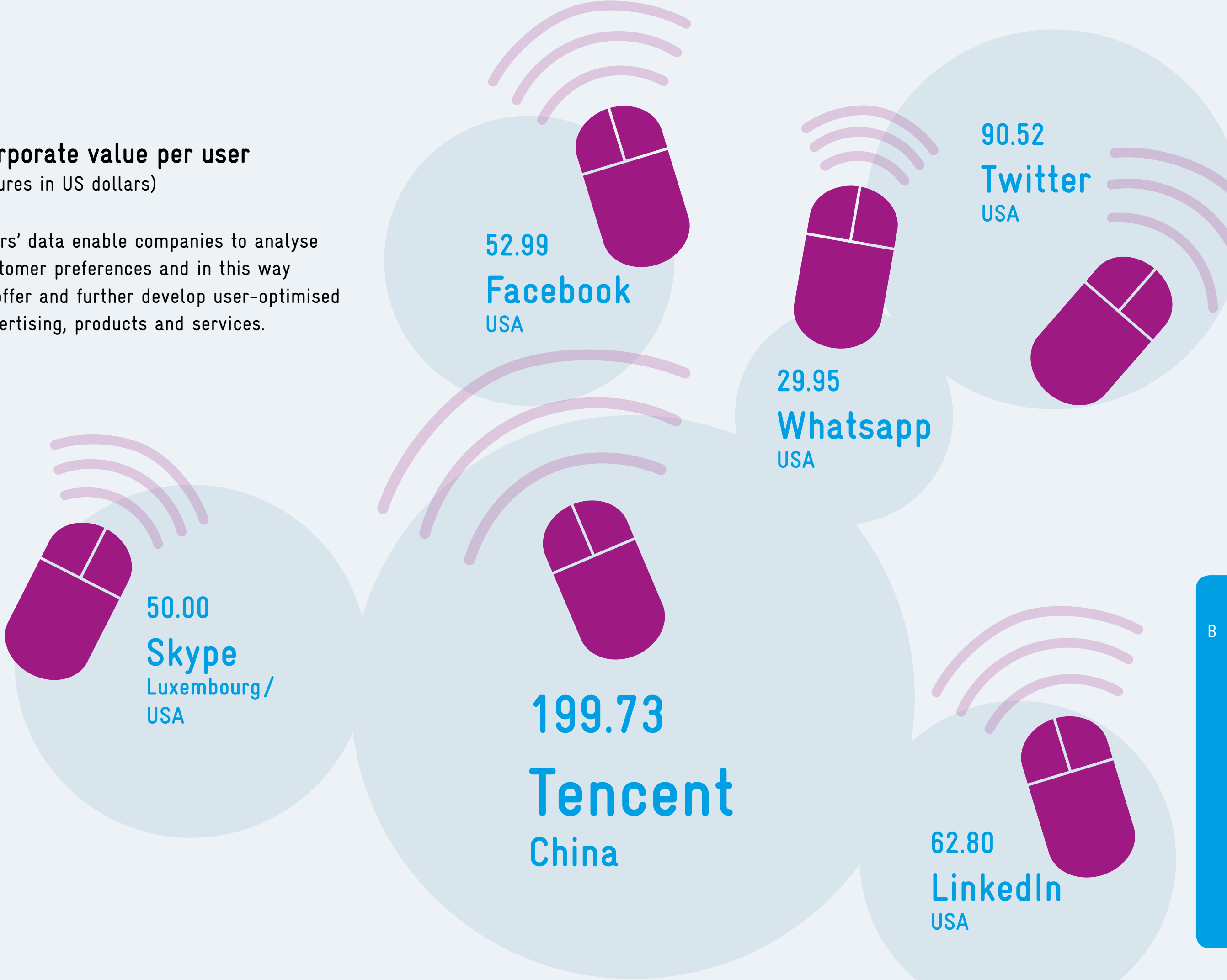
Most frequently visited websites in Germany

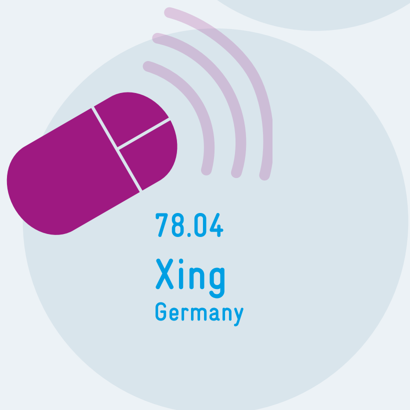
1. Google.de (USA)
2. Amazon.de (USA)
3. Facebook.de (USA)
4. Youtube.com (USA)
5. Ebay.de (USA)

Source: on market capitalisation, cf. Müller et al. (2016). Statistics on the most frequently visited websites, cf. Alexa.com (last accessed on 5 January 2016).

Corporate value per user
(figures in US dollars)

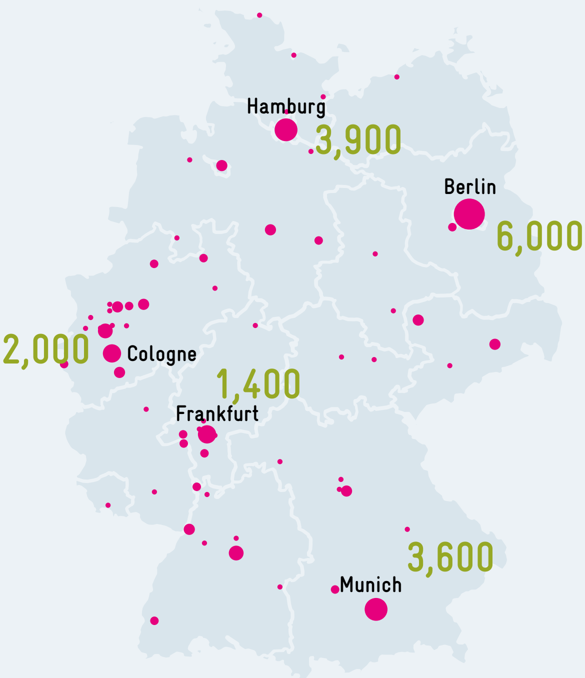
Users' data enable companies to analyse customer preferences and in this way to offer and further develop user-optimised advertising, products and services.





Four out of five digital start-ups take place in the internet economy

Start-ups in the German internet economy between 2000 and 2014



Source: for information on start-up statistics and corporate value per user, cf. Müller et al. (2016).

Download data

B 3 Business models of the digital economy

The digitisation of the economy and society has been progressing for over 40 years. Contrary to some statements made in politics, the media and science, it is not a new phenomenon. But the advancing connectedness of people and objects, as well as their integration into the internet, is creating entirely new spheres of action. Policy-makers, businesses and society face major challenges as a result of this development.

Innovative business models in the digital economy, which build on software- and internet-based technologies such as cloud computing and the analytics of large quantities of data (big data),[206] are currently being adopted particularly by young enterprises and are driving growth in the internet economy. Established companies that do not embrace this development are running the risk of losing competitiveness.

The current situation is alarming. Germany has lost ground not only in the traditional information and communication technologies (ICT) in the last few decades.[207] Much more serious is the fact that German companies have not yet been able to build up any strengths in the new digital-economy fields in which skills in the use of IT-based processes are crucial. US companies dominate activities in the international internet economy. In addition, policy-makers in Germany have for a long time failed to create sound framework conditions for new, internet-based business models. Rather, they have tended to support established structures and incumbent business models.[208] There is currently a lack of a convincing strategic approach to research and innovation policy (R&I policy) in the field of digital innovation.

The example of automotive engineering – one of Germany's most important industries in terms of employment and exports – illustrates how massively the development of new digital business models can change existing value creation. Here, the companies face two key challenges:

– Internet platforms continuously collect data on the behaviour of vehicle users and their preferences. Mobile devices enable the platform operators to offer attractive services (e.g. navigation, search, music or other information services) which complement or substitute the products and services of incumbent original equipment manufacturers (OEMs). The car's value for customers and their willingness to pay declines. In this context, automotive engineering

Box B 3-1

Business models, innovative business models and business models in the digital economy

A business model is a model-based description of the logical mechanisms showing how an organisation or enterprise generates values for customers, reaches out to customers, and secures business returns.[209]

The introduction of new and innovative business models, or changes to existing business models, alter not only the use of resources, technologies and skills in an organisation, but also the organisational structures, the range of products and services, and targeted customer groups that generate income.[210]

Innovative business models in the digital economy relate to specific technologies. They are based on applications of software- and internet-based technologies such as cloud computing or on the analytics of large quantities of data (big data). At the core of the business models considered here is the intensive use of the internet.

could be pushed into the role of a supplier in the value chain for mobility services. In such a scenario, the strategically most important position in the value chain – that of the greatest proximity to the customer – is occupied by information providers.
– In addition, automobile manufacturers will also have to reckon with competitive entries in the production of vehicles in the medium term.[211] Internet companies like Apple and Alphabet are no longer limiting themselves to the above-described role of internet platforms and service providers. They – like the incumbent OEMs – are currently planning the launch of 'autonomous driving' and will probably succeed in developing their own manufacturing of electric vehicles.

However, in an analysis of digitisation from the perspective of innovation economics, it would be too narrow to concentrate only on industries that have hitherto been particularly important in the German innovation model. Digitisation affects the economy and society across the board and in all sectors. In the view of the Commission of Experts, it is therefore counterproductive to focus R&I policy on the field of manufacturing. The importance of data-driven services and business models for value creation has risen sharply in recent years and will – most probably – continue to do so. The reason for this is that the collected information and user data are no longer seen only as supporting elements in value creation, but as sources of value in their own right.[212]

The Commission of Experts already mentioned in its last report the great opportunities – but also the considerable risks – for Germany as a location for business and innovation that stem from digitisation and connectedness. This discussion will be continued in this chapter, paying special attention to innovative internet-based business models.[213]

B 3-1 Definitions

According to the definition of the Federal Ministry for Economic Affairs and Energy (BMWi), the digital economy includes both the ICT sector[214] – with its hard- and software manufacturers and service providers – and the internet economy.[215] When delimiting the internet economy, the BMWi takes its orientation from national expenditure accounting, which records turnover with internet-based consumption, investment and foreign trade.[216]

The German Digital Economy Association (BVDW) uses a narrower definition of the digital economy.[217] It focuses strongly on the use of internet technologies.[218] In contrast to the BMWi's definition, it does not include ICT-based infrastructure or consumer electronics in the digital economy. Three areas of activity are highlighted as the core of the digital economy:

1. Internet service access: this covers all mobile and stationary data services for accessing the internet, internet exchange services and domain allocation.
2. Applications and services: this includes IT outsourcing, hosting, cloud computing, the creation of internet presentations, online marketing, software applications for web applications including e-learning, digital print prepress and web-to-print applications.
3. End-user interaction: this field comprises all end users, companies and consumers, i.e. all B2B (business-to-business) e-commerce, online banking, B2C (business-to-consumer) e-commerce with goods and online services (e.g. dating agencies, tickets, travel and tourism, etc.), as well as original web content (e.g. online publishing, media downloads, mobile apps, etc.).

If the focus is exclusively on the use of internet technologies, then any company, regardless of its actual industry classification, can be counted as part of the digital economy, provided that its business processes are largely digitised and web-based.[219]

Business models in the digital economy by international comparison B 3–2

Growing market dominance of US companies in the digital economy

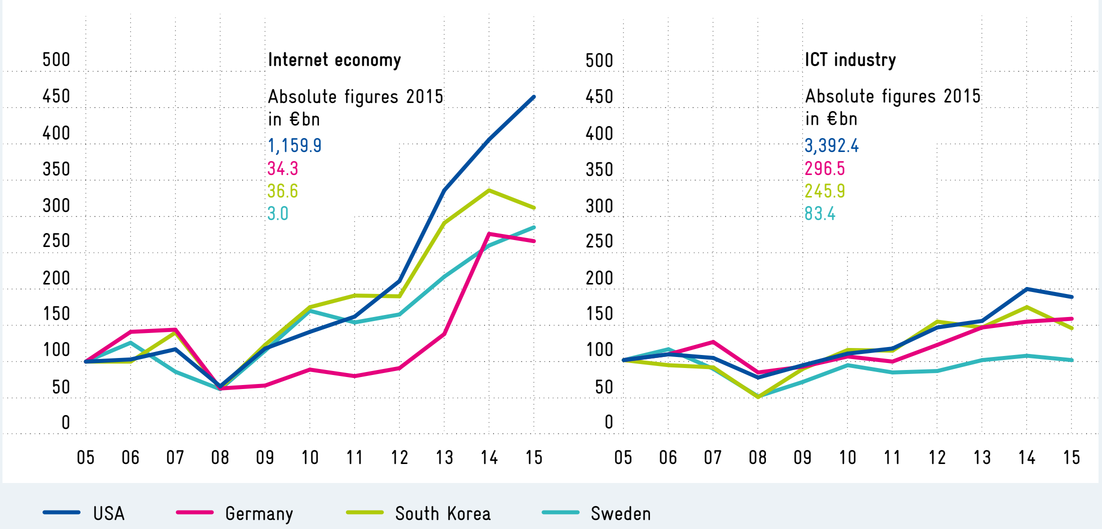
The rapid development and the high value-creation potential of the internet economy and the ICT sector[220] can be illustrated by looking at the market capitalisation of companies in the two fields. Figure B 3-2 compares performance in different countries over the last ten years.[221] The market capitalisation of the internet economy rose much faster than the 'classic' ICT industry in this period.

The dominance of US companies throughout the entire digital economy, and especially the strong growth in the field of the internet economy, are

Fig. B 3-2

Download data

Market capitalisation in the internet economy (left) and the ICT industry (right): comparison of countries 2005-2015 (index, base year 2005) and absolute figures for 2015



Source: own diagram based on Müller et al. (2016).

remarkable. The market capitalisation of the US companies in 2015 alone (1,159 billion euros) was about 15 times the size of the entire internet economy in Germany (34 billion euros), South Korea (36 billion euros) and Sweden (3 billion euros) together. In the last ten years, the market capitalisation of the US companies has increased almost fivefold, and in South Korea it has more than tripled. Like Sweden, Germany recorded only moderate growth and is falling further behind the USA.[222]

In the past 15 years, many young companies in the US internet economy have grown very quickly – e.g. Facebook, Alphabet, Twitter and LinkedIn – and in some cases have exceeded the capitalisation of longer established companies in the ICT sector such as Microsoft (cf. Figure B 3-3). The three financially strongest companies in Germany with (at least some) key business activities in the ICT sector are Siemens, SAP and Deutsche Telekom (cf. Figure B 3-4). Their growth is only very weak compared to the dynamics of the new internet companies in the USA.

The market capitalisation of Alphabet alone exceeds that of all German companies in the entire digital economy. The financially strongest internet-economy companies in Germany include Zalando, United Internet and established companies like Axel Springer. Even their market capitalisation has grown only very slowly compared to the group of the new US corporations. The structure of the internet economy is thus dominated by relatively young US companies.

Growing importance of users and access to the end customer

The importance of data-driven services is further growing. Personal data from customers or users of digital services have come to be regarded as an important resource, since they secure long-term access to end customers. Companies with a large number of users are therefore especially attractive for many investors.[223] At the same time, users represent an important source of innovation for companies in the digital economy. Internet-economy companies now regard them as far more important than, for example, cooperation with tertiary education or research institutions.[224]

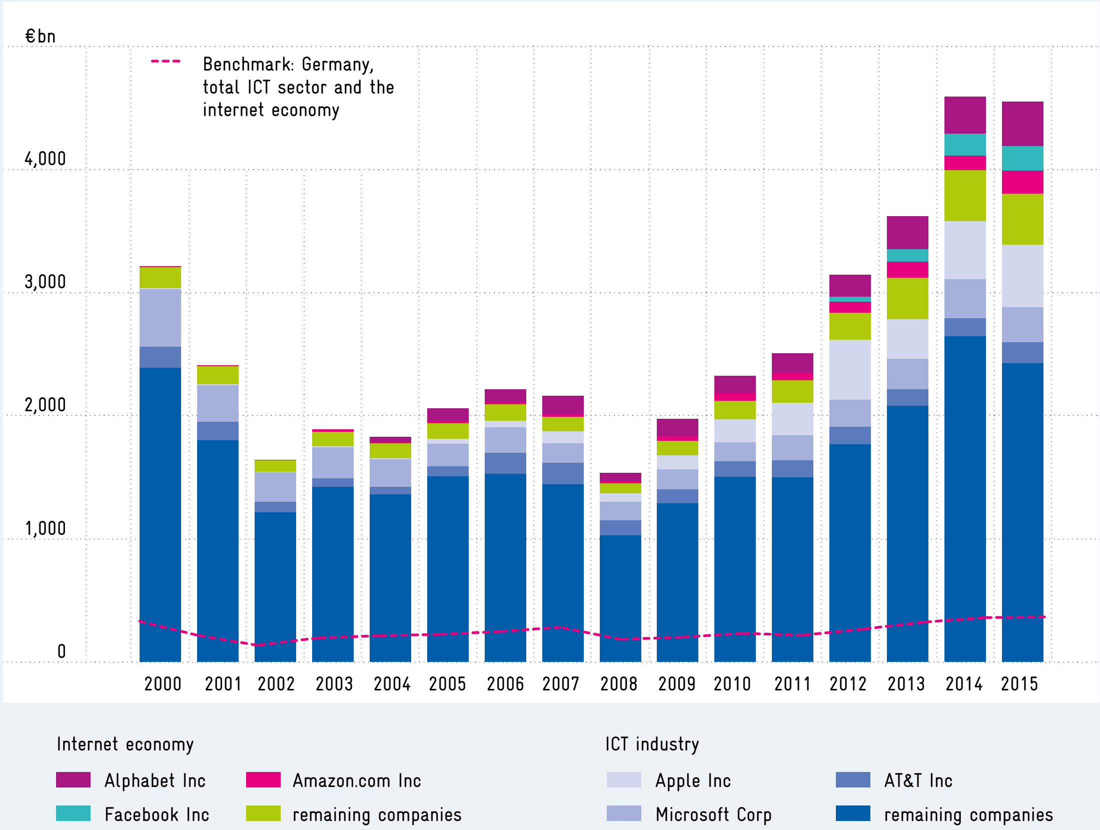
Takeovers and market valuations of companies with large numbers of users show that investors recognised a long time ago that the generation and use of personal data would become very profitable (cf. Table B 3-5). Although the business model does not yet seem to have been finally clarified in some digital services, very high valuations are already being

Fig. B 3-3

Download data

Market capitalisation of US companies in the ICT sector and the internet economy

Top 3 companies by market capitalisation; market capitalisation of the remaining companies, 2000 to 2015, in billions of euros



Source: own diagram (stacking diagram) based on Müller et al. (2016).

realised in acquisitions and IPOs. Relating the corporate or acquisition value of the digital business models to the number of their users, Facebook, for example, paid 30 US dollars per user when it took over Instagram.[225] Comparable valuations per user are also realised for other service providers with a large number of users, such as YouTube, Skype or Twitter.[226]

Many initiatives and pilot projects launched by companies in the sectors of education, energy, health, banking, transport and administration show that further networking and the introduction of innovative digital business models are likely to proceed at a rapid pace in all sectors of the economy.[227] The opportunities and risks for companies' value creation are therefore by no means limited to the classic ICT or internet sectors. Box B 3-6 shows an example of new business models in the digital economy in healthcare, banking and the energy sector. Incumbent companies in many sectors must reckon with interfaces to the end customer being occupied by new intermediaries such as platform providers.[228]

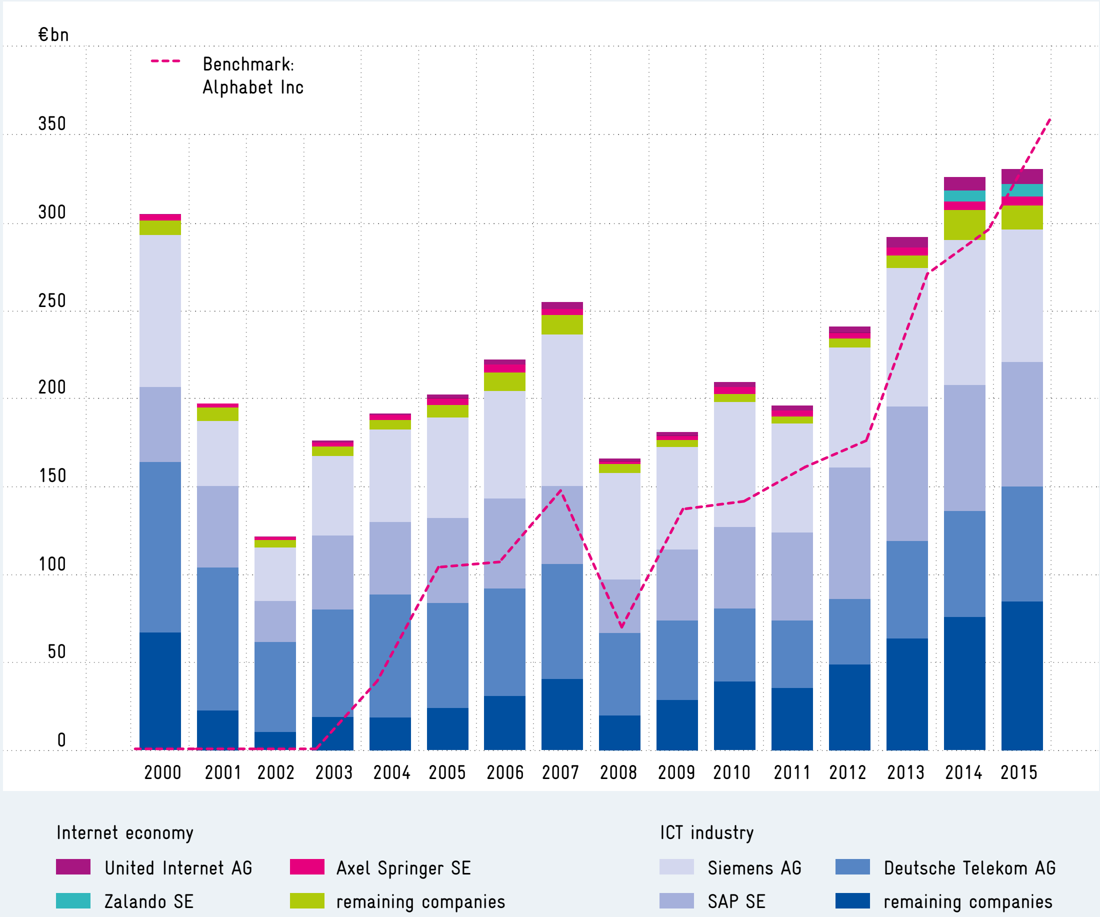
For example, banks in the USA are being confronted with new competitors in innovative mobile payment systems. There, payments are increasingly being handled via smartphones. Similar developments are also taking place in Europe. Banks are being subjected to considerable competitive pressure both by start-ups in the so-called FinTech (financial technology) field, and by global internet companies such as Apple, Alphabet, PayPal or Amazon (cf. Box B 3-6).

Fig. B 3-4

Download data

Market capitalisation of German companies in the ICT industry and the internet economy

Top 3 companies by market capitalisation; market capitalisation of the remaining companies, 2000 to 2015, in billions of euros



Source: own diagram (stacking diagram) based on Müller et al. (2016).

Tab. B 3-5

Download data

Corporate value[229] per end user

Companies	Company value per end user (US dollars)	Year	State
Tencent	199.73 [a]	2014	China
Twitter	90.52 [b]	2014	USA
Xing	78.04 [c]	2014–2015	Germany
LinkedIn	62.80 [b]	2015	USA
Facebook	52.99 [b]	2013–2014	USA
Skype	50.00 [d]	2011	Luxembourg / USA
Whatsapp	29.95 [d]	2014	USA

Source: own diagram based on Müller et al. (2016).
Reference figure: a: Number of monthly active users (in millions); b: Annual average monthly active users worldwide (in millions); c: Monthly users (in millions); d: Figure generated via company acquisition.

The importance of services in general will continue to grow as things are increasingly connected, while the value-added by pure production will tend to decline.[230] The provision of services is now already of great importance for industrial companies, too. According to a business consultancy, services are already responsible for half of the profits of European industrial companies.[231] Business models in the digital economy have drastically reduced the entry barriers for new competitors in the services sector. This applies i.a. for cloud-based services providers, which can develop and market their products and services without investing in IT infrastructure. Incumbent firms must therefore now expect to be challenged faster and more frequently by such innovators.[232]

In view of the fact that digital business models are emerging in all sectors, the Commission of Experts calls into question industry-targeted support strategies. Yet the Federal Government's approaches seem to be pursuing precisely this avenue (Industry 4.0, Smart Service World, E-Health, etc.). One critical issue is cross-sectoral weaknesses – for example in the field of internet-related software and digital business models – that cannot be sensibly tackled. Rather, there is a risk that the lack of skills will not be addressed, and that the learning effects and positive externalities that can result from funding will only be partially used.

B

Box B 3-6

New digital-economy business models in healthcare, banking and energy[233]

The internet platform 'ZocDoc', founded in New York in 2007, provides a fast and efficient service arranging doctors' appointments. It is one example of digital interaction and dialogue with patients in the healthcare sector. By collecting additional customer information, such as a patient's medical history, the system aims to use data-driven analyses to suggest suitable screening examinations and other health services.[234] The company is estimated to be worth around 1.5 billion US dollars.[235] A start-up in Germany called 'doxter.de' offers a similar service; it is a spin-off from Berlin's Charité hospital.

In the banking sector, Apple Pay and Google Wallet are examples of the development and use of mobile payment systems based on new digital business models. Due to the dominance of Alphabet and Apple in mobile operating systems, it is highly likely that in future money transfers will increasingly be handled via their services. Since Alphabet and Apple also control the corresponding hardware interfaces – e.g. Near Field Communication (NFC) – via their operating systems, the two corporations could also ensure interoperability with other payment systems, e.g. in the retail trade. The number of payments using NFC technology rose sharply after Apple Pay was announced in September 2014, underlining the potential of this technology.[236] However, money transfers between users could also form the basis for further profitable business models – Facebook, for example, is currently making inroads into this field with the payment function of its 'Messenger'. Start-ups in Germany in the field of internet-based payment systems include Cringle, SumUp and Barzahlen. European banks are also now getting involved in the field of internet-based payment systems.

In the energy sector, Alphabet purchased the company Nest in 2014. Like the German competitor Tado, this company makes smart thermostats which can regulate the temperature dynamically depending on how many people are present in the house. After extended periods of use, the system can use learning algorithms to raise efficiency and thus reduce energy costs.
On the basis of information on the estimated power consumption, Nest (i.e. Alphabet) could control devices such as air conditioning or heating systems in such a way that peak loads[237] are avoided. This ability could turn Nest into a competitor for established players in electricity markets. A parallel product line from Nest with intelligent smoke detectors is now being linked with building-insurance companies. When a smart detector is installed, the companies give a discount on the insurance premium.
The high degree of networking between thermostats, smoke detectors and other sensors in smart homes represents a step toward the Internet of Things.

A lot of start-up activity in digital-economy business models

Digital-economy business models are frequently at the core of innovative start-ups. Start-ups that are particularly attractive for investors are currently to be found in the fields of banking and finance (Fin(ancial) Tech), education (Edu(cation)Tech), e-commerce, the Internet of Things (IoT) and social networks (social, crowd and curation models).[238] In the period from 2000 to 2014, a particularly large number of new internet companies were launched in major German cities such as Berlin (approx. 6,000 start-ups), Hamburg (approx. 3,900), Munich (approx. 3,600), Cologne (approx. 2,000) and Frankfurt (approx. 1,400) (cf. Figure B 3-7). About four out of five digital start-ups belong to the internet economy – compared to a significantly smaller number of start-ups in the 'classic' ICT industry. It is remarkable in this context that Berlin of all places – a region that does not stand out as having a strong industrial base in manufacturing – is benefiting from start-ups in the internet economy.[239]

Yet the market for venture capital, which also provides the external equity capital for start-ups in the digital economy, remains marked in Germany by a severe shortage of privately provided venture capital. While the public funding of start-ups has developed well as a result of the EXIST start-up grants and the financing offered by the High-Tech Gründerfonds, the framework conditions for private investors during the growth phase[240] remain poor. The Commission of Experts has already criticised this shortcoming and the evident regional disadvantage it causes in several reports.[241] Yet Germany and Europe continue to fall even further behind the USA. For example, not only was significantly more private venture capital available in total in the US than in Europe in 2014, but almost 50 percent of the funds financed US start-ups in the fields of ICT hardware, programming, data processes and data hosting.[242] Investment in these important areas of the digital economy make up only 20 percent of the resources invested in Europe.[243]

It is not only in the field of venture-capital financing that German business incubators are lagging behind other European cities. For example, a recent study, the European Digital City Index 2015, points to regional weaknesses especially in the field of digital infrastructure: e.g. the relatively high cost of broadband internet and the low average speeds of mobile internet connections and broadband downloads.[244] In addition, the study refers to the high labour cost of skilled personnel, a lack of crowdfunding finance, and poorer access to mentors for start-ups in the digital industry. In the overall ranking of European business incubators, there is not one German city among the top five cities (London, Amsterdam, Stockholm, Helsinki and Copenhagen).[245]

A typology of business models in the digital economy

Numerous different business models are deployed in the digital economy (cf. Box B 3-8). Entrepreneurs often experiment with different forms of digital business models to identify the ones that are especially profitable.

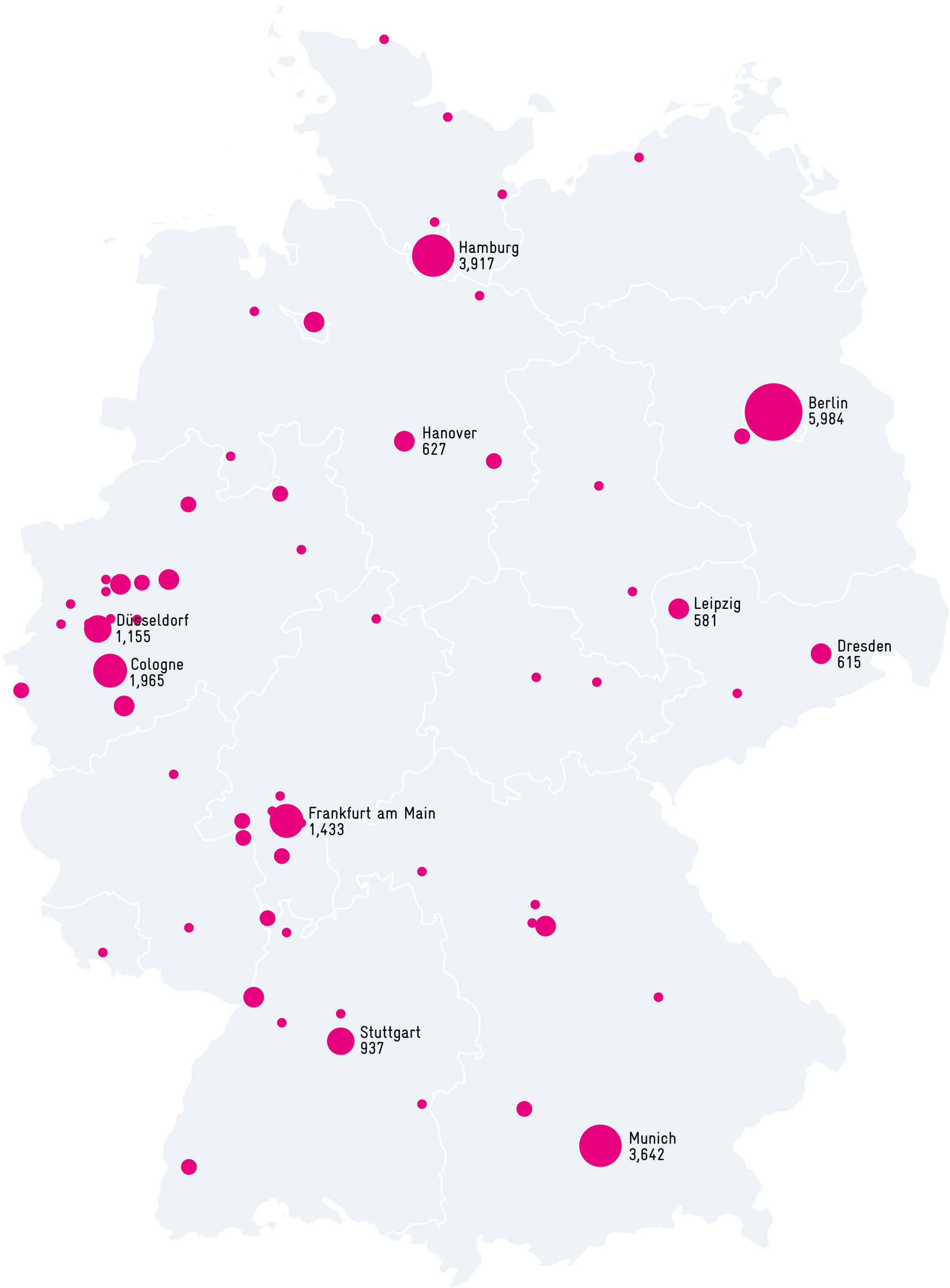
Many business models in the digital economy aim to gain access to the end customer or user. The survival and growth of a start-up often depends on whether it succeeds in establishing as an intermediary with a large base of users. In this way a start-up can, if successful, partly or completely take over the existing access to customers from incumbent companies or manufacturers by taking on a coordinator role or by arbitrage between supply and demand. For their part, incumbent companies stand to lose part of their value added, or must at least expect that start-ups or new intermediaries will gain bargaining power within value chains.

New companies often create additional customer benefit on the basis of digital business models, e.g. by greatly cutting the users' transaction costs. Established markets – whether online or offline – can be made a lot more transparent, competitive and innovative from the users' point of view, leading to falling prices or increasing quality of supply. At the same time this is likely to induce a more differentiated supply, and therefore broader range of services and products. Among other things, a cross-sectoral or platform-driven exchange of data can lead to attractive new bundles of services and products as the scale of connectedness grows. Greater involvement by consumers and users in the value-creation processes of the digital economy also increases the likelihood that users too will generate more innovations.

Fig. B 3-7

Download data

Number of business start-ups in the internet economy in Germany, 2000-2014



Source: own diagram based on Müller et al. (2016).
Remarks: Identification of start-ups based on commercial register entries (ORBIS database).

Expansion of the digital economy

More and more new fields of business activity are emerging in the digital economy as the scale of connectedness increases. These are no longer limited to the initial application fields 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 suggest that new fields of application are currently being opened up which up to now have not been among the core activities of the digital economy (cf. Table B 3-9).

These new fields of application, which are leading to the further expansion of the digital economy, include among others sectors such as Smart Home, the Internet of Things (IoT), new forms of communication like WhatsApp, robotics (cf. Chapter B 2), augmented reality (using computers and data glasses[246]), virtual reality, mobility and security. At the same time, most of these activities are currently being driven by the financially strong corporations of the internet economy, above all US and Asian companies. They have already acquired numerous companies from other industries, including German firms. However, systematic studies suggest that companies from Europe are relatively rarely the target of such acquisitions, and that they very rarely take on the role of buyers.[247]

B 3-3 Digital business models in established companies

Status quo – reticence among small and medium-sized enterprises

Survey results indicate that established companies in Germany expect digital technologies to lead to changes primarily in the overall economy or in their sector. On the other hand, they only expect a minor impact on their own company.[248] About a third of the firms say they see no need for digitisation activities and are therefore not planning to invest. Only two reasons are given more often to explain why companies are not investing in digital change: budget restrictions and a lack of skills.[249] Yet many businesspeople are well aware that, in the course of digital change, they will have to expect new competitors and a growing dependence on other companies playing a key role in the value-creation network – for example platform services.[250]

Examples of digital-economy business models

'Free-of-charge platforms'
are business models containing the following elements:
- 'Free-of-charge services' offer a free basic service (called a freemium) in order to establish a broad customer base. Income is generated by additional offerings for which a charge is made, or by other forms of returns.
- The 'coordinator role' combines the value-creation activities of different companies to offer customers an aggregated product.
- In 'two-sided markets', different customer groups are served – partly for free, partly for a fee – by a platform.
- The 'differentiated demand' approach is characterised by the fact that customized offers are made to heterogeneous users, and income is generated via many small payments.
- Example: Soundcloud is a platform for making contact between artists and their fans. Artists can upload up to three hours of audio material free of charge. Charges are made for larger volumes of audio material or a more comprehensive profile. Further examples of this business model include Google, LinkedIn or Xing.

'Experience-oriented crowd users'
are business models containing the following elements:
- 'User experience' means that the customer's (emotional) experience is at the centre of the use of the service.
- In 'crowdsourcing', key activities of value creation are outsourced to the crowd, i.e. to the general public or a selected group of users.
- 'Value added from user data' aims to generate additional income from the analysis of customer data.
- Example: Researchgate is a website and social network for scientists. The users can hold discussions with researchers in their specialist fields and upload their publications. This creates a unique atmosphere for the users, and the site benefits from the contributions of all users. Further examples of this business model include Facebook, Twitter, Flickr, YouTube or Instagram.

Box B 3-8

'Subscriptions for differentiated consumers'
are business models containing the following elements:
- 'Differentiated demand' (see above).
- 'Subscriptions' requiring periodic payments by the user to the provider for a fixed term. The offer can subsequently be used in the manner stipulated in the contract. Since the reproduction of digital goods generates virtually no costs, these goods can be offered cheaply.
- Example: Babbel offers language-learning subscriptions for fixed-term, periodic payments. Alternative examples of the business model are Spotify, Apple Music or Netflix.

'Partnership platforms'
are business models containing the following elements:
- 'Two-sided market', 'coordinator role' and 'differentiated demand' (see above).
- 'Partnership' refers here to commission paid for passing customers on to third parties.
- Example: Lieferheld pools the ranges of many delivery services in a region and offers the customer easy access via the platform. Alternative examples of the business model are Idealo, Billiger.de or Check24.

'E-direct sales'
are business models containing the following elements:
- In classic 'trading-commerce', products or services are offered for sale via the internet.
- 'Direct sale' means that the products are sold directly to the customers by the producers, i.e. without intermediaries.
- Example: Zalando is a typical online trader specialising in shoes and fashion. Alternative examples of the business model are Amazon or Alibaba.

'Additional offer and cross-section function'
are business models containing the following elements:
- 'Cross-section function' and 'subscriptions' (see above).
- In the case of an 'additional offer' a basic range is first offered relatively cheaply. The user has to pay a surcharge for an offer with more options.
- Example: ArangoDB offers its NoSQL database to many different industries. Higher fees are charged if larger quantities of data are to be supported. Alternative examples of the business model are GitHub, TeamViewer or Dropbox.

'Coordinators of individualised mass products'
are business models containing the following elements:
- 'Coordinator role' and 'two-sided market' (see above).
- 'Individualised mass products' means that products are mass produced, but customized at the same time.
- Income is generated by 'cross-sectional functions' when services or products are offered for a certain part of the value chain in different industries. This digital-economy business model thus combines an individual offer with a platform on which the part-offers of individual partner providers are available.
- Example: Test Birds offers customers an individual app for testing the functional performance of websites. The business model is implemented by the crowd. Here, Test Birds functions as the intermediary between users who test and users who want to have their websites tested. Alternative examples of the business model include 3D Hubs, MakeXYZ or MakeTime.

Source: Own illustration based on Müller et al. (2016). Note: A multi-level cluster procedure was used to identify ideal-typical forms of business models in the digital economy from a sample of both successful and unsuccessful digital-economy start-ups in Germany (Crunchbase database).

Tab. B 3-9

Download data

Selected holdings and take-overs

Buyer companies		Target companies			Year
Name	**Country**	**Name**	**Country**	**Business area**	
Amazon.com Inc	USA	2lemetry Inc	USA	IoT platform for corporate purposes (relation to CRM, production and social network)	2015
Apple Inc	USA	Metaio GmbH	Germany	Augmented reality applications (relation to network)	2015
Facebook Inc	USA	Surreal Vision Ltd	United Kingdom	3D vision connected with ‘mixed’ reality and autonomous robots	2015
Intel Corp	USA	Vuzix Corp	USA	Wearables (e.g. glasses with built-in video monitor)	2015
SoftBank Corp	Japan	Aldebaran Robotics SAS	France	Humanoid robots, developer for customer applications	2015
Samsung Electronics	South Korea	Sigfox Wireless SA	France	IoT/mobile communications	2015
Alibaba Group Holding Ltd	China	Lyft Inc	USA	Car-sharing software	2014
Deutsche Telekom AG	Germany	brightONE GmbH-Health-care Bus	Germany	Healthcare business	2014
Alphabet Inc	USA	Titan Aerospace	USA	Solar-driven drone technology	2014
Alphabet Inc	USA	Nest Labs	USA	Developers of thermostatic systems	2014
Qualcomm Inc	USA	Beijing Wanghe Times Tech Co	China	Smart Home device developers	2014
Alphabet Inc	USA	Boston Dynamics Inc	USA	Humanoid robots, autonomous military robots	2013
Alphabet Inc	USA	Schaft Inc	Japan	Humanoid robots	2013

Source: own diagram based on Müller et al. (2016).[251]

B

The use of digital technologies is a suitable indicator for determining the degree of digitisation of value creation and the potential advantages for German companies of launching digital business models of their own. Cloud computing and big-data analytics currently have an especially high priority for companies in Germany. Technologies and processes like mobile enterprise, social business and sensor networks in the context of Industry 4.0 are of only secondary importance.[252]

Interviews with company representatives confirm that many large German companies have been using IT to support or automate their business processes, e.g. with integrated information systems or workflow management systems. For example, digital platforms can be also used to organise research and development processes within the company and make them more efficient (cf. Box B 3-10).[253] Such process improvements are currently only just being introduced in established small and medium-sized enterprises (SMEs).[257]

Box B 3-10

New processes for product design and R&D in companies

The Austrian company Swarovski's central innovation and communication platform – iCloud Community – is an example of the integration of internet-based technologies into the research process. It is a web-based solution for generating ideas and assessment by all employees; it was introduced back in 2004. The decisive elements for the success of employee participation were, on the one hand, the organisational integration and, on the other, the adjustment of the entire corporate culture, so that work on the ideas community was not regarded as a sideline alongside work.[254]

'TechnoWeb 2.0' was introduced at Siemens AG in 2010 as a web-based social network – also in the field of R&D – and aims to improve knowledge networking and flows within the group. It enables all employees to find experts to consult on specific specialist topics across all corporate divisions. To do this, employees use personal profile pages – or networks or groups to which they allocate themselves and where they can exchange information and specialist opinions. The platform also supports the user-specific assignment of roles and rights, as well as the simple integration and evaluation of content from the internet and intranet.[255]

Box B 3-11

Case study on the use of digitisation in a medium-sized manufacturing company[256]

A medium-sized industrial company with approximately 100 employees manufactures cooking systems and distributes these products throughout Europe. The company bases its business model on its industry-specific expertise in the development of cooking systems for large-scale catering and in processing blanks into final products. The company avoids experiments with digital technologies. However, it is open to established digital technologies if it can foresee that they will yield benefits. On the other hand, it is sceptical about the security aspect. Digital technologies have been introduced, particularly in development, planning and distribution. For example, price lists, brochures and operating instructions are digitally updated and delivered. Customer service, too, is supported by video telephony in some cases. However, the product range is not expanded by additional digital offers. Although digitisation is seen by management as an opportunity, it is also seen as a cost driver, since it creates additional work for the SME.

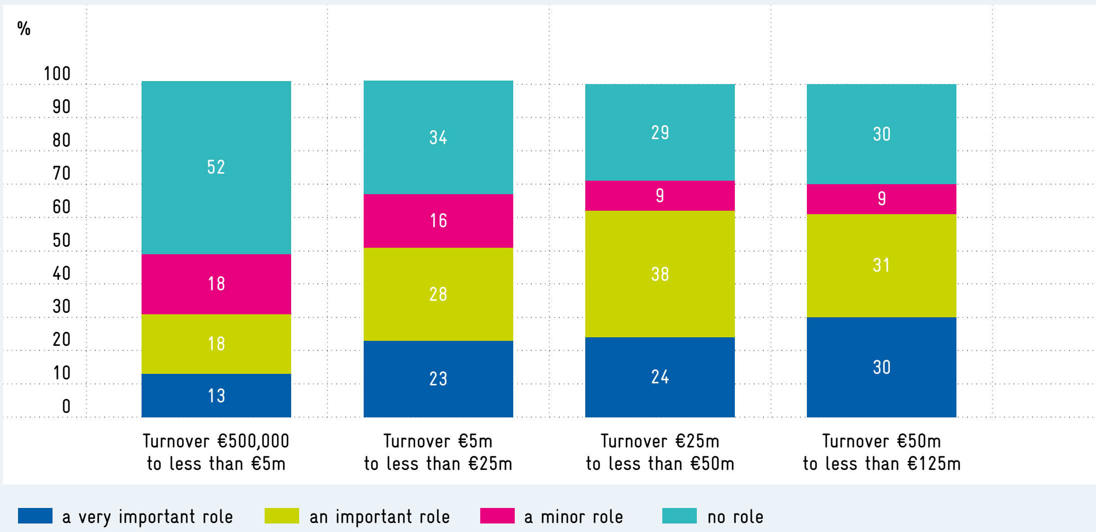
However, the different sectors vary – in some cases considerably – as regards the use of digital technologies. A recent study confirms that there is already a relatively high level of digital maturity in companies in the automotive engineering industry, as well as in logistics and transport.[258] The authors of this study say that Germany is a long way behind in sectors such as healthcare, financial services, commerce, services and construction. There are evidently deficits specifically in those industries where digitisation is expected to have an especially big influence in the future.

SMEs seem to have particular difficulties with implementing new digital business models (cf. Box B 3-11). The smaller the company, the less important digital technologies are, according to the companies surveyed.[259] The Commission of Experts is therefore concerned that a large proportion of SMEs are underestimating the importance of digital change (cf. Figure B 3-12).

Fig. B 3-12

Download data

Importance of digital technologies for manufacturing and value added by company size (turnover), percentage of respondents



Source: GfK (2014: 7). Note: the sample comprises SMEs with an annual turnover of between €500,000 and €125 million.

Box B 3-13

Definitions of big data and cloud computing

The term big data covers technological developments in the field of data storage and processing, which make it possible to integrate ever greater amounts of data in many different formats and to process them more and more quickly.[260] Big data thus offers an opportunity to keep control of the exponentially rising data volumes caused by the growing ubiquity of ICT and, above all, to use it to generate value.[261]

According to a definition by the Federal Office for Information Security, cloud computing refers to offering, using and charging for IT services over the internet. The services provided can be rapidly adapted to changing needs.[262] They 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 infrastructure (e.g. computing power, memory), platforms and software. Cloud computing typically has the following five characteristics:

- Automated set-up: the initial provision of the resources (e.g. computing power, memory) takes place automatically without any customer-specific interaction with the service provider.
- Easy access via the internet: the services are available with standard mechanisms via the internet and are not tied to a specific client.
- Virtual pooling of resources: the provider's resources are to be found in a pool which many users can pick from (multi-tenant model). The users do not know where the resources are located, but they can contractually stipulate the location of the memory, e.g. the region, country or data centre.
- High elasticity: the services can be made available quickly and with great elasticity – in many cases automatically.
- Costs depend on usage: resource usage is a measurable service for which the cloud users are charged.

The advantages of the cloud-computing service models[263] for companies lie primarily in a lower need for investment, greater flexibility, and the easy scalability of cloud services, especially when capacity requirements fluctuate.

Germany lags behind in the use of big data and cloud computing

Big data and cloud computing are especially important digital technologies because both are said to have a disruptive effect (cf. Box B 3-13).[264] Disruptive technologies are technological innovations that supersede existing technologies, products or services and frequently lead to the emergence of entirely new markets.

A recent study on big data shows that in 2014 only 9 percent of the German companies surveyed were using big-data solutions; another 31 percent had concrete plans for their use.[265] While 28 percent of respondents were still at the decision-making stage, 33 percent had not yet looked into the subject.

Here, too, considerable differences can be seen between large companies and SMEs in the use of big-data approaches.[266] While only 7 percent of SMEs actually apply big data approaches and 29 percent have concrete plans to use them, 27 percent of the major corporations are already users, and a further 42 percent have concrete plans. 36 percent of the SMEs say they have not yet considered big-data concepts, compared to only 8 percent of major companies.

In an international comparison, Germany is well below the average in the use of big-data approaches among the countries studied.[267] Companies in India, the USA, Mexico and the United Kingdom use (or plan to use) big data twice as often as German companies.

Furthermore, only 11 percent of SMEs with 10 to 249 employees used cloud computing in Germany in 2014.[268] By contrast, these services were used by 27 percent of German companies with more than 250 employees. The most important reason given by SMEs for not using them is the perceived risk of security problems. In many other European countries, use by both SMEs and large companies is much more widespread – e.g. in Finland (50 and 69 percent respectively), Italy (40/47 percent) and Sweden (39/62 percent).

Improving the framework conditions for the digital economy B 3–4

Quickly clarify fundamental legal issues

Data-based business models raise a number of fundamental legal questions. Uncertainty regarding property rights to the data can develop into an obstacle for the digital economy. Similarly, issues involving exploitation rights and liability must be clarified promptly, but with great care. In the meantime, not only specialist bodies, but also the Bundestag are looking into these questions.[269] It is important not to create new forms of property rights over-hastily – as in the case of the protection of databases set up by the European Commission.

Furthermore, questions of copyright, consumer protection and data protection overlap with competition issues. The Commission of Experts supports the position of the Monopolies Commission, which calls initially for an improvement in the legal opportunities of market participants to enforce market-relevant individual rights like copyright, and does not see competition law as the preferred approach for solving all problems in the field of the digital economy.

Closely monitor competition processes, ensure continuous innovation competition

It is imperative to closely monitor competition processes in the digital economy. A strong concentration of providers is taking place in many areas of the digital economy. For example, Alphabet has a market share of over 90 percent in the fields of desktop search, mobile applications and apps. The aim here must be to use the regulation of competition to prevent the emergence and consolidation of monopolies, and in this way to ensure continuous innovation competition.[270] Competition in the markets for data and user information in particular should have a high priority here, as these markets provide key resources for new business models and business start-ups in the digital economy. The increased exchange of data leads to considerable networking, so that network effects will play an even bigger role in the digital economy in the future. Because network effects can reinforce the concentration of competition, dominant market positions must be expected to be more common in the future.

No overhasty regulatory interventions

The Commission of Experts is concerned that too detailed or premature regulation in Germany and Europe could hamper the further development and emergence of innovative business models in the digital economy. Therefore, like the Monopolies Commission and the Münchner Kreis, the Commission of Experts suggests examining flexible and dynamically adaptive regulatory measures, preferably at the international level.[271] It recommends in particular considering the repeal of historically grown restrictions on competition in situations where incumbent firms are confronted by new services in regulated sectors. For example, in the view of the Commission of Experts the first regulatory attempts made by policy-makers in the case of Uber are to some extent going in the wrong direction. In some cases, the argument of consumer protection was put forward in order to obstruct rivalry from new competitors. This conflicts with the intention of promoting innovations via the emergence of new business models. A need for regulation is also highly likely to emerge in the developing internet-based sharing economy. But overhasty action resulting in preferential treatment being given only to incumbent structures and actors must be avoided.

Guarantee data protection and data security – at the European level

The huge potential of digital technologies and business models comes up against understandable reservations from citizens when it comes to the protection of data privacy and data security. At present, 87 percent of people surveyed in Germany find it unacceptable for online applications to access personal data automatically. At the same time, data-intensive services, such as social networks and cloud services, are being used more and more by citizens – also in Germany.[272] Therefore, there is a need for action on statutory data-protection regulations – e.g. rules on open administration data (cf. Chapter B 4) or the cross-border transfer of personal data – in order to build trust among users and increase the acceptance of the digital economy.

The EU General Data Protection Regulation agreed in December 2015 by the European Council, the European Parliament and the European Commission makes it possible to develop an independent European position and practice in this field. The Commission of Experts explicitly welcomes this new regulation. Although it is by nature a political compromise whose individual norms are controversially discussed,[273] it must be regarded as a great success that this new regulation will apply throughout Europe and will harmonise data-protection laws in the 28 member countries of the European Union. The regulation is to come into force at the beginning of 2018, replacing the existing EU Data Protection Directive (Directive 95/46/EC), which has been applied since 1995. It is especially important that the new regulation also establishes the validity of European data protection law for companies that offer their services within the EU, even though they are not resident in the EU and therefore process their data outside of the EU (lex loci solutionis).[274]

The Commission of Experts also welcomes the ongoing efforts of the European Commission within the framework of the common digital single market, especially the initiatives aiming to strengthen the cross-border traffic in non-personal data.[275] In addition to improving technical feasibility through common standards and interfaces – especially in the field of the Internet of Things – this should also include the certification and facilitated switching of cloud services and the planned establishment of a European Research Cloud. The Commission of Experts also regards the establishment of an Industrial Data Space within the framework of the Industry 4.0 platform as an expedient way to reduce reservations about cloud computing, especially among SMEs in the manufacturing sector.[276]

In principle, (new) regulatory measures by policy-makers – especially in the big-data field – are desirable if such measures create stronger incentives for the exchange of data in the digital economy. Merging complementary data often forms the basis for new applications and business models in the digital economy. However, this benefit can only result if business risks like the loss of intellectual property in the course of data exchange are limited in a sensible way. In this area, too, what is currently needed above all is courageous experimentation among actors from business, science and policy.

Rethink start-up funding – take business-model innovation seriously

Competition in the digital economy can primarily be secured by creating better framework conditions for innovative start-ups in this field. Even though only very few start-ups survive in the digital economy, thanks to the usually low switching costs or multi-homing for users these also ensure that dominant companies are constantly offering improved or innovative services.[277]

In existing public start-up funding, too, the aim should be to focus more on acute needs in the digital economy. Within the framework of the BMWi's EXIST programme, as a rule start-ups are currently only funded if they pursue technologically demanding start-up concepts. Public funding of start-ups on the basis of innovative business models of the digital economy is generally not possible, but it should be considered. In addition, the overall decline in the number of start-ups in Germany as a result of the demographic development must at last be countered by suitable measures from policy-makers. In particular, start-ups in the German internet economy which are greatly affected by the demographic development should therefore step up their recruitment efforts among the international pool of talent. This should be flanked by corresponding measures to attract start-up entrepreneurs or entrepreneur teams from abroad (cf. Chapter B 1).

B 3-5 Assessments and recommendations

Looking at the overall picture of digitisation activities, Germany is currently at the level of international average at best.[278] Up to now, it has not been able to build up noteworthy strengths either in the classic ICT industry or in internet-based industries. Business models in the digital economy represent disruptive innovations. The Commission of Experts takes it as given that

- they lead to the development of considerable value-creation potential, but
- at the same time they also trigger considerable upheavals in established industries.

Value creation, employment and prosperity are redistributed as a consequence of these developments.

R&I policy in Germany must therefore pursue a double strategy: on the one hand, German firms must be supported in their efforts to open up new value-creation potential in the internet-based economy; on the other hand, support must be provided for the transformation of sectors that are threatened by disruptive innovation.

Review of existing policy measures

The Federal and Länder governments have become aware of the challenges due to digitisation. However, the Commission of Experts observes a fragmentation of funding activities and strong policy competition between government departments. The new opportunities are only being recognised hesitatingly; the focus lies on defending incumbent and hitherto successful sectors and actors. The Federal Government's policy seems defensive.

The Commission of Experts believes that the Federal Government's strong focus on a relatively small area of digitisation is unlikely to yield the intended results. For example, Industry 4.0 one-sidedly targets efficiency gains in the field of manufacturing technology.[279] Similarly, other industry- or application-specific initiatives – such as Smart Service Welt or eHealth – are limited in their ability to generate positive funding effects across the broad range of digital applications.[280]

The Commission of Experts welcomes the fact that the Federal Government has already initiated some important steps since the beginning of the legislative period. These include:

- the conversion of Industry 4.0 from a platform of industrial associations into a more clearly structured and fast-working 'Platform Industry 4.0' involving important government departments;[281]
- the conception and funding of internet-related security research by the BMBF;[282]
- increased funding for medical informatics, also by the BMBF;[283]
- the systematic processing of steps that have been decided by the government parties in the Digital Agenda – in this field, more than half of the measures have now been implemented under the auspices of the BMWi;[284]
- work on an Industrial Data Space, primarily geared to the needs of SMEs;[285]
- the establishment of an Institute for Internet Research to engage in interdisciplinary research into "the ethical, legal, economic and participatory aspects of the internet and digitisation";[286]
- the funding of digitisation in SMEs under the BMBF's recently announced ten-point programme.[287]

B

However, a convincing overall strategy is still lacking at present. At the beginning of the legislative period the Digital Agenda was a useful collection of analyses and areas requiring action. Up to now, however, it has not been developed into a consistent strategic overall concept that clearly identifies Germany's weaknesses in digitisation and develops across-the-board measures aimed at improving Germany's position. Instead, separate fields of action have formed – separately run by government departments, often competing with each other for a dominant position – e.g. Industry 4.0, Smart Services, Smart Home. Connections and complementarities between these fields of action remain unclear. There is still a considerable need for action here.

Recommendations for further measures of R&I and industrial policy

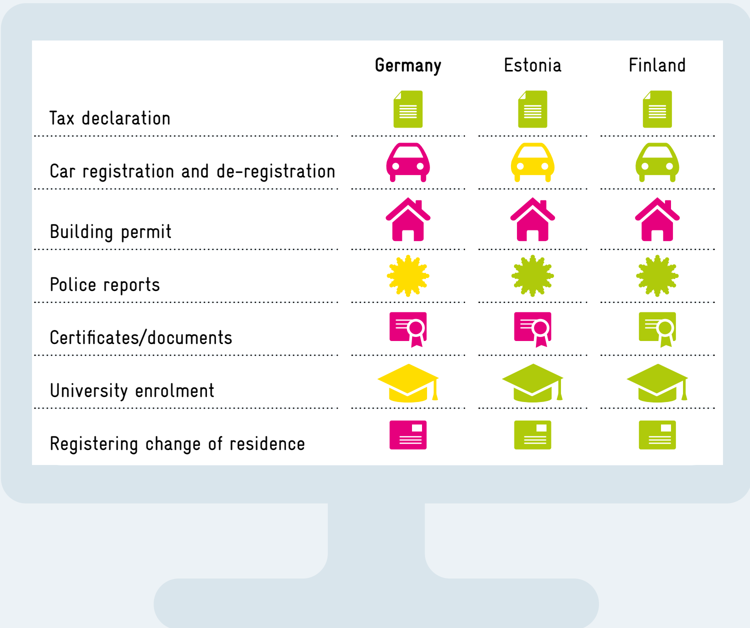
- German companies are lagging behind their competitors in other countries in the application of cloud computing and big-data approaches. Software, digital technologies and new business models are too often seen as cost drivers and too rarely as opportunities to attain a promising edge over the competition. The onus here is on the corporate sector; to rest on the laurels of past export and innovation successes in the face of an emerging wave of disruptive innovations is not the appropriate strategy.
- At the same time, Federal Government policy in particular must lead by good example. The quality of e-government in Germany is in urgent need of improvement (cf. Chapter B 4). This would stimulate government-induced demand specifically for German suppliers.
- The Commission of Experts is concerned that a 'digital divide' could emerge in the corporate sector. SMEs in particular seem not yet fully aware of the importance of the upcoming changes. Funding restrictions make it difficult for these companies to tackle the necessary changes. The process of developing new digital business models could be considerably delayed in many German SMEs. There is a risk of losing market shares even in niches where German companies have hitherto been operating very successfully. The Federal and Länder governments should try to give interested SMEs access to 'business-model academies' which teach implementation strategies for digital business models.
- Germany has a large number of start-ups that are building up new sources of value creation with ambitious business-model innovations. But these companies currently do not have sufficient access to venture capital. They must seek their medium-term growth abroad in view of the lack of a suitable stock-market segment. The Commission of Experts reiterates its recommendation to work towards setting up such a stock market segment.[288]
- German citizens and households – like German companies – are lagging behind international standards in handling digital technologies and models. For example, the Eurostat indicators point to a lack of skills in the population in the field of digital technologies – particularly when it comes to internet skills.[289] Skills development in handling digital technologies and models of their application should be supported across the board – in all education and further-training segments. People should be encouraged to practise sensible ways of handling their own data as early as possible. School curricula should pay more attention to fundamental digital skills than they have hitherto.
- Students of all subjects at tertiary-education institutions should be proficient in software coding for the applications in their respective disciplines. Computer sciences should be understood as a new key discipline and be incorporated more closely into the curricula of other training courses.

The Commission of Experts is confident that Germany can succeed in the catching-up and adjusting process that it must undergo. The challenges are not to be underestimated, but Germany in particular has every reason to approach these tasks with optimism. After all, it already mastered one wave of digitisation in the 1980s.

B

E-government in Germany: much room for improvement

The term e-government is an abbreviation of electronic government (and administration). In e-government, public services and administrative matters are digitised and made available online. It is an important instrument for improving the quality of services provided by the public administration and for cutting red tape.

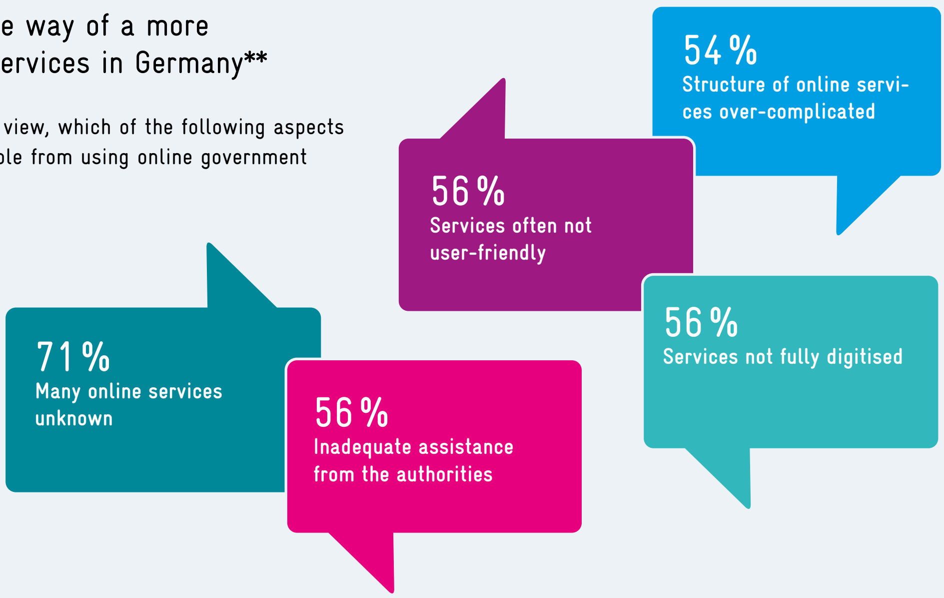


Services and full digitisation of central services for citizens*

- Not available as a fully digitised, nationwide, uniform e-government service.
- Not available as a fully digitised e-government service.
- Available as a fully digitised e-government service.

Barriers that stand in the way of a more intensive use of online services in Germany**

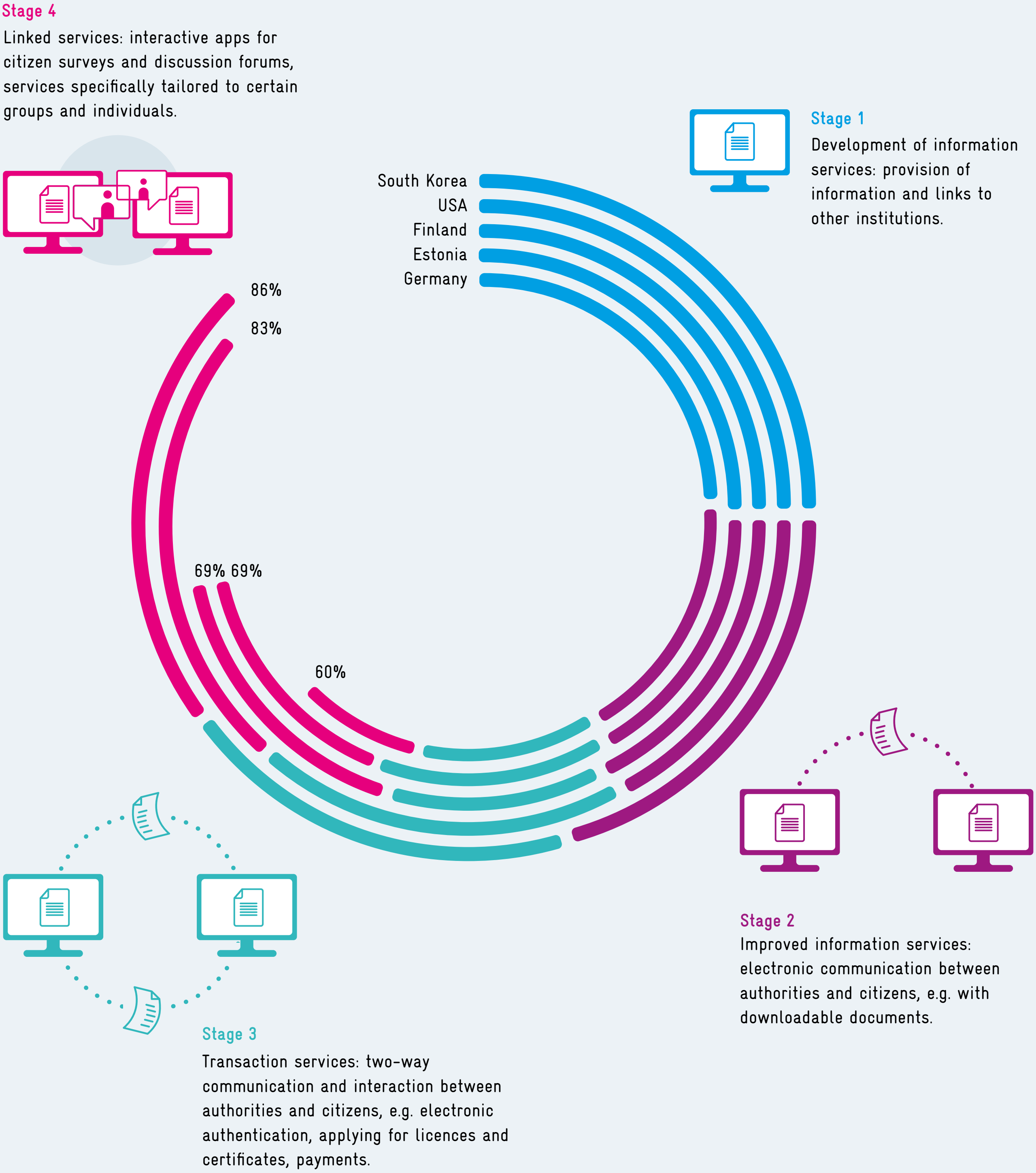
Answers to the question: "In your view, which of the following aspects are key obstacles preventing people from using online government services?"



* Source: European Commission (2015).
** Cf. Initiative D21 and IPIMA (2015: 15f.).

Quality levels of German e-government services by international comparison

The E-Government Development Index of the United Nations measures the state of development of e-government services provided by all member states on the basis of a four-stage measure. Germany is a long way behind compared to other industrialised countries. The percentages show the overall result of the respective country.



Source: United Nations (2014).

Download data

B 4 E-government in Germany: much room for improvement

B

B 4–1 E-government's potential for service and innovation

New and better services through e-government

E-government (electronic government) stands for using information and communication technologies based on electronic media to run governmental and administrative processes.[290] In e-government, public services and administrative matters are digitised and made available online. Examples of e-government services in Germany and South Korea are described in Box B 4-1. South Korea serves as a reference country in this chapter because it has a particularly well-developed system of e-government.

E-government represents an innovation in the public sector. Consistently implemented, it opens up significant potential for value creation. E-government allows the remote provision of high-quality public services at any time and at any location. In particular, services and administrative matters that require intensive contact with several authorities can be offered and dealt with centrally via a single website. For example, the birth of a child requires up to 15 administrative services in different authorities, all of which in principle lend themselves to central online processing.[291] This means that people no longer have to travel to public offices, which can save citizens, companies and public authorities a lot of time.[292] By relieving the pressure on authorities, e-government

Box B 4-1

Examples of e-government services in Germany and South Korea

Germany

VEMAGS (Process Management for Heavy Duty Transport) is a uniform, nationwide product that handles online the applications and authorisation procedure for heavy-duty transports in all 16 Länder (federal states) and nationwide. VEMAGS is an e-government product under the auspices of the federal state of Hesse. It is a highly efficient process. Its most important feature is that the entire process takes place via the internet: from the applicants submitting their data, to the administration handling the entire application and authorisation procedure. At the end of the process there is a digital certificate that is accessible 24 hours a day by the police as the monitoring authority. This has greatly simplified night-time controls and reduced the number of transport closures, thus improving road safety and benefiting the economy. In 2013, about 90 percent of all applications for heavy-duty transports were processed via VEMAGS.[293]

South Korea

KONEPS (Korea ON-line E-Procurement System) is the country's central portal for all public procurement. The entire procurement process – e.g. supplier registration, tendering, award of contract, monitoring and payment – is handled electronically by KONEPS. After a one-off registration, all public organisations can take part in the process.

With the introduction of KONEPS, South Korea has created one of the largest e-commerce markets in the world involving the participation of about 47,000 public institutions and 268,000 suppliers with a total transaction volume of around 53 billion euros (in 2013). Five countries (Costa Rica, Cameroon, Mongolia, Tunisia and Vietnam) have since introduced electronic procurement systems based on KONEPS. KONEPS is regarded worldwide as a prime example of innovation in the public sector.[294]

enables them to use freed-up capacity to improve and expand their services, which will in turn benefit citizens and businesses. A well-developed system of e-government makes a country more attractive for businesses and is regarded today as a considerable international competitive advantage.[295]

E-government makes it possible to offset infrastructure disadvantages in peripheral, structurally weak regions, since information and services can be used anywhere. This is of special benefit for people with restricted mobility.

E-government offers citizens enhanced participation in political consensus-building and decision-making processes through a direct exchange of information.

Box B 4-2

Business models based on open government data[296]

A US company called The Climate Corporation (www.climate.com) uses open data for weather forecasts and harvest predictions – information that farmers can use to decide where and when they plant field crops.

Propeller Health (www.propellerhealth.com) uses access to data from the US Center for Disease Control and Prevention (CDC). The US firm has developed a GPS-based tracking device that monitors the use of inhalers by asthmatics. By comparing user data with the CDC data on environmental triggers for asthma (e.g. the pollen count in the north east of the USA or volcanic fog in Hawaii), Propeller Health helps doctors develop personalised treatment plans and localised prevention options.

The British website findthebest.com has used open data to develop an app (UK Car Fuel Economy and Emission) that helps car buyers choose cars whose handling characteristics match their own driving patterns.

An app developed together with paramedics in the USA called iTriage (www.itriagehealth.com) helps patients to understand their disease symptoms, find nearby healthcare facilities or doctors, and make appointments with them. Since iTriage was launched in 2008, the app has been downloaded more than 15 million times.

This can include the submission and processing of suggestions, complaints and petitions, as well as topic-related online discussions, opinion polls and the use of innovative public services such as public hearings in real time.[297]

In addition, e-government can greatly increase the transparency of administrative processes. For example, citizens and businesses are given an opportunity to track the processing status of their application via the internet. It is also possible to fully document the use and forwarding of citizens' data and make it all transparent for the citizens.

The comprehensive use of e-government creates strong demand for IT solutions and can therefore be used as a driver of innovation for the IT and internet industry. According to current estimates made by the Fraunhofer Institute for Open Communication Systems, the creation of an efficient system of e-government in Germany would require a total investment volume of around 1.7 billion euros for development and five subsequent years of operation.[298]

The digitisation of public administration generates huge amounts of digitally usable data. After anonymisation or pseudonymisation, these data stocks can be made available as open government data on online portals and used by companies to develop new services and innovative business models (cf. Box B 4-2). This leads to new markets and jobs.[299] In addition, open government data are a valuable source of information for scientific research.[300]

Germany's e-government by international comparison B 4–2

Ambitious goals of German political decision-makers

Several studies show that, by international comparison, e-government in Germany is lagging behind considerably and therefore wasting important public and private innovation and value-creation potential.[301]

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.[302] In order to classify Germany's performance in the field of e-government, it therefore seems appropriate to use as a yardstick four OECD countries that regularly do especially well in such global studies as the E-Government Survey of the United Nations: Estonia, Finland, South Korea and the USA. Following a comparative analysis using key criteria such as services provided, user-friendliness and intensity of use, recommendations are formulated on ways to strengthen e-government in Germany.

E-government services in Germany are fragmentary

The E-Government Development Index[303] of the United Nations (UN) analyses the state of development of e-government services provided by all UN member states on the basis of a four-stage measure.[304] 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).[305] Services provided at Stage 3 allow two-way communication and interaction – e.g. applying for and issuing 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 interconnected services allowing a barrier-free exchange of information, knowledge and data between authorities and citizens or businesses.[306]

According to the E-Government Development Index, more public services are available online in South Korea, Estonia and the USA than in Germany. Furthermore, most of the services offered in these countries have been fully digitised.

Figure B 4-3 shows that development Stage 1 has been largely completed in all countries, including Germany. Germany is also at a similarly high level as Estonia, Finland and the USA when it comes to Stage 2 e-government services. Only South Korea offers more in this field.

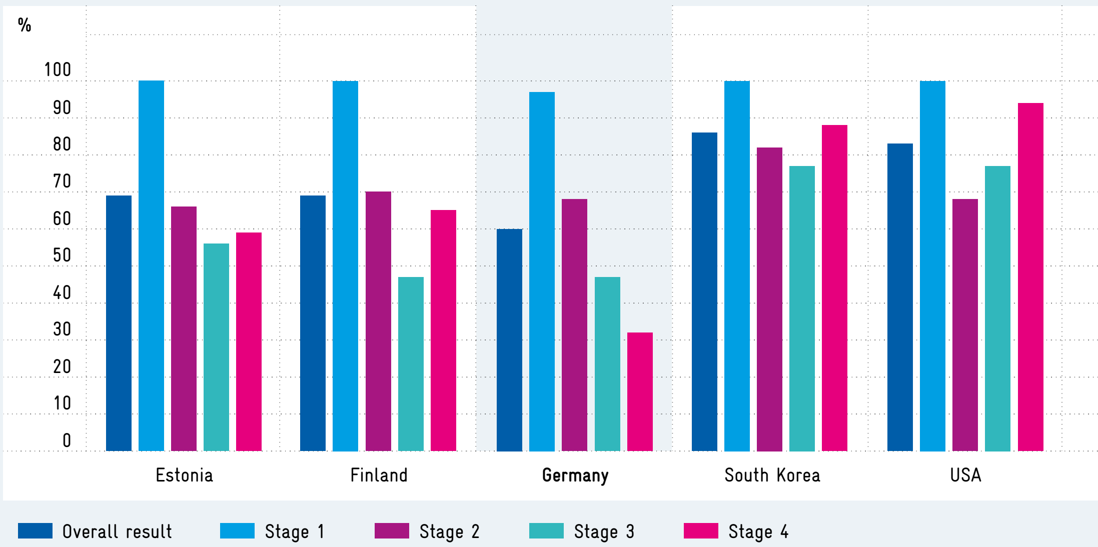
At Stage 3 and higher, Germany's deficits become evident. While the e-government services available in Estonia, South Korea and the USA offer a wide range of possibilities for two-way communication and interaction between citizens and public institutions, in Germany this is possible only to a limited extent.

By far the worst is Germany's performance in Stage 4 e-government services. Estonia, Finland, South Korea and the USA are well ahead of Germany in this sphere.[307]

Fig. B 4-3

Download data

Quality levels of German e-government services by international comparison, 2014[308]



Source: United Nations (2014).

Distinctions must be made in the level of development of e-government in Germany according to target groups. A comparative analysis of EU member states shows that key services for businesses (cf. Table B 4-5) have largely already been fully digitised, while this is not the case for key services for citizens (cf. Table B 4-4). Only three of the 16 services for citizens that were examined – tax declaration, job-seeking via the employment office, and reimbursement of medical treatment costs – are available fully digitised, while seven services (e.g. registering a change of address or registering/de-registering a car) cannot be accessed everywhere via the internet. Germany is a long way behind Estonia and Finland in terms of e-government services for citizens.[309]

E-government services are not very user-friendly

E-government services for citizens in Germany are fragmentary and largely not fully digitised. This is aggravated by the fact that the existing services are not user-friendly. In addition to full digitisation, an e-government service needs to broadly publicise the online services that are available. In order to be user-friendly, it also needs to be clearly structured, easy to operate and transparent.[310] Ideally, the electronic information and services are bundled and offered in one place: in a 'one-stop shop'.[311]

According to E-Government Monitor,[312] the main barrier to the use of e-government is the fact that a large number of citizens are unaware of many online services. Complex handling, inadequate assistance from the authorities, a lack of full digitisation and inscrutable structures are also mentioned as barriers that stand in the way of the use of online public services.

The results of the European Commission's E-Government Benchmark Report 2014[313] confirm these findings and show that e-government websites in Germany are given markedly worse usability ratings than those in Finland or Estonia.

Estonia, Finland, South Korea and the USA already have citizen-service portals where all online services are offered uniformly and clearly in a one-stop shop.[314] By contrast, the central German e-government portal primarily offers information about public-service job vacancies and public-sector invitations to tender.[315] Key services for citizens and businesses are not listed.[316] To access these services, citizens must still consult the individual websites of the responsible authorities.

Also in need of improvement is the transparency of e-government services in Germany. In principle, e-government offers public administration the technical ability to tell users what they are responsible for, how they process applications, etc., and how they use and forward data. However, public administration in Germany has so far made little use of this ability. It is therefore not surprising that the transparency of e-government services in Germany is rated markedly worse than in the reference countries Estonia and Finland.[317]

Estonia's good performance in matters of transparency is explained, among other things, by the fact that the Estonian, centrally coordinated e-government system is based on the principle that the data belong to the citizens. Citizens can track which authorities have accessed their personal data on which occasions via the Estonian service portal eesti.ee.[318]

User-unfriendliness 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.[319] In Germany the main complaint is the lack of clear structures, the difficulty of finding online services, and the lack of a one-stop shop.[320] The results of the E-Government Benchmark Report show that the user-friendliness of German e-government services for companies shows deficits by European comparison. For example, the user orientation of online services for regular business operations is given a much worse rating in Germany than in other EU countries.[321]

Poor user-friendliness explains low levels of use

As a result of the fragmentary range of e-government services and their lack of user-friendliness, e-government is used less frequently in Germany than in other countries.[322] International comparative analyses clearly show that the use of online services correlates with the scope of the services offered, the degree of digitisation, and user-friendliness.[323] This suggests that online services would be used more in Germany, too, if the quantity and quality of the services offered were improved – above all by creating a central e-government portal offering clearly structured and fully digitised services.

Tab. B 4-4

Download data

Full digitisation of central services for citizens[324]

	Germany	Estonia	Finland
Tax declaration (submission, checking processing status)	green	green	green
Job-seeking via the employment offices's website	green	green	green
Social services:			
– Unemployment benefit	dark yellow	yellow	green
– Child allowance	dark yellow	green	yellow
– Medical treatment costs	green *	green	green
– Student loan	dark yellow	green	green
Personal documents:			
– Passport/ID	magenta	green	green
– Driving license	magenta	magenta	magenta
Car registration and de-registration	magenta	yellow	green
Building permits	magenta	magenta	magenta
Police reports (e.g. theft, break-ins)	dark yellow	green	green
Certificates/documents: application and issue (e.g. marriage/birth certificate)	magenta	magenta	green
University enrolment	dark yellow	green	green
Registering a change of residence	magenta	green	green
Health services	magenta	green	yellow
Public libraries (online catalogue and -search)	dark yellow	green	green

* Reimbursement of treatment costs need not be applied for by people with statutory health insurance.
(green) Available as a fully digitised e-government service.
(dark yellow) Not available as a fully digitised e-government service.
(magenta) Not available as a fully digitised, nor as a nationwide, uniform e-government service.

Source: European Commission (2015) and Recherche IW Consult. Own diagrambased on Bahrke et al. (2016).

Tab. B 4-5

Download data

Full digitisation of central services for companies

	Germany	Estonia	Finland
Sicail security contributions for employees	green	green	green
Corporation tax declaration (submission, checking processing status)	green	green	green
Value added tax (payment, checking processing status)	green	green	green
Business start-up and registration	magenta	green	yellow
Transfer of data to statistical offices	green	green	green
Customs declaration	green	green	green
Environmental permits (incl. reporting)	green	green	yellow
Public procurement	green	green	green

(green) Available as a fully digitised e-government service.
(dark yellow) Not available as a fully digitised e-government service.
(magenta) Not available as a fully digitised, nor as a nationwide, uniform e-government service.

Source: European Commission (2015) and Recherche IW Consult. Own diagrambased on Bahrke et al. (2016).

B 4-3 Open government data in Germany

German data portal not supported by all Länder

The term open (government) data refers to data stocks that are made publicly available for further use and distribution. Data that are subject to data-protection regulations or are sensitive for security reasons are excluded from public use from the outset.[325]

Businesses, citizens and civil-society players can use the publicly available data – e.g. geodata, traffic information or public statistics – to develop innovative business models.[326]

The G8 Open Data Charter of June 2013 forms the basis for the provision of public data. In this charter, Germany and the other G8 countries have agreed on five basic principles for implementing open data – in particular, it is to be standard practice in the future to make administrative data available in an open way.[327] The Federal Government has developed a national action plan for the implementation of the Charter.[328] It outlines the structure of an open-data portal through which the data collected from Federal, Länder and municipal authorities will be made available to the public. After a test phase lasting almost two years, 'GovData – The Data Portal for Germany' began regular operations at the beginning of 2015.[329]

However, GovData has been criticised since its inception because it does not meet the internationally recognised open-data standards, which is why the originally planned additional word 'Open' had to be removed from the name.[330] Furthermore, there are no guidelines on what data have to be made available by the authorities. Each authority decides for itself which data sets it publishes.[331] The result of this practice is that primarily small-scale, not very topical data sets are offered; most of them are not machine-readable and therefore of only very limited usefulness.[332] According to a study compiled on behalf of the Federal Ministry of the Interior, only 0.4 percent of the data released fully comply with the criterion of being machine-readable.[333]

In principle, there would be great interest in Germany for a central portal with very comprehensive public data sets. However, the attractiveness of GovData is restricted by the fact that six Länder are not participating in its funding and have therefore been excluded from access to the portal since June 2015.[334] Yet the value of such a portal is all the greater, the more Länder feed their data into the central portal instead of setting up their own portals. Only with a central portal is it possible to ensure that data are clearly structured and mutually compatible, thus avoiding transaction costs and potential multiple investments. A central solution at the federal level therefore has great advantages over decentralised approaches at the state and municipal level.

South Korea could be a model for the provision of open data. It has already built up a powerful central open-data portal (www.data.go.kr). An open-data law obliges all authorities and ministries to make their data available to the public on this portal. There is also a mediation committee that helps private companies demand data from public institutions.[335]

B 4-4 General framework affecting e-government in Germany

Improvements in coordination needed

In recent years, the Federal Government has repeatedly and emphatically called for the expansion of e-government in Germany.[336] Notwithstanding the numerous strategy papers, international declarations and legislative initiatives, Germany's e-government is nevertheless still below average by international comparison.[337]

The country's federal structures are the biggest obstacle to the development and expansion of e-government in Germany. In Germany, the Länder are responsible for the organisation of administration,[338] although Federal and Länder governments can work together on the basis of Article 91c of the Basic Law (Germany's constitution) in the field of information technology, which also includes e-government.[339] Cooperation between the Federal and Länder governments is therefore required in order to implement strategies and legislation on nationwide e-government.[340] 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.[341] However, the IT Planning Council only has very limited resources and political power at its disposal. Its purpose is above all to ensure a "continuous exchange of experience between representatives of the Federation, the Länder and the municipalities".[342]

The expansion of e-government in Germany is based on the principle of voluntariness; there are hardly any legally binding requirements.[343] Since the interests of the federal players 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. In practice there are only a few e-government services – such as ELSTER (electronic tax declaration) or VEMAGS (traffic-management system) – that are centrally structured and controlled. The dominant feature overall is locally developed services, many of which are island solutions, especially at the municipal level.[344]

In order to improve federal IT cooperation – and thus also cooperation in the field of e-government – the IT Planning Council has created a joint federal and Länder working group called FITKO (which stands for Federal IT Cooperation). The working group has analysed federal cooperation in the field of e-government and found numerous shortcomings. In order to be able to systematically plan and implement federal IT cooperation in the future, the working group recommends substantial changes in the organisation of existing structures and more operational support for the IT Planning Council. It proposes the establishment of an independent organisation borne by the Federal and Länder governments to support the IT Planning Council in exercising its coordination and control function.[345]

B 4–5 Recommendations

- 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.[346] This goal has not been met. On the contrary, by international comparison Germany's e-government is underdeveloped.
- This deficit primarily reflects a limited and not very user-friendly range of e-government services. Fully integrated, digitised and uniform e-government services nationwide are still the exception. In Germany there is neither an overriding, binding strategy, nor the kind of strong, central body of enforcement and coordination that distinguishes pioneering nations of e-government like South Korea and Estonia.
- The problems in the field of open data are very similar. The Federal Government has called data the raw material of the 21st century.[347] According to the Federal Government, open, well-structured access to data stocks is also an important contribution to the further development of a knowledge-based society. The innovative potential is thus recognised by the state,[348] but a coordinated approach to running an efficient central data portal is lacking.
- The Federal Government should greatly intensify activities to create and develop both a central e-government portal and an open-data portal. The e-government portal should offer as many services as possible from the Federal Government, Länder and municipalities in concentrated form, arranged according to the concerns they address, and in the form of a one-stop shop for citizens and businesses. To achieve this the Federal Government, Länder and municipalities must agree on uniform interfaces for digitisation.
- Parallel to the e-government portal, the existing data portal for Germany, GovData, should be developed into an open-data portal that is worthy of the name 'open'. To achieve this, the data sets offered there must be not only freely accessible, but also machine-readable and ready for further use. It must also be ensured that all Länder and municipalities take part in the project and make their data available for the portal.
- The expansion of services offered by e-government must go hand in hand with an improvement in user-friendliness. It is essential in this context to create centralised, uniform and clear structures, as well as help, feedback and precise search functions. The mere provision of e-government services and large amounts of data is not enough, and this applies both to the e-government portal and to the data portal. Both projects could fail unless user-friendly structures are established. The level of dissatisfaction with the present situation among citizens and businesses is alarming, and could well handicap the socially desirable development of e-government.
- The development of a comprehensive, fully digitised and integrated e-government service requires the introduction of binding milestones for the Federal Government, the Länder and the municipalities. The Federal Government should create a central coordination office for e-government in the Chancellery. This should be supported by the IT Planning Council, which must be equipped with the corresponding authority to ensure the constructive cooperation of all players.

STRUCTURE AND TRENDS

Contents

C 6 Patents

C 7 Scientific publications

C 8 Production, value added and employment

Overview

Measuring and reporting Germany's performance as a research and innovation location forms 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.[349] Furthermore, individual indicators are shown at the Länder level to identify 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 in order to develop 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, universities 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 firms 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, however, is referred to as 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 Funding of research and innovation

The financing of business and, in particular, R&D activities is a key challenge, especially 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 industries – 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 transfer phase of scientific knowledge to the development of new products and processes.

C 6 Patents

Patents are intellectual property rights for new technical inventions. They thus 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 comparative international data on education and training presented in this chapter are based for the first time on the ISCED 2011 classification, newly introduced by the OECD. As a result, the latest values of the indicators – i.e. C 1-1 Qualification levels of gainfully employed persons in selected EU countries, C 1-2 Number of new tertiary students as a percentage of the relevant age group in selected OECD countries, and C 1-6a Percentage participation of individuals and companies in further training – differ, in some cases significantly, from the figures of past years.

Up until last year, the indicators mentioned were based on the ISCED 1997 classification. The differences between the ISCED 1997 and ISCED 2011 classifications stem primarily from the introduction of additional qualification levels. While ISCED 1997 used seven levels to classify levels of qualification, ISCED 2011 uses nine. For example, in the field of higher education ISCED 2011 distinguishes between four instead of two levels (ISCED 1997: Levels 5A and 6; ISCED 2011: Levels 5 to 8), and in the field of secondary education ISCED 2011 additionally distinguishes between 'general and vocational upper secondary education without direct access to tertiary education (ISCED 3*)' and 'general and vocational upper secondary education with direct access to tertiary education (ISCED 3**)'.

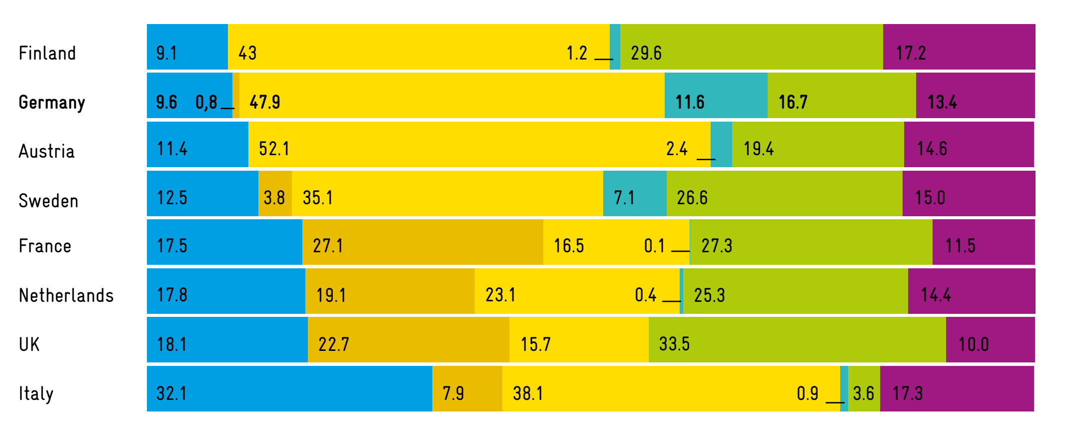
The breaks resulting from the use of the new ISCED 2011 classification reveal national peculiarities, which can be traced back partly to peculiarities of the educational systems and partly to resultant reclassifications of qualifications, so that it is almost impossible to compare results in different countries and from different time periods. In Germany, for example, the introduction of the ISCED 2011 classification led to a shift in the assignment of the schools of the healthcare system. In the past these belonged to ISCED 5B. In the national implementation of the ISCED 2011 classification, the two- and three-year programmes at schools of the healthcare system now belong to ISCED 4 (post-secondary non-tertiary education). The consequence of this is that, even if the ISCED 5A and 5B levels according to the old ISCED 1997 classification are considered together, and compared with the combined levels 5, 6 and 7 of the ISCED 2011 classification, the figures are not compatible and therefore not comparable.[350]

This example shows how important it is to follow definitions and methods precisely when collecting international comparative data. Even small changes in the classification can have a massive influence on a country's performance in international hit lists and rankings and lead the reader to false conclusions. Therefore, before conclusions relevant to education policy are drawn on the basis of country comparisons, the definitions and delimitations of the indicators in the reference countries should be examined very carefully.

Fig. C 1-1

Download data

Qualification levels of gainfully employed persons in selected EU countries, 2014 (figures in percent)



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: Post-secondary non-tertiary education, (technical) higher education entrance qualification with apprenticeship.
- ISCED 5+6: Short, job-related tertiary education (2 to less than 3 years), bachelor's degree, training as a master craftsman or technician or equivalent qualification.
- ISCED 7+8: Master's degree, PhD or equivalent qualification

Note: figures for 2014 were compiled according to ISCED 2011, figures before 2014 according to ISCED 97; this table is therefore not comparable with previous years. ISCED 2011 used here has nine levels, while ISCED 1997 only had seven. ISCED 2011 distinguishes between four instead of two levels in the field of higher education (ISCED 1997: Levels 5A and 6; ISCED 2011: Levels 5 to 8) and 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. p. 97.

* 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 NIW. In: Cordes and Kerst (2016).

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	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013[1]	2013*
Germany	**36**	**37**	**36**	**35**	**34**	**36**	**40**	**42**	**46**	**53**	**59**	**53**
France	39	–	–	–	–	–	–	–	39	41	–	–
Japan	40	40	41	45	46	48	49	51	52	52	–	–
Sweden	80	79	76	76	73	65	68	76	72	60	56	51
Switzerland	38	38	37	38	39	38	41	44	44	44	76	–
South Korea	47	49	54	59	61	71	71	71	69	69	–	–
United Kingdom	48	52	51	57	55	57	61	63	64	67	58	51
USA	63	63	64	64	65	64	70	74	72	71	52	51
OECD average	**53**	**53**	**54**	**56**	**56**	**56**	**59**	**61**	**60**	**58**	**67**	**60**
China	–	–	–	–	–	–	17	17	19	18	–	–

[1] The table shows the university entry rates according to the ISCED classification for levels 5, 6 und 7.

Note: figures for 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 only had seven. ISCED 2011 distinguishes between four instead of two levels in the field of higher education (ISCED 1997: Levels 5A and 6; ISCED 2011: Levels 5 to 8) and 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. p. 97.

* Adjusted rate excluding new international tertiary students.

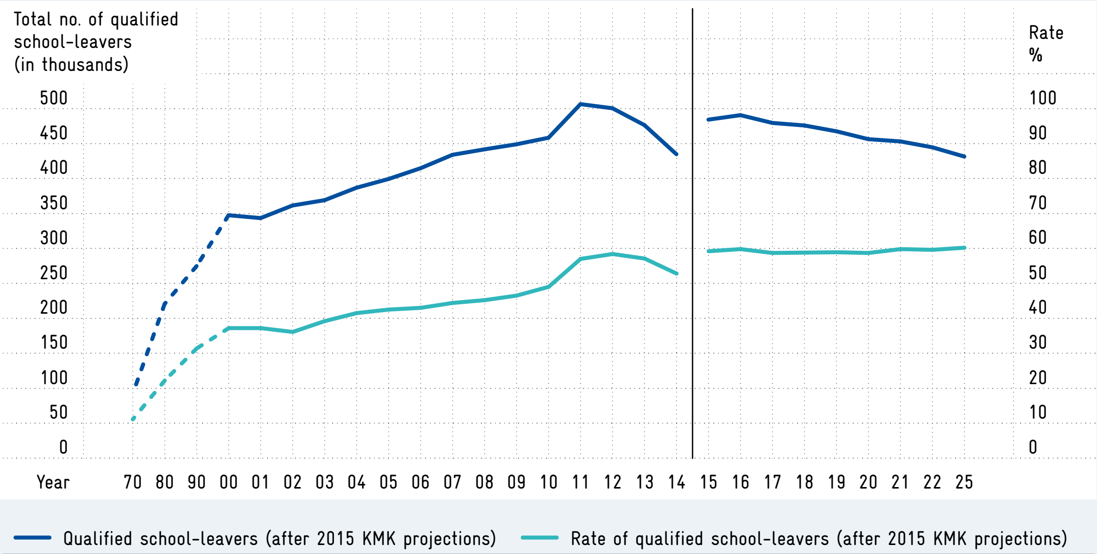
Sources: OECD (ed.): Education at a glance. OECD indicators, various years. In: Cordes and Kerst (2016).

Fig. C 1-3

Download data

School-leavers qualified for higher education in Germany, 1970 to 2025 (figures after 2015 are projections)

School-leavers qualified for higher education: either with a 'general' or 'technical' school-leaving certificate* (in Germany Abitur).



Source of actual figures: Statistisches Bundesamt (Federal Statistical Office) (2015). In: Cordes and Kerst (2016).
Source of forecast figures: Statistical Publications of the Standing Conference of Education Ministers. In: Cordes and Kerst (2016).
* Since 2013, the actual figures no longer include school leavers who have passed the school part of the 'technical' Abitur but must still do a period of professional practical training according to Länder rules

C

Tab. C 1-4

Download data

Number of first-time graduates and subjects structure rates

First-time graduates and subjects structure rate: the subjects structure rate indicates the percentage of first-degree graduates who have completed their studies in a particular subject or group of subjects. First-time graduates are persons who successfully complete a first degree

	2000	2005	2007	2009	2010	2011	2012	2013	2014
Total number of graduates	**176,654**	**207,936**	**239,877**	**287,997**	**294,330**	**307,271**	**309,621**	**309,870**	**313,796**
Percentage of women	45.6	50.8	51.8	51.7	52.1	51.4	51.3	51.5	51.1
Percentage of university graduates	64.3	60.8	62.4	62.0	62.0	62.1	61.3	59.9	59.0
Linguistic and cultural sciences	**29,911**	**35,732**	**43,827**	**53,003**	**54,808**	**56,140**	**55,659**	**56,313**	**57,016**
Percentage for subject group	16.9	17.2	18.3	18.4	18.6	18.3	18.0	18.2	18.2
Law, business and social sciences	**62,732**	**76,566**	**85,838**	**101,391**	**102,315**	**105,589**	**105,024**	**105,105**	**107,400**
Percentage for subject group	35.5	36.8	35.8	35.2	34.9	34.4	33.9	33.9	34.2
Human medicine/ healthcare sciences	**10,620**	**11,817**	**13,358**	**15,142**	**15,222**	**15,686**	**15,856**	**16,534**	**17,331**
Percentage for subject group	6.0	5.7	5.6	5.3	5.2	5.1	5.1	5.3	5.5
Agriculture, forestry, nutrition sciences	**4,761**	**5,312**	**5,661**	**6,787**	**6,215**	**6,563**	**6,405**	**6,193**	**6,042**
Percentage for subject group	2.7	2.6	2.4	2.3	2.1	2.1	2.1	2.0	1.9
Art and art-related subjects	**7,630**	**9,678**	**10,399**	**11,541**	**11,820**	**12,525**	**12,866**	**12,542**	**11,913**
Percentage for subject group	4.3	4.7	4.3	4.0	4.0	4.1	4.2	4.0	3.8
Mathematics, natural sciences	**21,844**	**30,737**	**38,417**	**47,782**	**48,561**	**49,593**	**48,231**	**46,707**	**47,046**
Percentage for subject group	12.4	14.8	16.0	16.6	16.5	16.1	15.6	15.1	15.0
Engineering sciences	**35,725**	**34,339**	**38,065**	**47,004**	**49,860**	**55,631**	**60,259**	**62,007**	**62,607**
Percentage for subject group	20.2	16.5	15.9	16.3	16.9	18.1	19.5	20.0	20.0

Source: Statistisches Bundesamt (Federal Statistical Office) and research in DZHW-ICE. In: Cordes and Kerst (2016).

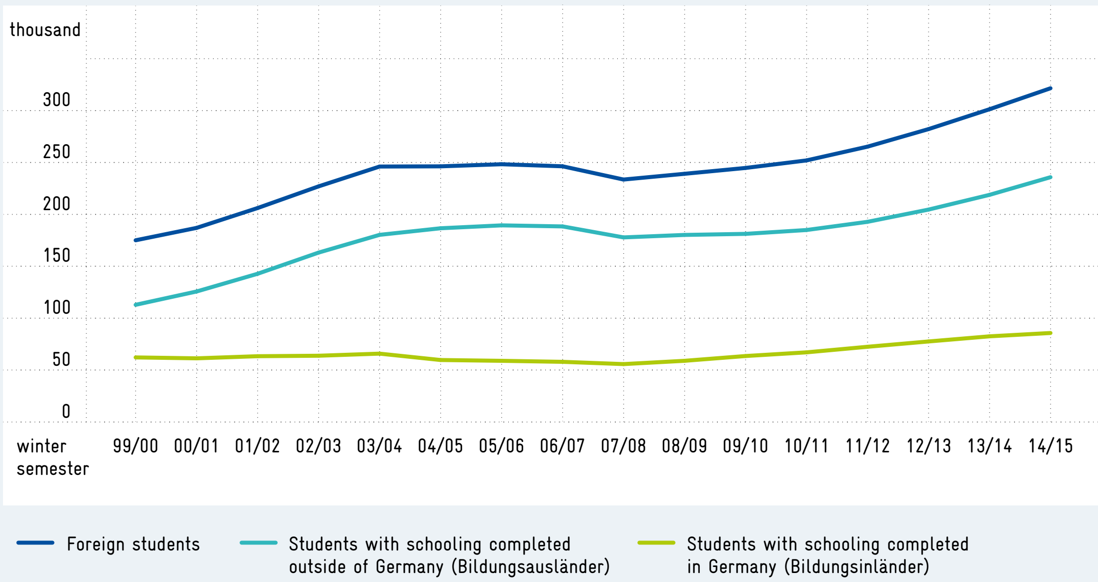
C

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: Statistisches Bundesamt (Federal Statistical Office) and research in DZHW-ICE. In: Cordes and Kerst (2016).

C

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 within 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
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
Gainfully employed persons	**6.4**	**5.7**	**5.9**	**6.4**	**5.8**	**5.6**	**5.6**	**5.9**	**5.6**	**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
medium (ISCED 3-4)	4.5	4.0	4.1	4.4	4.2	3.9	3.9	4.1	3.9	4.2
high (ISCED 5-8)	12.1	11.2	11.4	12.2	10.6	10.5	10.3	10.6	10.1	9.4
Unemployed persons	**3.1**	**2.8**	**3.1**	**4.9**	**4.3**	**3.9**	**4.6**	**3.8**	**3.6**	**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
medium (ISCED 3-4)	2.8	3.0	2.9	5.3	4.0	3.2	4.0	3.6	3.4	3.3
high (ISCED 5-8)	6.1	5.6	5.4	8.1	8.4	8.3	10.0	6.6	5.4	6.4
Inactive persons	**2.0**	**1.6**	**1.7**	**2.3**	**1.9**	**2.0**	**1.9**	**1.6**	**1.8**	**1.8**
low (ISCED 0-2)	0.9	0.9	0.8	1.4	1.8	1.6	1.5	1.4	1.4	1.3
medium (ISCED 3-4)	2.0	1.3	1.7	1.8	1.5	1.8	1.9	1.4	1.5	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
b) Corporate participation in further training	**42.7**	**-**	**45.5**	**49.0**	**44.6**	**44.1**	**52.6**	**53.1**	**52.1**	**-**
By sector										
Knowledge-intensive manufacturing	55.7	-	65.3	65.1	52.6	55.9	62.9	65.5	66.7	-
Non-knowledge-intensive manufacturing	32.4	-	33.2	37.8	32.5	33.3	41.2	43.2	41.8	-
Knowledge-intensive services	58.8	-	63.2	68.3	58.7	57.1	68.7	67.2	67.4	-
Non-knowledgeintensive services	34.9	-	37.3	39.4	38.0	37.5	44.9	45.3	44.3	-
Non-industrial economy	46.9	-	49.9	53.8	51.9	51.2	59.0	60.3	58.4	-
By company size										
< 50 employees	40.5	-	43.2	46.9	42.5	41.8	50.5	50.9	49.8	-
50 – 249 employees	82.9	-	85.1	86.7	81.3	83.3	90.8	89.7	90.1	-
250 – 499 employees	95.6	-	95.2	95.9	92.0	93.3	95.9	96.5	97.0	-
≥ 500 employees	97.0	-	95.3	97.8	96.0	97.9	98.4	97.8	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 covered by social security.
Source a): European Labour Force Survey (special evaluation). Calculations by NIW. In: Cordes and Kerst (2016).
Source b): IAB Establishment Panel (special evaluation). Calculations by NIW. In: Cordes and Kerst (2016).
* 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

C 2 Research and development

In Germany, a total of 83.6 billion euros was spent on research and development (R&D) by companies, tertiary education institutions, and public or publicly funded R&D institutions in 2014. This corresponds to 2.87 percent of the gross domestic product (C 2-1). In the previous year, the expenditure amounted to 79.7 billion euros or 2.83 percent of GDP.[351] According to the preliminary results available to date, this growth was generated exclusively by a significant increase in corporate R&D expenditure.

The budget estimates for civil R&D (C 2-2) again indicate strong growth for South Korea and Switzerland, while the figures rose only slightly in Germany and Sweden. In France, the UK, Japan and the USA, the budget estimates have been stagnating for some years.

The distribution of gross domestic expenditure on R&D by performing sector (C 2-3) shows that the corporate share fell from 69.8 percent in 2004 to 68.1 percent in 2014 in Germany. The tertiary education institutions' share of R&D expenditure rose in the same period from 16.5 to 17.1 percent, public R&D expenditure from 13.7 to 14.7 percent.

The R&D intensity of Germany's Länder (C 2-4) is increased in almost all Länder in the decade from 2003 to 2013. Only in Berlin did R&D intensity decline slightly from 3.65 to 3.57 percent. This fall was caused by the lower R&D intensity of the business sector in Berlin.

R&D growth in the German economy is borne primarily by the automotive engineering industry. Total expenditure by all companies conducting research in Germany amounted to 53.3 billion euros. Of this, 19.2 billion euros alone came from the vehicle-construction economic sector alone, followed by the economic sectors electrical engineering/electronics with 9.5 billion euros, mechanical engineering with 5.4 billion euros, the pharmaceutical industry with 4.1 billion euros, and the chemical industry with 3.4 billion euros (C 2-5).

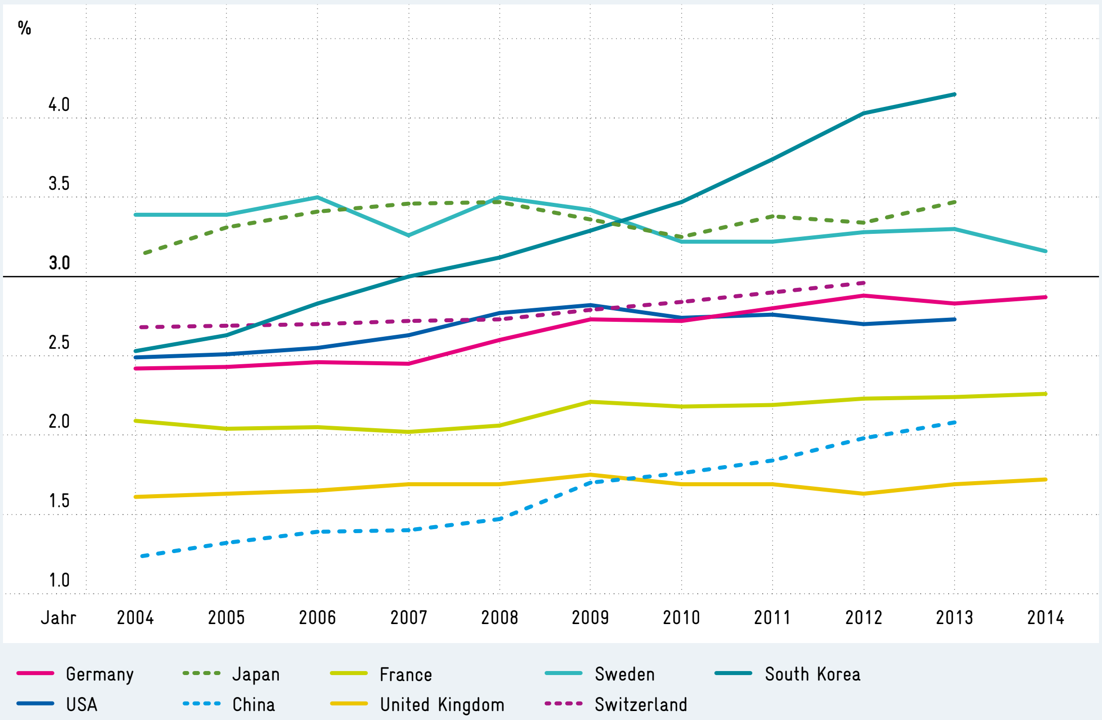
The indicator 'internal corporate R&D expenditure as a percentage of turnover from the company's own products' (C 2-6) shows that the average R&D intensity of the manufacturing sector rose slightly from 2013 to 2014. This increase was due mainly to the growth of R&D intensity in the automotive engineering industry. Although internal R&D expenditure also grew slightly in absolute terms from 2013 to 2014 in the economic sectors data-processing devices, electronic and optical products, and aerospace, turnover in these sectors grew more quickly in the same period, so that the R&D intensities decreased again.[352]

Fig. C 2-1

Download data

R&D intensity in selected OECD countries and China 2004 to 2014 (figures in percent)

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



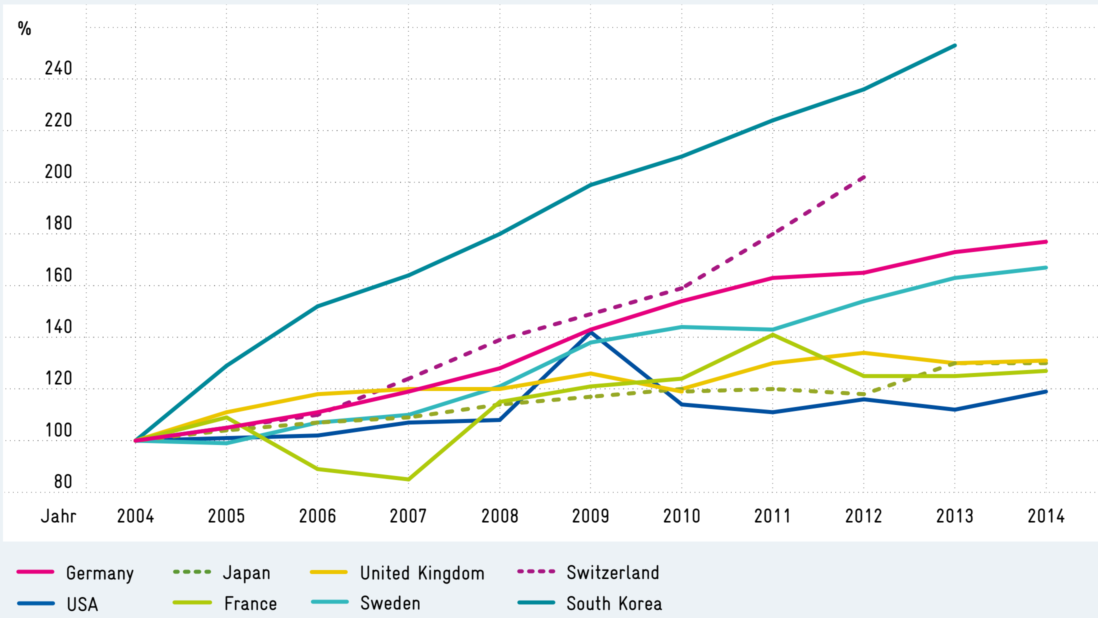
Source: OECD, EUROSTAT. Calculations and estimates by NIW in Schasse et al. (2016).

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: 2004 = 100, data partially based on estimates.
Source: OECD, EUROSTAT. Calculations and estimates by NIW in Schasse et al. (2016).

C

Tab. C 2-3

Download data

Distribution of gross domestic expenditure on R&D (GERD) by performing sector, 2004 and 2014

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

	2004					2014				
		of which ... was performed by ... (in %)					of which ... was performed by ... (in %)			
Countries	GERD in USD m	private sector	higher education sector	public sector	private nonprofit	GERD in USD m	private sector	higher education sector	public sector	private nonprofit
France	37,986	63.1	18.6	17.0	1.3	58,023	64.8	20.6	13.1	1.5
Germany[1]	**61,331**	**69.8**	**16.5**	**13.7**	**–**	**106,276**	**68.1**	**17.1**	**14.7**	**–**
Japan[2]	117,598	75.2	13.4	9.5	1.9	160,247	76.1	13.5	9.2	1.3
South Korea[3]	27,942	76.7	10.1	12.1	1.2	68,937	78.5	9.2	10.9	1.3
Sweden	10,452	73.5	22.9	3.1	0.4	13,839	67.0	29.0	3.7	0.2
Switzerland[3]	7,472	73.7	22.9	1.1	2.3	13,251	69.3	28.1	0.8	1.8
UK	32,024	62.6	24.7	10.7	2.0	43,624	64.4	26.1	7.8	1.7
USA[2]	305,640	68.2	14.7	12.6	4.6	456,977	70.6	14.2	11.2	4.1
China[2]	69,269	66.8	10.2	23.0	–	336,495	76.6	7.2	16.2	–

[1] provisional. [2] 2013 instead of 2014. [3] 2012 instead of 2014.
Private non-profit organisations are included under the 'public sector' in some countries (e.g. Germany).
Source: OECD, EUROSTAT. Calculations by NIW in Schasse et al. (2016).

Tab. C 2-4

Download data

R&D intensity of Germany's Länder, 2003 and 2013 (figures in percent)

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

Länder	2003				2013			
	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, Statistisches Bundesamt (Federal Statistical Office). Calculations by NIW 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 R&D: research and development that is conducted inside the company, either for the company's own purposes or commissioned by a third party.

	Internal R&D expenditure				
	Total	of which ... was funded by			
		private sector	public sector	other domestic entities	foreign entities
	in €1,000	in percent			
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 ceramic industries	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 bis 499 employees	4,708,916	88.2	6.4	0.3	5.1
500 bis 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 revenue expended on R&D)	13,404,548	90.4	3.2	0.0	6.3
High-value technology (3-9 percent of revenue expended on R&D)	27,113,163	94.4	1.1	0.2	4.3

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

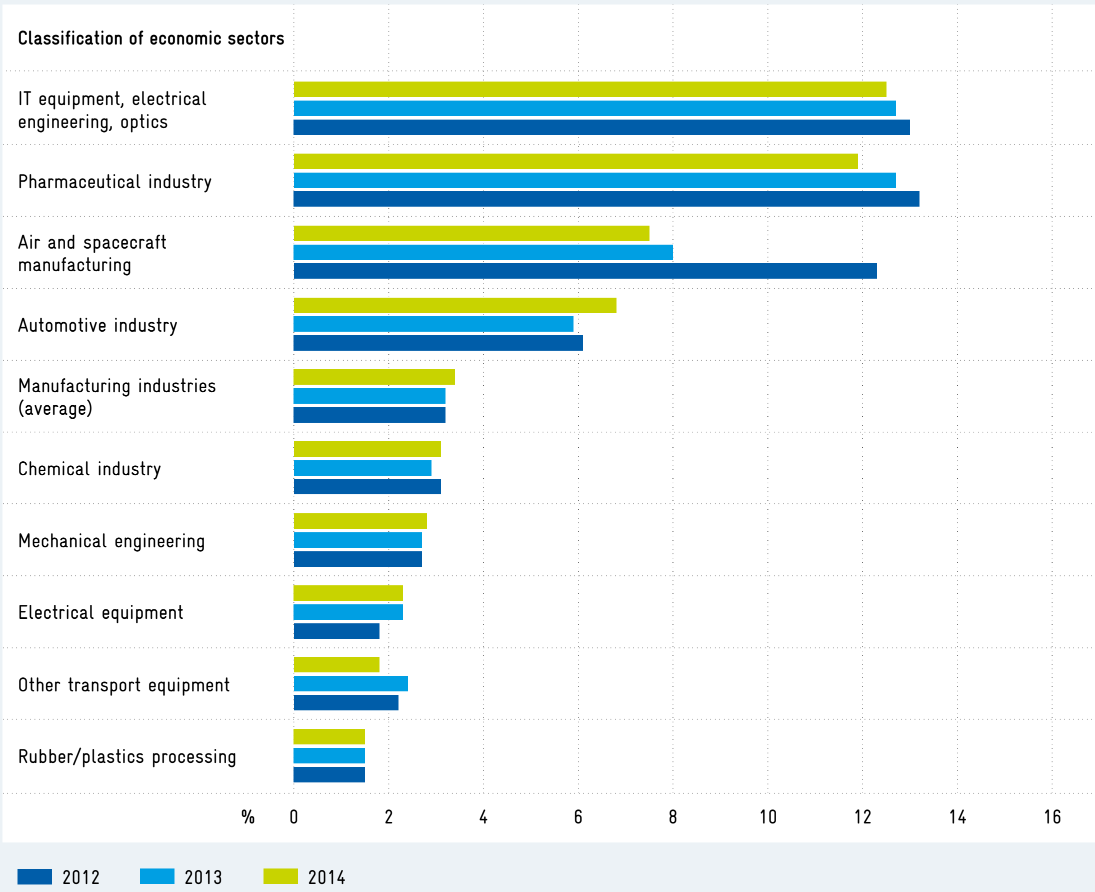
C

Fig. C 2-6

Download data

Internal corporate R&D expenditure as a percentage of turnover from the company's own products, 2012, 2013 and 2014

Internal R&D: research and development that is conducted inside 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 NIW in Schasse et al. (2016).

C 3 Innovation behaviour in the private sector

The Europe-wide Community Innovation Surveys (CIS) are conducted every two years and provide the data for the international comparison of the private sector's innovation behaviour (C 3-1).[353] Coordinated by Eurostat and based on a harmonised methodology, the CIS are conducted by all of the 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 2012 (CIS 2012). In that year, Germany's innovation intensity amounted to 2.8 percent. It was thus higher than that of most reference countries. However, Sweden's innovation intensity was considerably higher at 3.6 percent.

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. 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 the R&D-intensive industry amounted to 8.6 percent in 2014, thus almost equalling the peak figure reached in 2013 (8.8 percent).[354] In other industry, the figure was unchanged at 1.4 percent since 2010. Whereas innovation intensity in knowledge-intensive services (excluding financial services) fell from 5.1 percent in 2013 to 4.5 percent in 2014, it rose in financial services from 0.5 percent to 0.7 percent, thus returning to its level prior to the financial crisis. Innovation intensity stagnated in other services (0.6 percent).

The percentage of turnover generated by new products in 2014 in the R&D-intensive industry was significantly higher, at 33.3 percent, than in knowledge-intensive services (9.6 percent), other industry (7.0 percent) and other services (5.7 percent).

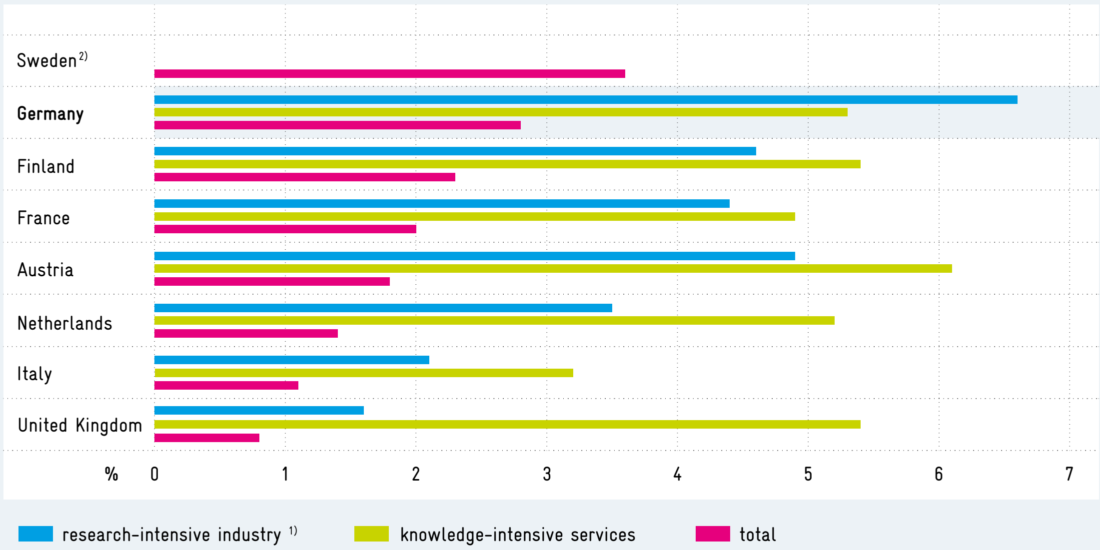
Standardisation is an important factor in the commercialisation of innovative technologies. At the international level, standards are developed in the committees of the International Organisation for Standardisation (ISO). Through participation in these committees, a country can make a significant impact on global technical infrastructures (C 3-4).[355] German companies are more frequently involved in the work of the ISO than representatives of all other countries.

Innovation intensity in 2012 by European comparison (figures in percent)

Fig. C 3-1

Download data

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



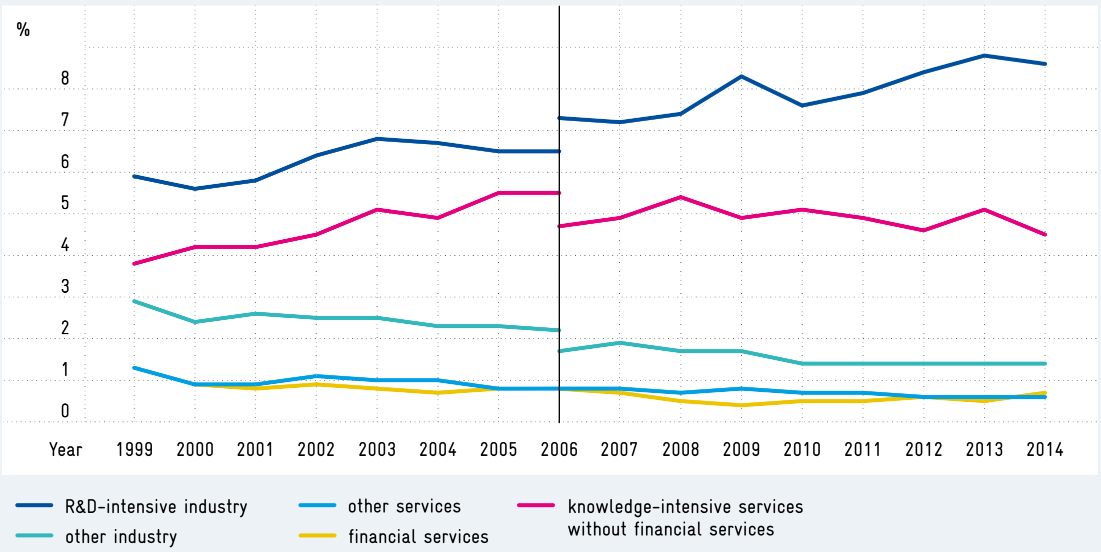
1) Research-intensive industry: divisions 19-22, 25-30 of WZ classification. Since data are not available for all sectors in all countries, the definition of research-intensive industries used in the European comparison differs from the definition normally used by the EFI.
2) No figures are available for research-intensive industry or knowledge-intensive services in Sweden.
Source: Eurostat, Community Innovation Surveys 2012. Calculations by ZEW (Centre for European Economic Research).

Innovation intensity in Germany's industry and knowledge-intensive services (figures in percent)

Fig. C 3-2

Download data

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

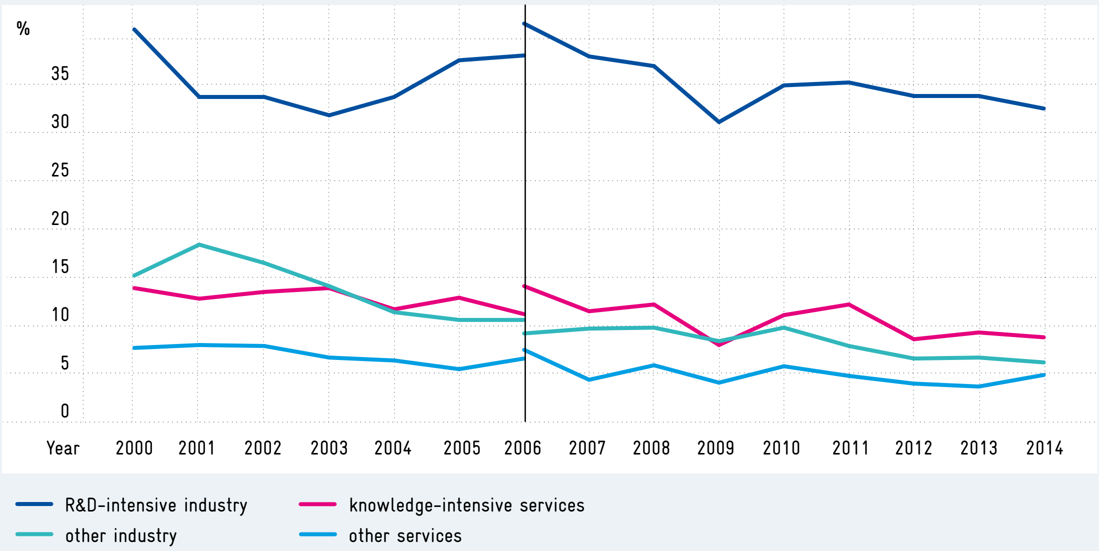


2006: break in series. Figures for 2014 are provisional.
Source: Mannheim Innovation Panel. Calculations by ZEW (Centre for European Economic Research).

Fig. C 3-3

Download data

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

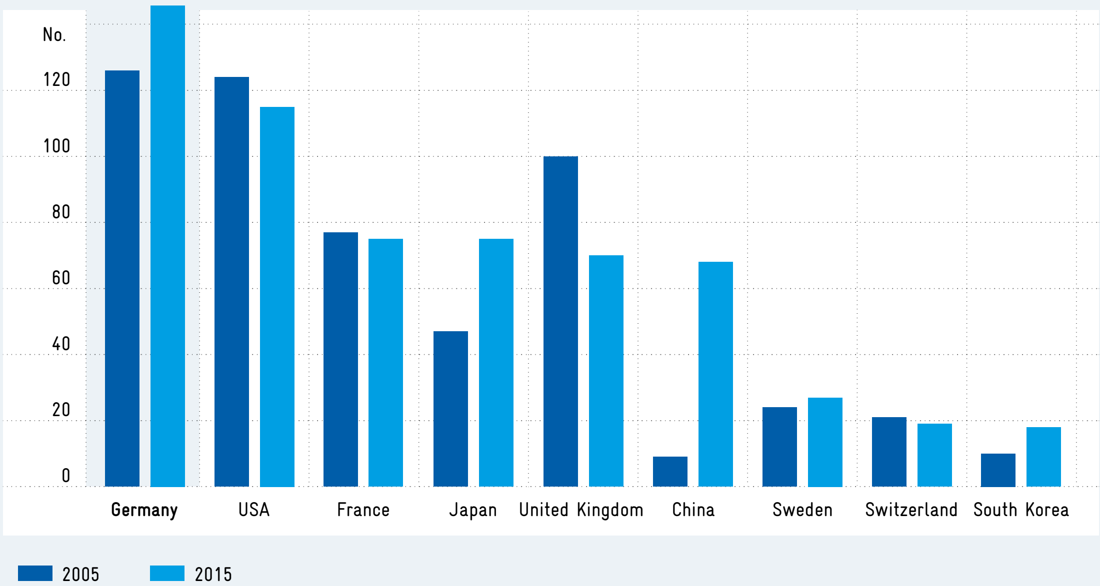


2006: break in series. Figures for 2014 are provisional.
Source: Mannheim Innovation Panel. Calculations by ZEW (Centre for European Economic Research).

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 (2006:15) and
http://www.iso.org/iso/home/about/iso_members.htm?membertype=membertype_MB (last accessed on 17 November 2015).

Funding of research and innovation

C 4

The public funding of research and development (R&D) in the private sector makes a distinction between direct R&D funding (project funding) and funding through R&D tax credits.[356] Figure C 4-1 shows direct and tax-related 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. R&D tax credits represent an indirect form of R&D funding. Here, companies receive tax credits in proportion to the amount of their R&D expenditure. While this instrument is available to companies in most OECD countries, Germany does not yet make use of this form of funding.

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. As in the previous years, Sweden and Finland recorded the highest level of venture-capital investment in 2014. Venture-capital investment in 2014 increased significantly in Sweden, taking over the top position from Finland. In 2014 venture-capital investment also rose significantly in the United Kingdom, enabling this country to climb from sixth to third place.

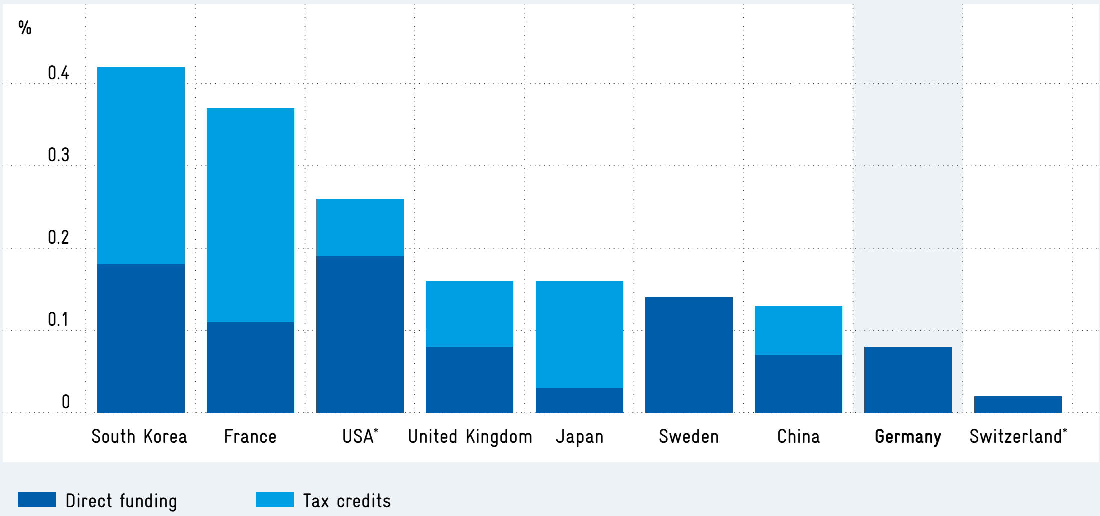
In Germany, venture-capital investment fell slightly in 2014. The decline was mainly due to a fall in 'later stage' investment. Investment remained approximately constant in the 'early stage' field, which comprises the seed and start-up phases (C 4-3).

Fig. C 4-1

Download data

R&D spending in the business sector directly and indirectly funded by the public sector in 2013 as a percentage of national GDP

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



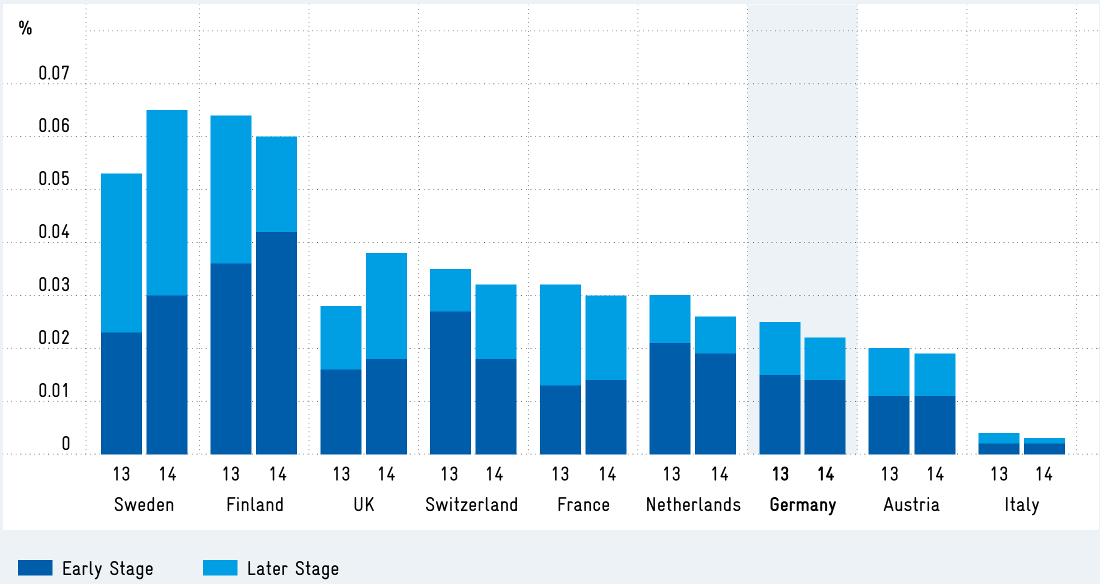
*2012
Source: OECD

Fig. C 4-2

Download data

Venture-capital investment as a percentage of national GDP in 2013 and 2014

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



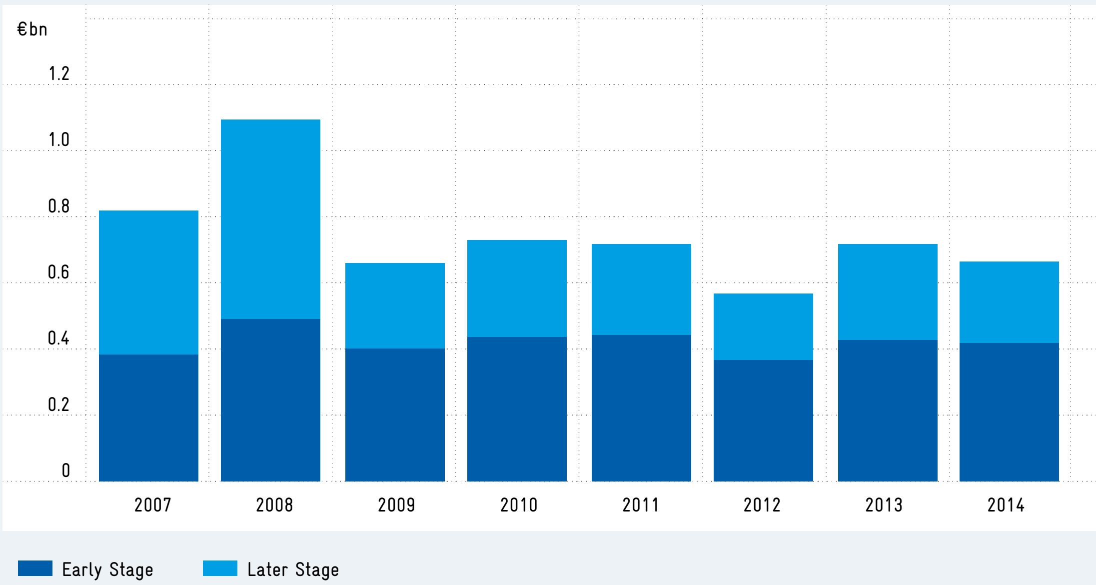
Investments according to registered office of the portfolio companies. Early stage comprises the seed phase and the start-up phase.
Source: EVCA (2015), Eurostat. Own calculations.

Fig. C 4-3

Download data

Development of venture-capital investment in Germany, 2007 to 2014, 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 (2015).

C

C 5 New enterprises[357]

An international comparison of start-up rates – i.e. the number of start-up businesses as a percentage of the total number of companies – can only be made at the European level.[358] The Business Demography Statistics provided by Eurostat are used here for this purpose (cf. 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 supplied by the Federal Statistical Office's business demography statistics, which are derived from an evaluation of the German business register.[359] In 2013, the start-up rate in Germany was around 7.4 percent, well below the rate in the UK, which had the highest figure (14.7 percent) of the countries considered here. Even in R&D-intensive industry (4.1 percent) and knowledge-intensive services (8.7 percent), Germany's start-up rates were well below those of the leader UK (10.5 percent and 17 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; the term 'start-ups' applies only to original, newly formed companies.[360] The start-up rate shown in Figure C 5-2 is calculated on the basis of different data than those used in the Business Demography Statistics, which means that a direct comparison cannot be made here.[361] According to the data provided by the MUP, the start-up rate in the knowledge economy fell continuously from 6.8 to 4.8 percent in the period between 2009 and 2014 (C 5-2). Against this trend, the start-up rate in cutting-edge technology rose slightly in 2014 compared to the previous year – by 0.4 percentage points to 4.8 percent.

The closure rate in the knowledge-based economy was 5.6 percent in 2014, slightly higher than in 2013 (C 5-3). Particularly low closure rates were recorded in cutting-edge technology and high-value technology (3 and 3.4 percent). Here, the rates were lower than in the previous year (3.4 and 3.6 percent).

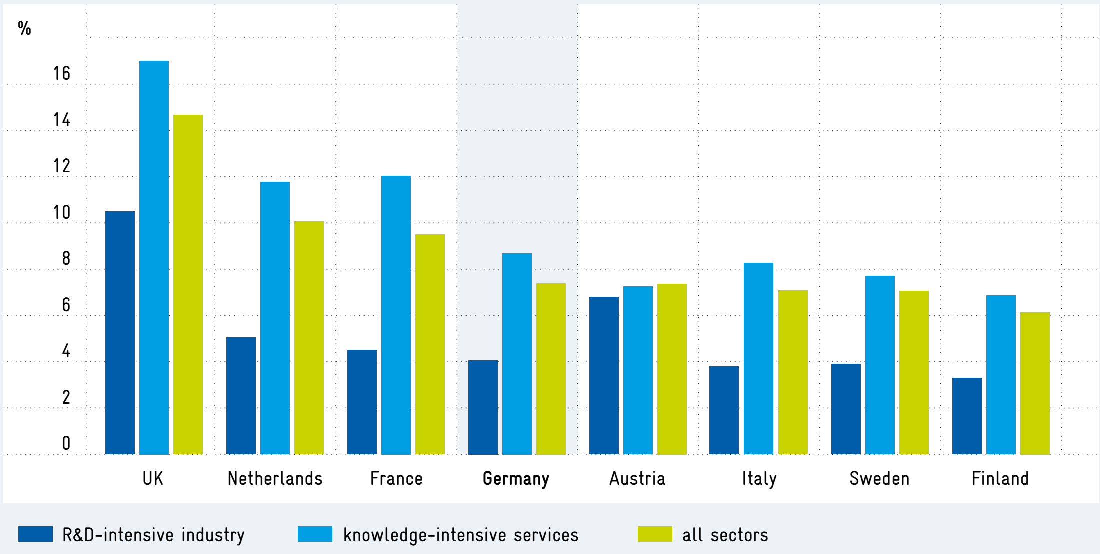
The comparison at the Länder level reveals significant differences in start-up rates within Germany (C 5-4). Berlin had the highest start-up rates of all Länder: across all industries (7.3 percent), in R&D-intensive industry (5.2 percent), and in knowledge-intensive services (7.3 percent). Thuringia recorded the lowest start-up rates across all industries (3.6 percent), Hesse in R&D-intensive industry (2.7 percent), and Mecklenburg-Vorpommern in knowledge-intensive services (3.5 percent).

Fig. C 5-1

Download data

Start-up rates in 2013 by international comparison (figures in percent)

Start-up rate: number of start-up businesses as a percentage of total number of companies.



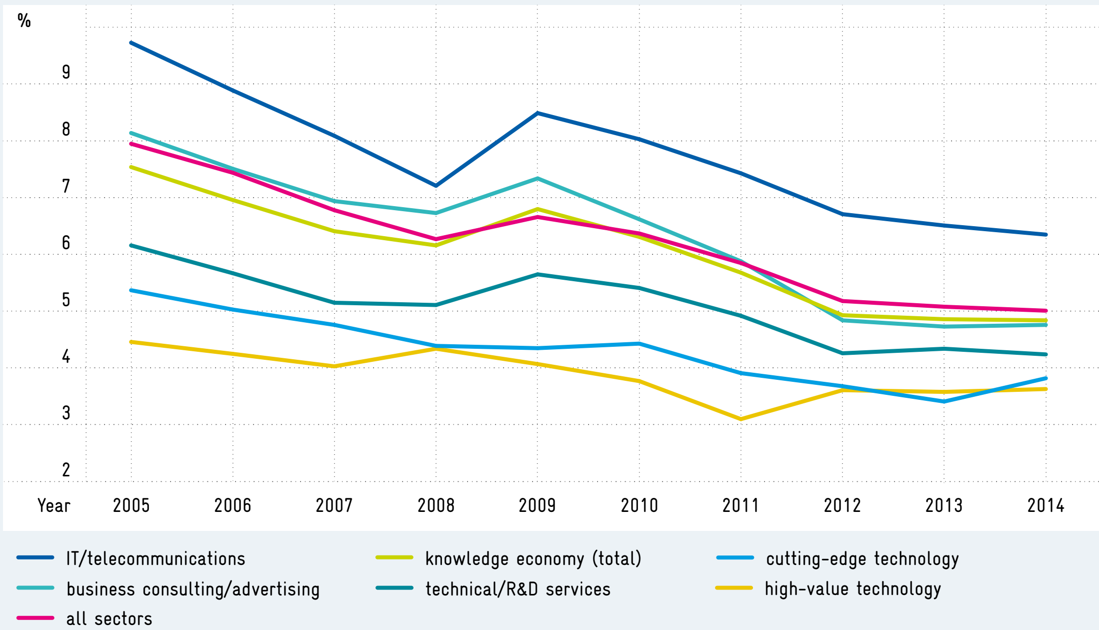
Source: Business Demography Statistics (Eurostat).
Calculations by ZEW in Bersch et al. (2016)

Fig. C 5-2

Download data

Start-up rates in Germany's knowledge economy, 2005 to 2014 (figures in percent)

Start-up rate: number of start-up businesses as a percentage of total number of companies.



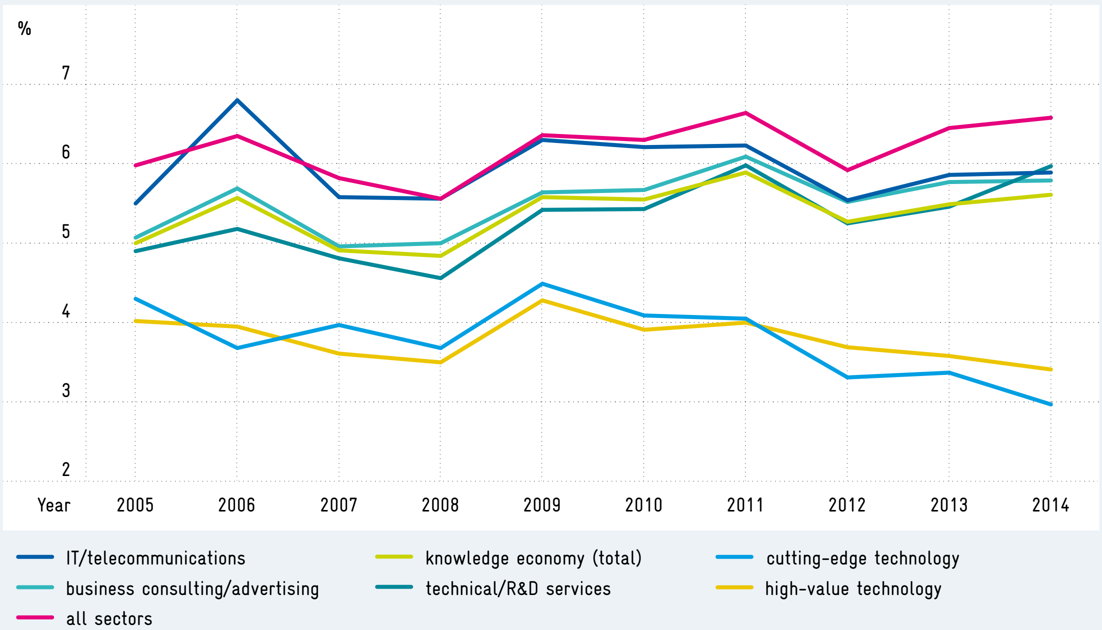
All figures are provisional.
Source: Mannheim Enterprise Panel (ZEW). Calculations by ZEW in Müller et al. (2016)

Fig. C 5-3

Download data

Closure rates in Germany's knowledge economy, 2005 to 2014 (figures in percent)

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



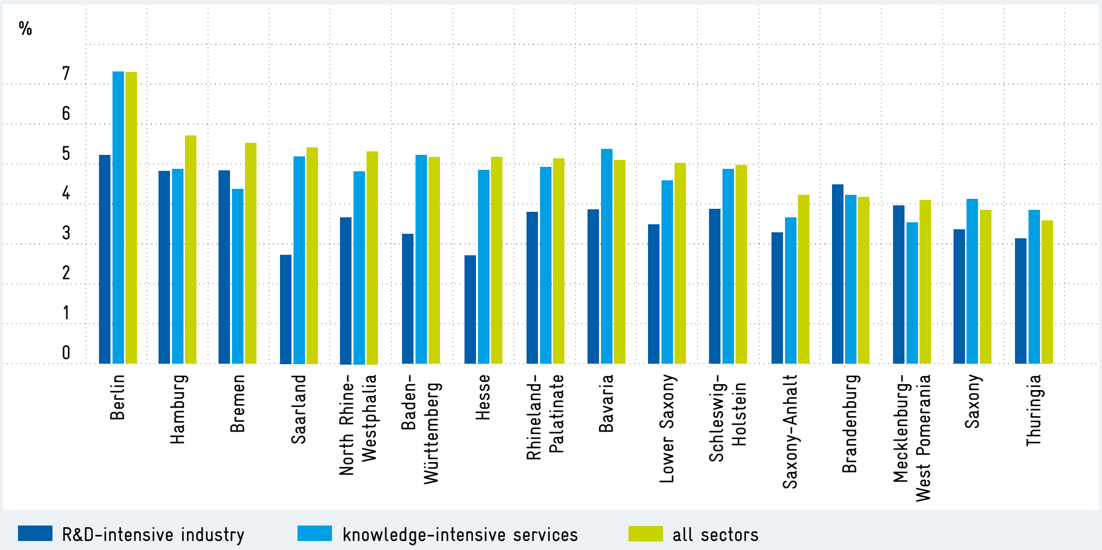
All figures are provisional.
Source: Mannheim Enterprise Panel (ZEW). Calculations by ZEW in Müller et al. (2016)

Fig. C 5-4

Download data

Start-up rates by Länder, 2012 to 2014 (figures in percent)

Start-up rate: number of start-up businesses as a percentage of total number of companies.



All figures are provisional.
Source: Mannheim Enterprise Panel (ZEW). Calculations by ZEW in Müller et al. (2016)

C

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 (cf. 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 the USA, Japan and Germany.

While the USA is in the lead in terms of the absolute number of applications, it is 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 Finland, Switzerland and Sweden, followed by Japan, Germany and South Korea. Patents are an important tool for securing market shares in the context of the international technology trade. High patent intensity, therefore reflects both a strong international orientation and a pronounced export focus on the part of the economy concerned.

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.

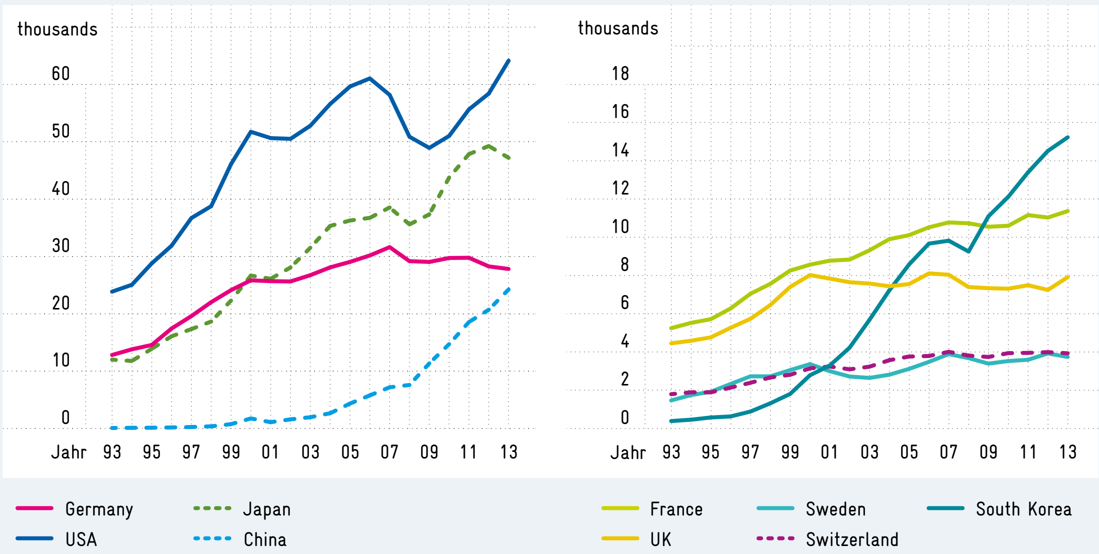
By contrast, China, South Korea and the USA are particularly specialised in cutting-edge technology (C 6-4). Germany remains poorly positioned in cutting-edge technology and is now even lagging behind all the reference nations.

Fig. C 6-1

Download data

Development of the number of transnational patent applications in selected countries

Transnational patent applications comprise applications in 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.



Source: EPA (PATSTAT). Calculations by Fraunhofer ISI in Neuhäusler et al. (2016)

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 2013

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: R&D-intensive technology	Growth (2003 = 100) [1]	Growth of R&D-intensive technology (2003 = 100)
Total	**246,588**	**–**	**–**	**143**	**146**
Canada	3,829	216	136	128	121
China	24,246	32	23	1,231	1,347
EU-28	74,080	344	196	115	114
Finland	2,050	835	489	126	111
France	11,371	441	262	122	124
Germany	**27,817**	**704**	**395**	**104**	**101**
Italy	5,351	241	123	105	110
Japan	47,188	748	473	150	146
Netherlands	4,284	517	282	107	103
South Korea	15,230	608	403	268	264
Sweden	3,740	795	545	141	161
Switzerland	3,934	882	462	122	116
United Kingdom	7,914	264	159	104	106
USA	64,131	446	292	121	121

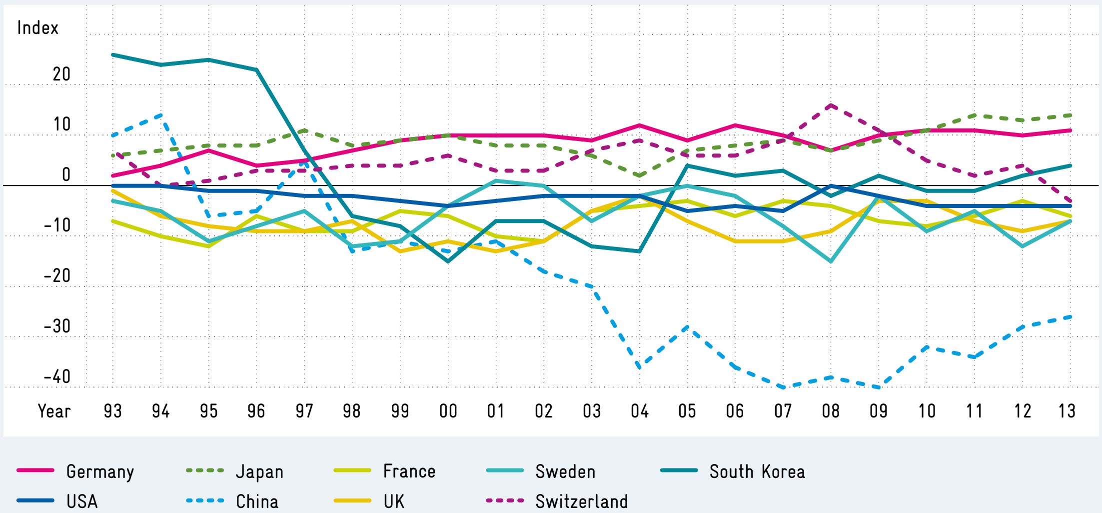
[1] Figures refer to all industries.
Source: EPA (PATSTAT). OECD (MISTI). Calculations by Fraunhofer ISI in Neuhäusler et al. (2016)

Fig. C 6-3

Download data

Development of the specialisation index in selected countries: 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.



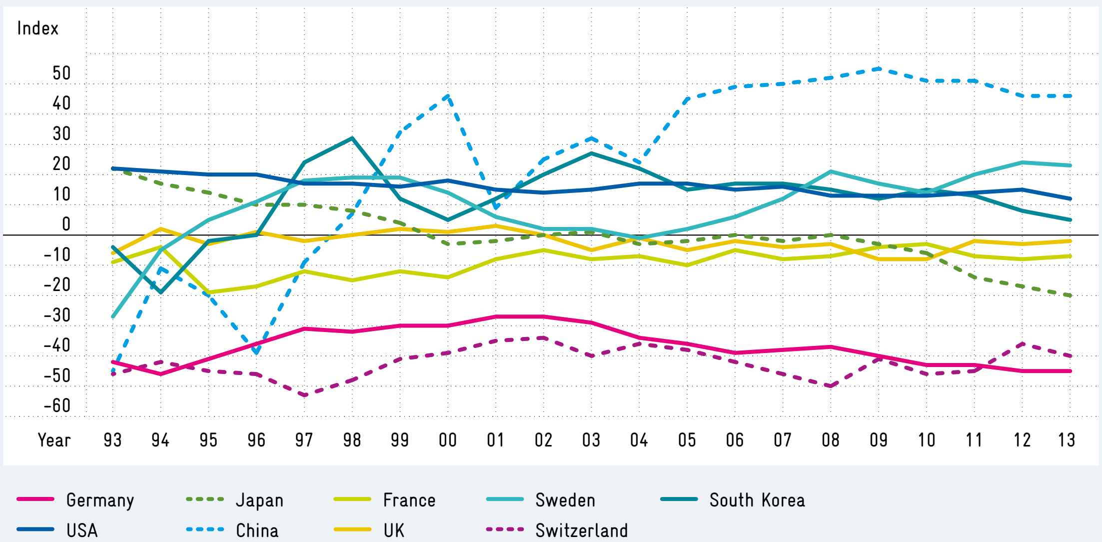
Source: Questel (EPPATENT, WOPATENT). EPA (PATSTAT). Calculations by Fraunhofer ISI in Neuhäusler et al. (2016)

Fig. C 6-4

Download data

Development of the specialisation index in selected countries: 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



Source: Questel (EPPATENT, WOPATENT). EPA (PATSTAT). Calculations by Fraunhofer ISI in Neuhäusler et al. (2016)

C

C 7 Scientific publications

A large proportion of new technologies and services are 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 a scientist 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 2004 and 2014 (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 2004 and 2012 respectively.

Looking only at the number of publications, individual countries' shares of all WoS publications changed considerably between 2004 and 2014 (C 7-1).[362] China in particular managed to almost triple its share from 5.7 to 15.0 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 6.1 to 4.8 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 the Netherlands, Denmark, Poland, Spain and Italy, among others.

Looking at the qualitative indicators, the following trends emerge. In 2012, scientists above all in Switzerland, the Netherlands and the USA succeeded in placing their publications primarily in scientific journals with an international audience (IA, cf. C 7-2). According to this quality indicator, Germany was on a comparable level with the UK, Sweden and Israel in 2012, having successfully caught up with these countries since 2004, albeit without quite reaching the top group of countries. By contrast, since 2004 scientists from the USA seem to have lost ground in terms of both the quantity (see above) and the quality of their published works. Most of the BRICS countries – with the exception of Brazil – succeeded in improving their position in the index over time.

The scientific regard (SR) of publications shows that in 2012 publications from the Netherlands, Denmark, Switzerland and, for the first time, also from China were cited particularly frequently in scientific journals by international comparison (C 7-3) – more frequently than publications authored in the USA, the UK or Germany. Germany has worsened slightly since 2004.

Another important quality indicator, the so-called excellence rate (no illustration) – i.e. the weighted share of discipline-specific publications from Germany among the top 10 percent of the most cited publications worldwide – indicates a slight improvement in Germany's position over time.[363]

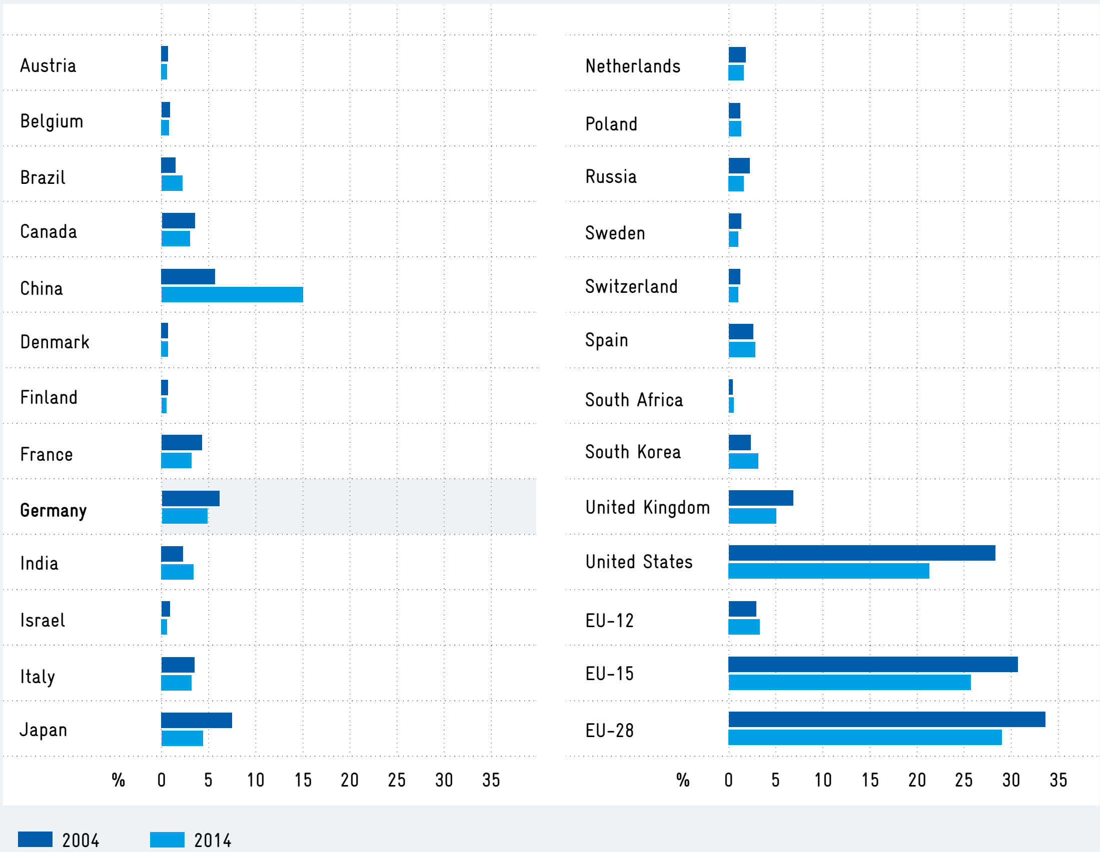
A general overview of the indicators used gives a mixed picture of the way the performance of Germany's research and science system has developed. Despite a declining share of international publications (C 7-1) and a slight fall in the number of citations in scientific journals (C 7-3), scientific publications from Germany succeeded in getting closer to the countries in the top group in terms of international orientation (C 7-2) and the 10-percent excellence rate.

Fig. C 7-1

Download data

Percentages of all publications in the Web of Science that stem from selected countries and regions, 2004 and 2014

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



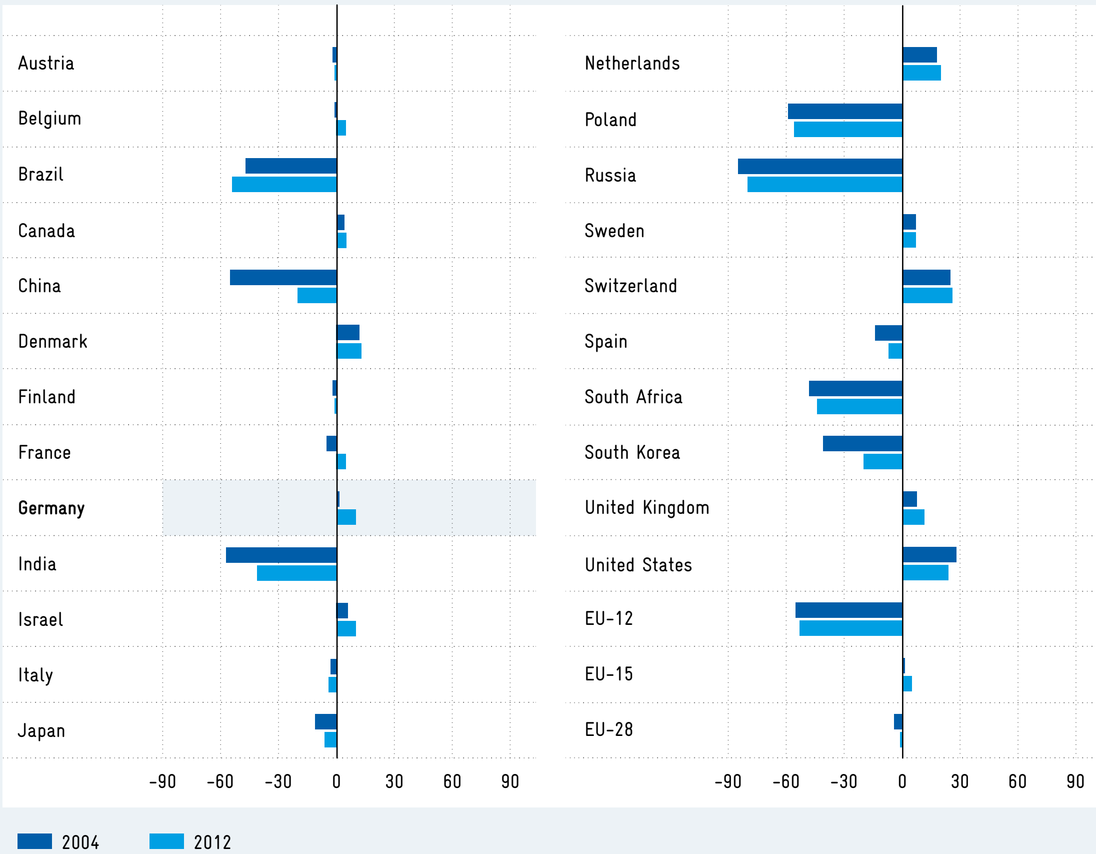
Source: Web of Science. Research and calculations by Fraunhofer ISI in Gruber et al. (2016) . Fractional counting.

Fig. C 7-2

Download data

International alignment (IA) of publications in the Web of Science from selected countries and regions, 2004 and 2012 (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.



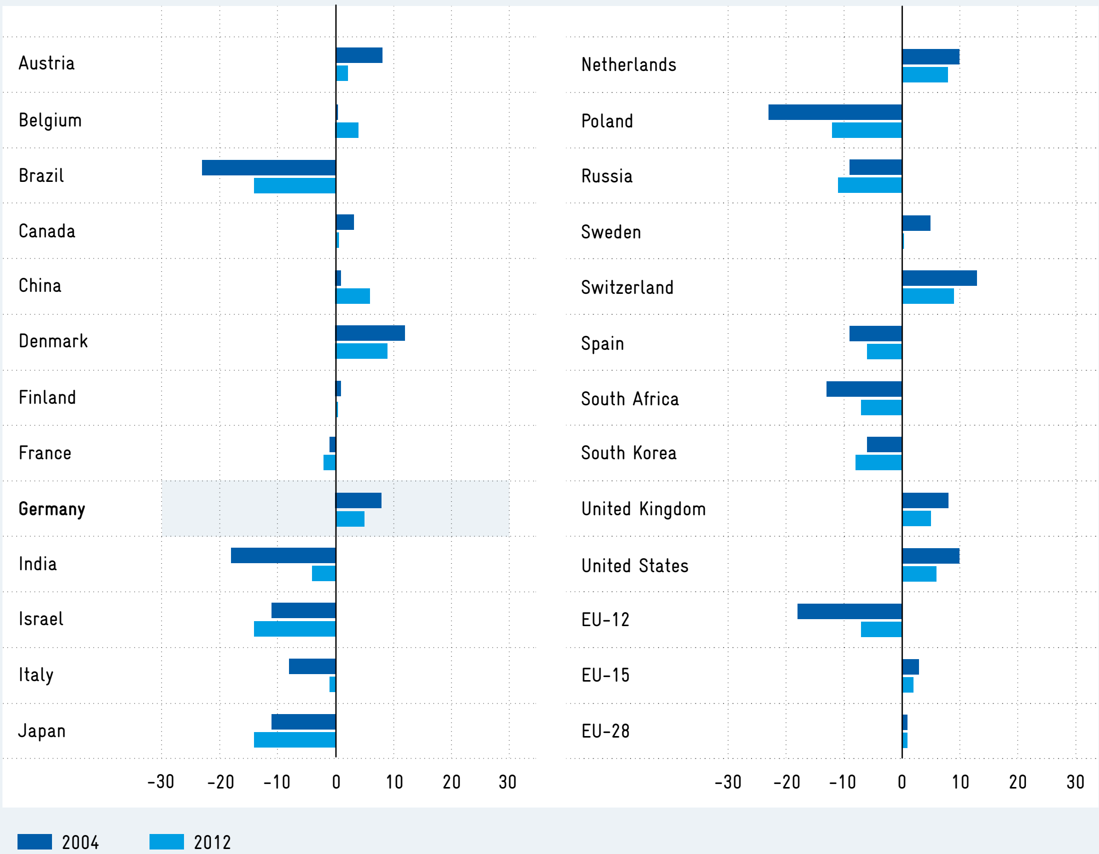
Source: Web of Science. Research and calculations by Fraunhofer ISI in Gruber et al. (2016) . Fractional counting.

Fig. C 7-3

Download data

Scientific regard (SR) of publications in the Web of Science from selected countries and regions, 2004 and 2012 (index values)

The SR index indicates whether a country's articles are cited on average more frequently or more seldom 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 Gruber et al. (2016) . Fractional counting.

C 8 Production, value added and employment[364]

A country's specialisation pattern in foreign trade can be measured using the RCA indicator,[365] 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 showed a comparative advantage in trade in R&D-intensive goods in 2014 (C 8-1). R&D-intensive goods are made up of high-value technology goods and cutting-edge technology goods. A more precise analysis of these two groups of goods shows that Germany has a positive comparative advantage only in trade in high-value technology goods; in trade in cutting-edge technology goods it has a negative comparative advantage, albeit with a slightly positive trend. France, South Korea, Switzerland, the UK and the USA have a positive RCA indicator for cutting-edge technology; Japan and China, on the other hand, have a negative RCA indicator here.

The contribution of research-intensive industries and knowledge-intensive services to a country's value added reflects their importance and allows conclusions to be drawn about the country's technological performance (C 8-2). Relative to the reference countries, Germany has the highest share of value added in the field of high-value technology. In 2013, the share amounted to 8.4 percent of total German value added. It is concentrated primarily on two industries: 4.4 percent of the value creation takes place in 'manufacture of motor vehicles and motor-vehicle parts', and 3.9 percent in mechanical engineering. In the field of cutting-edge technology, Germany's figure of 2.8 percent is much lower than the front-runners South Korea (8.0 percent) and Switzerland (7.0 percent).

Following the decline in gross value added in several industry sectors in the crisis year of 2009, value creation has recovered in Germany since 2010 (C 8-3). As in 2012, the increase in 2013 was again highest in knowledge-intensive services at 3.8 percent (2012: 3.6 percent). By contrast to the previous year, a significant increase in value added was also recorded in 2013 in non-knowledge-intensive services (3.0 percent vs. 0.6 percent in 2012). In manufacturing, on the other hand, the increase in value added was significantly lower in 2013 than in 2012. In 2013, it was 0.5 percent in knowledge-intensive manufacturing (2012: 2.8 percent), and 1.3 percent in non-knowledge-intensive manufacturing (2012: 2.6 percent).

The increase in employment subject to social security contributions in various industry sectors in Germany between 2008 and 2014 is mainly attributable to services sector. Employment rose by 9.1 percent in non-knowledge-intensive services, and by 13.7 percent in knowledge-intensive services during this period. Employment subject to social insurance contributions rose by only 1.0 percent in the non-knowledge-intensive manufacturing industry, and by 4.9 percent in the knowledge-intensive manufacturing industry.

Tab. C 8-1

Download data

Revealed comparative advantage (RCA) of selected countries in foreign trade in research-intensive goods, 2000 to 2014

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
2014	-28	7	**14**	36	18	-7	21	4	7
				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
2014	-12	-5	**29**	72	17	-2	15	5	-6
				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
2014	-42	24	**-24**	-34	19	-22	34	2	29

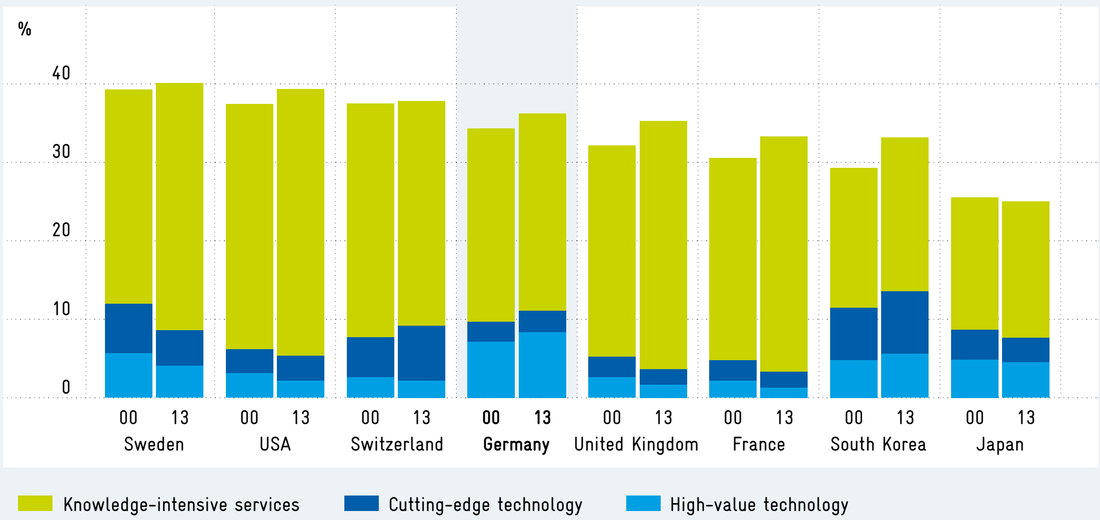
1) IIncl. Hong Kong. 2) From 2009, data for the USA were revised on the basis of national sources.
Source: UN COMTRADE Database. Calculations and estimates by NIW in Gehrke and Schiersch (2016).

Fig. C 8-2

Download data

R&D-intensive industries and knowledge-intensive services as a percentage of value added, 2000 and 2013

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 (2015), Eurostat (2015), EUKLEMS (2013, 2007), Bank of Korea (2015), Statistics Bureau Ministry of Internal Affairs and Communications Japan (2015). Calculations and estimates by DIW Berlin in Gehrke and Schiersch (2016).

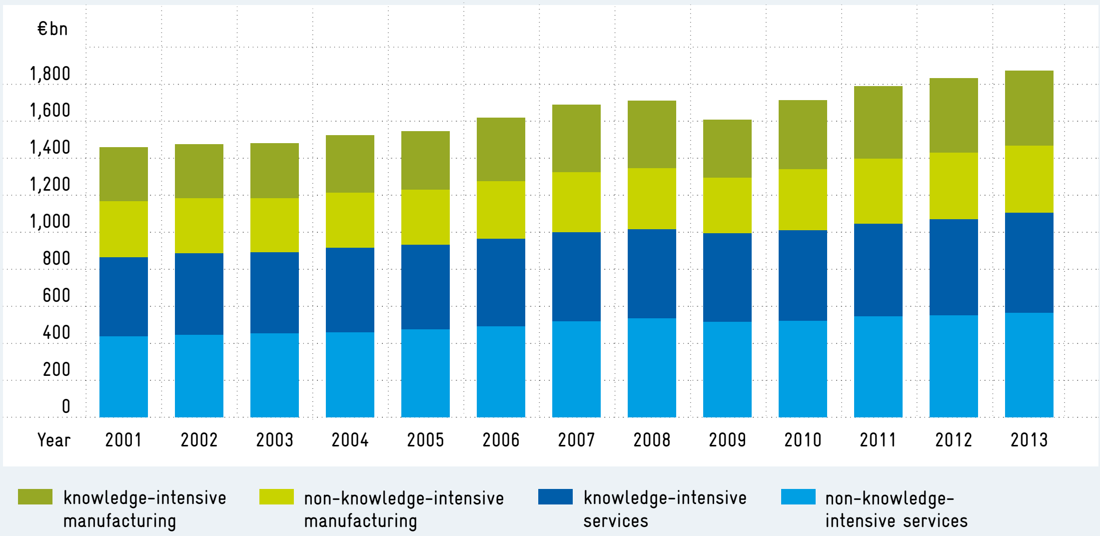
C

Fig. C 8-3

Download data

Development of gross value added in different economic sectors in Germany, 2001 to 2013, in billions of euros

Gross value added is the difference between the total value of all goods and services produced and the intermediate inputs received from other companies 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 NIW in Gehrke and Schiersch (2016).

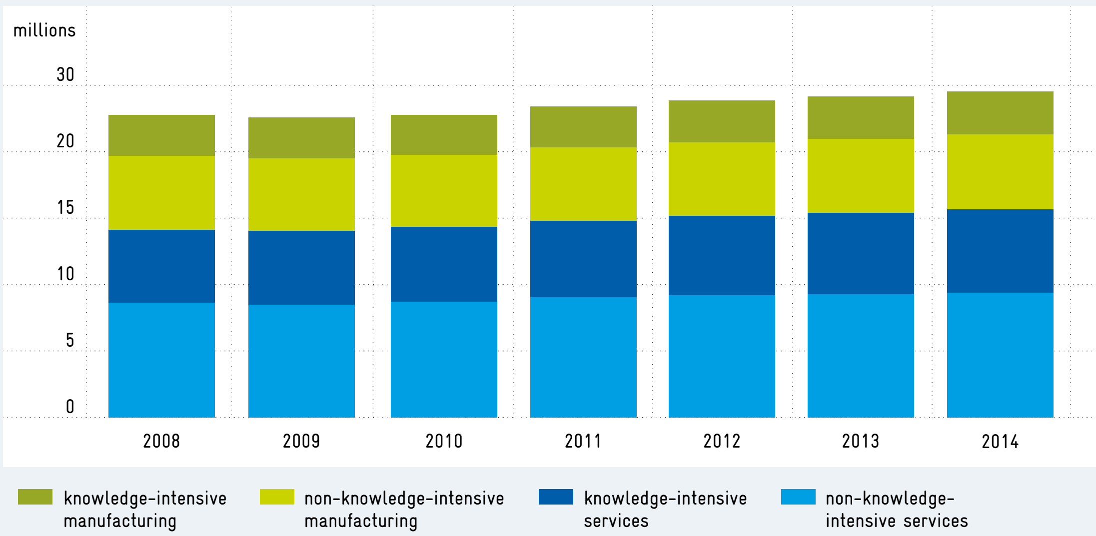
C

Fig. C 8-4

Download data

Development of employees covered by social security insurance in different industrial sectors of the economy in Germany, 2008 to 2014

Employees covered by social security insurance 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 NIW in Gehrke and Schiersch

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List of abbreviations

BEPS base erosion and profit shifting
BMAS Bundesministerium für Arbeit und Soziales (Federal Ministry of Labour and Social Affairs)
BMBF Bundesministerium für Bildung und Forschung (Federal Ministry of Education and Research)
BMWi Bundesministerium für Wirtschaft und Energie (Federal Ministry for Economic Affairs and Energy)
BVDW Bundesverband Digitale Wirtschaft (German Digital Economy Association)
B2B business-to-business
B2C business-to-consumer
CDC Centre for Disease Control and Prevention
CIS Community Innovation Survey
CNC computer numerical control
DFKI Deutsches Forschungszentrum für Künstliche Intelligenz (German Research Centre for Artificial Intelligence)
ELSTER ELektronische STeuerERklärung (electronic tax declaration)
EU European Union
Eurostat Statistical Office of the European Union
FITKO Föderale IT-Kooperation (Federal IT Cooperation)
G20 group of the twenty most important industrialised states and emerging economies
GDP gross domestic product
GWK Gemeinsame Wissenschaftskonferenz (Joint Science Conference)
ICT information and communications technologies
IfM Institut für Mittelstandsforschung (Institute for Mittelstand Research)
IFR International Federation of Robotics
IoT Internet of Things
ISCED International Standard Classification of Education
ISO International Organisation for Standardisation
IT information technology
KmK Kultusministerkonferenz (Standing Conference of the Ministers of Education and Cultural Affairs of the Länder)
KONEPS Korea ON-line E-Procurement System
MIP Mannheimer Innovationspanel (Mannheim Innovation Panel)
MMI man-machine interaction
MOOC massive open online course

MUP	Mannheimer Unternehmenspanel (Mannheim Enterprise Panel)
NFC	near-field communication
OECD	Organisation of Economic Co-operation and Development
R&D	research and development
R&I	research and innovation
ROS	robot operating system
PCT	Patent Cooperation Treaty
RWTH	Rheinisch-Westfälische Technische Hochschule (RWTH Aachen University)
SMEs	small and medium-sized enterprises
STEM	science, technology, engineering, mathematics
SUS	Strukturelle Unternehmensstatistik (structural business statistics)
VEMAGS	Verfahrensmanagement für Großraum- und Schwertransporte (Process Management for Heavy Duty Transport)
WissZeitVG	Wissenschaftszeitvertragsgesetz (Law on Fixed-Term Employment Contracts in Science)
ZEW	Zentrum für Europäische Wirtschaftsforschung GmbH (Centre for European Economic Research)

D

List of figures, tables and boxes

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Economic sectors in R&D-intensive industries and knowledge-intensive industrial services[366]

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 electro-therapeutic 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 metal forming machinery
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

R&D-intensive industrial sectors within the Classification of Economic Activities, 2008 edition (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 communications

611 Wired telecommunications activities
612 Wireless telecommunications activities
613 Satellite telecommunications activities
619 Other telecommunications activities
620 Computer programming, consultancy and related activities
631 Data processing, hosting and related activities, web portals
639 Other information service activities n.e.c.

Emphasis on technical consulting and research

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

Actuators, actuatorics
Actuators convert control signals primarily into movement, but also, for example, into pressure or temperature. In actuatorics, which is seen as a branch of drive engineering, distinctions are made between mechanical, pneumatic, electromechanical, biological, optical and thermal actuators.

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.

Citizen science
Citizen science is a form of science in which non-scientists participate in the implementation of research projects – for example by collecting data.

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 of Excellence
Funding line of the Excellence Initiative (cf. ibid). Clusters of Excellence 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 profile of the universities and create excellent research and career conditions for young scientists.

Collaborative robots
Up to now, heavy, powerful and specialised industrial robots (cf. ibid) have dominated the factory halls. These robots can only work in clearly defined areas to which people have no access during operations. Smaller, more flexible lightweight robots are increasingly leaving these safety areas and collaborating with human staff whenever the latter lack the necessary strength or precision.

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 analyses the economic effects of innovation on the economy (i.e. on competition, employment, economic growth, trade models, etc.) on the basis of surveys of a representative sample of companies.

Computerised numerical control (CNC)
Computerised numerical control (CNC) refers to computer-aided processes for the electronic control of machine tools. The first CNC processes stem from the 1960s. They allow the rationalisation of series and individual production in a process that is still developing today. These days, nearly all newly developed machine tools are equipped with a CNC control system.

Curricular standard value
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.

Cyber-physical systems

Cyber-physical systems (CPS) are created by the networking of embedded systems via communications networks. Cyber-physical systems are thus characterised by a linkage between real (physical) objects and processes on the one hand, and information-processing (virtual) objects and processes on the other, via open, partly global, permanently interconnected information networks such as the internet.

Data mining

Data mining comprises all statistical evaluations of large data stocks (cf. 'Big data') with the aim of deducing new knowledge from these data. To do this, data mining uses computer-based data-analysis and detection algorithms, which identify systematic and thus non-random relationships and trends. As yet there is no established German translation for the English term data mining. Suggestions regularly made in this context include data-pattern recognition (Datenmustererkennung) or the broader definition as knowledge discovery in databases (Wissensentdeckung in Datenbanken).

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, 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 based on electronic media to run governmental and administrative processes. In e-government, public services and administrative matters are digitised and made available online.

EU-12 countries

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

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, 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

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 being 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 Future Concepts (cf. ibid). The current Excellence Initiative will run until 2017. A continuation is planned.

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 or 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.

Future Concepts (Zukunftskonzepte)

Funding line of the Excellence Initiative (cf. ibid). Future Concepts aim to strengthen universities as entire institutions and to establish them in the top group of international competition. The Future Concepts of each supported universities contain holistic strategies for funding top-level research at the university as a whole.

Graduate school

Funding line of the Excellence Initiative (cf. ibid). Graduate schools 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).

Hidden champions

The term 'hidden champions' was coined by Hermann Simon in a study completed in 1990.[367] It refers to a group of companies, often relatively unknown, most of which are owner-managed and not quoted on the stock exchange. Each has an annual turnover of less than three billion euros, targets the world market, and is one of the top three companies in its respective market in terms of market share. Hidden champions operate mostly in narrow niche markets.

High-Tech Strategy

A policy initiative by the Federal Government to integrate innovation funding across all federal ministries. The current High-Tech Strategy was adopted by the Federal Cabinet in September 2014. The strategy process in the field of R&I policy, initiated in 2006, thus entered its third phase. In the first phase (2006 to 2009), the main focus was on key technologies and lead markets. In the second phase, the solution of the great societal challenges was at the centre of attention. The aim is to merge the two 'threads' of the first two phases in the third phase of the High-Tech Strategy. The core elements are priority challenges for value creation and quality of life, networking and transfer, innovation dynamics in the economy, an innovation-friendly framework, as well as transparency and participation

High-value technology

High-value technology refers to R&D-intensive goods (cf. ibid) in the production of which an annual average of more than 3 percent but not more than 9 percent of turnover is invested in research and development.

Horizon 2020

Horizon 2020 is the European Union's Framework Programme for Research and Innovation. It not only continues the EU's Seventh Research Framework Programme, but also integrates the European Institute of Innovation and Technology (EIT) and the innovation-related elements of the previous Competitiveness and Innovation Framework Programme (CIP).

Imboden Commission

The so-called Imboden Commission is a commission of international experts set up to evaluate the Excellence Initiative, which expires at the end of 2017. It is chaired by Dr Dieter Imboden.

Inducement prize contest

Inducement prize contests (IPCs) are an instrument for promoting innovation. They are competitions for prize money. The organisation and design of these competitions can vary greatly. Important elements which influence the effect of this instrument include the amount of prize money, the number of potential winners, any stipulations on the exploitation of intellectual property rights, and whether the award is tied to the market success of the proposed solutions.

Industrial robots

Industrial robots are programmable machines for the automatic handling, assembly or processing of components in an industrial context. They are computer-controlled, consist of manipulators with attached tools, and are manoeuvrable in several axes. Once programmed, industrial robots usually carry out work processes completely autonomously. Due to their high speed, precision and durability, they are especially widespread in automotive manufacturing.

Industry 4.0
In industrial production, machines, plants and products are connected to form an IT network of embedded systems to raise 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. The most important keywords of Industry 4.0 are the 'smart factory' and 'cyber-physical systems' (cf. ibid).

Innovation intensity
Innovation intensity is defined as spending on innovation as a percentage of turnover.

Intellectual property rights
Intellectual property refers to intangible goods such as ideas, concepts or inventions. These assets are legally protected if the legal system assigns corresponding rights, such as patents or copyrights. The holder of such a right can be the patent applicant or the creator of a copyrighted work.

Intermediaries
Intermediaries generally have a brokering function between supply and demand in markets. For example, financial intermediaries – such as banks, insurance companies or investment companies – mediate between capital providers and borrowers.

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. Competitors can gain knowledge by inspecting innovative products and processes, without having to bear the full cost of knowledge production themselves. Conversely, this means that innovators 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 innovator 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 holding 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
By far the largest part of industry comprising all industrial sectors with the exception of the energy and construction industry. 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. At present, approximately 95 percent of all gainfully employed persons in industry work in German manufacturing sectors.

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.

Mobile enterprise
Mobile enterprise, also known as enterprise mobility or mobile business (M-Business), is a generic term for the use of apps on mobile terminal devices which wholly or partially map, and thus support, a company's business processes.

Multihoming
Multihoming denotes the possibility for users to use several internet platforms in parallel.

Nexus approach
Cf. Patent box regime.

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 access
Open access means free access to scientific results in the internet.

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 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, which have been conducted four times in Europe to date. The most recent revision of the Oslo Manual dates from 2005.

Patent box schemes

Patent box schemes grant companies a reduced tax rate on income from intangible assets such as patents on certain conditions. If the tax relief is made dependent on the company itself carrying out the R&D that leads to the patent, this is referred to as the nexus approach.

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 Organisation (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 the 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 responsible for the actual granting of patents.

Polarisation hypothesis

The term polarisation of labour markets refers to growing inequalities of wages and employment opportunities. Studies from English-speaking countries indicate a growing polarisation of the labour markets there, which is ascribed to the effects of technological change. For example, it is said that in the USA jobs for people with intermediate qualifications are becoming increasingly at risk, as the routiniseable tasks that prevail there are being replaced by modern technologies. This is said to lead to lower wages and to falling employment in the intermediate-qualification segment. Low-skilled occupations, on the other hand, are not affected by technological change, and highly qualified professions actually benefit from technological progress. The polarisation hypothesis has been empirically proven for many countries, but cannot be transferred one-to-one to Germany.

Profit retention

Retention of company profits means that corporate profits are not distributed, but remain in the company to serve as equity capital there.

Public private partnerships (PPP)

Form of cooperation between public administrations and business enterprises in which the state discharges its duties in cooperation with business enterprises, or else transfers the tasks entirely to the business enterprises. Among other things, the companies benefit from the contacts and experience of public administration in the respective field, as well as from contract awards or investment opportunities. In turn, certain projects can only be carried out by the public authorities with the financial support of the businesses.

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.

R&D-intensive goods

R&D-intensive goods comprise cutting-edge technology goods (cf. ibid) and high-value technology goods (cf. ibid).

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
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.

Safe Harbor Agreement
The Safe Harbor Agreement (or Safe Harbor Pact) is the name of a decision by the European Commission relating to the data-protection law passed in 2000. It aimed to enable companies to transfer personal data from a country of the European Union to the USA in a way that is in line with the European Data Protection Directive. The Safe Harbor Agreement was declared invalid by the European Court of Justice (ECJ) in October 2015.

Seed phase
Cf. early stage.

Sensorics, sensors
Sensorics is the science and application of sensors for measuring and monitoring changes in technical systems in the vicinity of one or more sensors.
Sensors are technical components. For example, there are optical, acoustic and tactile sensors which make it possible to measure changes in the environment.

Service robots
All robots that are not used in production processes in manufacturing are categorised as service robots. Generally, a distinction is made between service robots for professional use and those made for private use. Technically sophisticated sensors and actuators (cf. ibid) enable modern service robots to also render their services in unstructured environments.

Smart factory
A smart factory is an idealised production environment in which assembly and logistics are organised and optimised largely automatically by networked information technology. The technical basis is provided by cyber-physical systems (cf. ibid) which communicate with each other, for example via the internet.

Social innovations
Changes in the way technologies are used, as well as changes in lifestyles, business and financial 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.

Start-up phase
Cf. Early stage.

Tenure track
A tenure track is a term that describes scientific careers which offer young scientists a permanent position after a successful evaluation.

Text mining
Text mining refers to all computer-based methods of analysis for discovering semantic structures in unstructured text data. Ideally, the statistical and linguistic methods used identify core information contained in the processed texts, the existence of which was previously unknown to the users. Advanced text-mining techniques can also generate, check and gradually refine hypotheses autonomously. Text mining is thus used in a similar way to data mining for knowledge discovery in textual data.

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.

Transnational patents
Inventions that are simultaneously the subject of at least one application filed with the World Intellectual Property Organisation (WIPO) via the PCT process, and one application filed with the European Patent Office (EPA). 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 high risk for the 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).

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 relating to the German innovation system

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 'Studies on the German innovation system'. The findings of these studies are integrated into the Report of the Commission of Experts.

1-2016
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Endnotes

A 1

1 Cf. Howaldt (2013); Hochgerner et al. (2011).

2 For example, the Commission's 2008 and 2011 Reports use the following definition of innovation in the private and public sectors: "all novel technological, organisational, social and other developments which have been or are being implemented. It has to be more than just a 'good idea'. In a market economy, innovation involves the development and commercialisation of new products and services or the internal deployment of such innovations (process innovation). In public institutions, innovations involve the introduction of new methods, processes, and procedures. Innovations can create long-term competitive advantages for the innovative companies. [..] Innovation in the sense of this definition only requires a combination of novelty and at least attempted application" (EFI 2008).

3 Cf. http://ec.europa.eu/growth/industry/innovation/policy/social/index_en.htm (last accessed on 5 January 2016).

4 Cf. Howaldt and Schwarz (2014). Examples of funding projects and initiatives in the field of social innovation include the following:
1) The Federal Ministry for Family Affairs, Senior Citizens, Women and Youth (BMFSFJ) has initiated multi-stakeholder discussions and staged a multi-stakeholder conference in 2013 which brought together various players engaged in the promotion of social innovations (cf. http://www.social-reporting-standard.de/wpcontent/uploads/2013/03/MSK-Workshop-ergebnisse.pdf, last accessed on 5 January 2016).
2) In 2010, the foundation 'Stiftung Mercator' initiated the Mercator research group 'Innovative Social Action – Social Entrepreneurship', which published the first comprehensive study on the applicability, benefits, limits and effects of social enterprises in Germany (cf. https://www.stiftung-mercator.de/de/pressemitteilungen/nachrichten/stiftung-mercator-gruendet-ersten-nationalen-forscherverbund-zum-thema-socialentrepreneurship/, last accessed on 5 January 2016).
3) From 2011 to 2014, the Federal Ministry for Education and Research (BMBF) funded the project 'Social Innovation in Germany', which was carried out at the World Vision Centre for Social Innovation (EBS Universität für Wirtschaft und Recht in Oestrich-Winkel/Wiesbaden) and conducted research into application areas and mechanisms of social innovation in Germany (cf. http://www.worldvision-stiftung.de/unsere-arbeit-uebermorgen-forschung-und-innovation-bmbf-forschungsprojekt-soziale-innovationen.php and http://www.ebs-init.de/de-praxis/konferenz-soziale-innovationen-in-deutschland/, last accessed on 5 January 2016).
4) Individual smaller BMBF funding programmes and programme projects aim to promote innovative approaches to overcoming such social challenges as the ageing society or the integration of disadvantaged groups into the labour market. These programmes include, among others, 'Workplace-Oriented Adult Literacy and Basic Education' and the programme 'Health and Service Regions of Tomorrow', which targets innovative services for older people.

5 Cf. BMBF (2014).

6 For example, as part of its planning for the two-million-euro 'Horizon Prize for Social Innovation' in 2016, the European Investment Bank has already held an open ballot on the internet, in which the challenges of an ageing society were mentioned especially frequently. Cf. http://institute.eib.org/2015/10/ageing-population-is-europes-main-social-challenge/ (last accessed on 5 January 2016).

7 Cf. EFI (2013: 23, 2015: 27).

8 For example, a technical meeting of the ITA Forum 2013 within the framework of the Innovation and Technology Analysis (ITA) examined the topic of Citizen Participation as a Motor of (Social) Innovation. Also in the agenda process entitled 'Securing and Shaping the Future – Socio-Scientific Research on Societal Challenges', new topics for funding announcements were selected in a dialogue process.

9 Cf. also EFI (2013: Chapter B 1) for a statement on market failures relating to innovations.

10 Cf. among others Williams (2012). Wright (1983) compares different funding mechanisms, such as prize contests, project funding and patents; he also describes scenarios in which, under certain conditions, patents are less effective from the point of view of cost-effectiveness than funding in the context of prizes or projects. The structure or design of competitions can vary greatly. Important elements which play an important role and influence the effect of this instrument include the amount of prize money, the number of potential winners, any stipulations on the exploitation of intellectual property rights, and whether the award is tied to the market success of the solution concepts. Only few prize contests have been systematically evaluated to date, even though the number of prize contests in the field of R&I policy has increased significantly in many countries in the past two decades. Cf. Gök (2013).

11 Cf. NESTA (2014a).

12 Cf. Ministerium für Wissenschaft, Forschung und Kunst Baden-Württemberg (2013).

13 Cf. https://mwk.baden-wuerttemberg.de/de/service/presse/pressemitteilung/pid/auf-dem-weg-in-die-nachhaltige-stadt-8-millionen-euro-fuer-staedtische-reallabore-in-baden-wuerttem/ (last accessed on 5 January 2016).

14 Cf. NESTA (2014a).

15 Cf. PwC (2015). With regard to the investment, although the evaluation takes into account the total amount of prize money disbursed, as well as the additional costs of supporting the participants – e.g. with specialist IT staff within

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the framework of the competition – it does not consider the time resources and investment that the competition participants themselves contributed to the process.

A 2

16 Cf. Evers et al. (2015: 504).
17 Cf. Evers et al. (2015: 503).
18 Cf. Evers et al. (2015: 505).
19 Supplementary protection certificates grant an extension of the period of protection for patents in the fields of pharmaceuticals and crop protection for a maximum of five years.
20 Cf. Evers et al. (2015: 505-508).
21 Notional royalties are payments that would be due if the intellectual property were in the possession of a third party.
22 Cf. Evers et al. (2015: 507).
23 Cf. Evers et al. (2015: 506).
24 When patent boxes were introduced, particularly in the United Kingdom, tax experts initially feared that this would lead to a fall in tax revenue, even if companies were attracted by them. Cf. Griffith et al. (2014). Interestingly, however, tax revenue has not declined. Cf. Griffith and Miller (2014). More patents are applied for in countries with low rates of taxation of income from patents; on the other hand, there are fewer patent applications in countries with a high level of taxation of income from patents. Cf. Böhm et al. (2014) and Griffith et al. (2014).
25 Cf. Alstadsæter et al. (2015).
26 Patents of high quality are defined here as patents belonging to the upper sector-specific quartile of the INPADOC family size. Cf. Alstadsæter et al. (2015: 18).
27 There is also the direct funding of R&D in the context of project funding. This will not be discussed further in this chapter.
28 Cf. Griffith and Miller (2010a, 2010b).
29 Cf. Schnitzer and Watzinger (2015).
30 Cf. Griffith et al. (2014).
31 Cf. OECD (2015a: 25).
32 Cf. OECD (2015a: 27-28).
33 Cf. OECD (2015a: 28).
34 Cf. OECD (2015a: 26). Rights that are functionally equivalent to patents include patents under a broad definition, e.g. utility models, copyright-protected software and, under certain conditions, further intellectual-property assets that are non-obvious, useful and new. Cf. OECD (2015a: 26).
35 Cf. OECD (2015a: 29).
36 Cf. http://www.oecd.org/tax/beps-about.htm (last accessed on 5 January 2016) and OECD (2015a: 3).
37 Cf. OECD (2015a: 24).
38 Cf. OECD (2015a: 30ff.). If the proof of a nexus between expenditures and income in relation to the intellectual property is unrealistic and arbitrary, it is also possible to document the nexus in relation to products or product groups that are based on intellectual-property assets. Here, too, comprehensive tracking and an understandable documentation are essential. Cf. OECD (2015a: 30ff.).
39 Cf. EFI (2011: 32), (2012: 26) and (2013: 23).

A 3

40 Cf. EFI (2012: Chapter B1), EFI (2014: 21) and EFI (2015: 22).
41 For information on recruiting staff from abroad, cf. DFG and WR (2015a: 92); on internationality and internationalisation, cf. DFG and WR (2015b: 107ff.).
42 Cf. DFG and WR (2015c: 206ff.).
43 In this regard and in the following, cf. o.V. (2014).
44 For more detail on the selection process, cf. DFG and WR (2015a: 8ff.).
45 The following could serve as orientation here: the twelve-year term of the DFG-funded collaborative research centres; the twelve-year term of the National Centres of Competence in Research (NCCRs) funded by the Swiss National Science Foundation (SNSF); or the ten-year term of the ESRC Research Centres funded by the British Economic and Social Research Council (ESRC). Collaborative research centres are research facilities of tertiary education institutions in which scientists work together between their respective disciplines, institutes, departments and faculties within the framework of a comprehensive and scientifically excellent research programme (cf. http://www.dfg.de/foerderung/programme/koordinierte_programme/sfb/, last accessed on 5 January 2016). The NCCRs support established researchers who work on long-term research projects on topics of strategic importance (cf. http://www.snf.ch/de/foerderung/programme/nationale-forschungsschwerpunkte/Seiten/default.aspx, last accessed on 5 January 2016, and Schweizerischer Nationalfonds zur Förderung der wissenschaftlichen Forschung 2014: 4ff.). The thematic focus of the ESRC Research Centres lies on one or several priority areas; the term is initially ten years including a mid-term evaluation after five years (http://www.kooperation-international.de/detail/info/esrc-forschungszentren.html, last accessed on 5 January 2016).
46 Cf. Jongmanns (2011: 13).
47 In this regard and in the following, cf. Jongmanns (2011).
48 For information on the other results of the evaluation, cf. Jongmanns (2011).
49 Cf. in the following Deutscher Bundestag (2015a and 2015b).
50 For example, the 2007 version of the Law on Fixed-Term Employment Contracts in Science contains the stipulation that periods of a fixed-term employment relationship prior to graduation do not count towards the permissible duration of employment pursuant to section 2(1). After the introduction of bachelor's and master's degrees in the course of the Bologna Reform, however, an unequivocal reference point was missing here. This had the result that the procedure for counting periods of employment was not consistent (cf. Jongmanns 2011: 4). The amendment of the Law on Fixed-Term Employment Contracts in Science therefore replaces the stipulation with one stating that fixed-term employment relationships for providing scientific or artistic auxiliary activities – with students enrolled at a German tertiary education institution for a course leading to a first or further vocational qualification – are allowed for a period of up to six years.

51 Cf. Konsortium Bundesbericht Wissenschaftlicher Nachwuchs (2013: 28).
52 Cf. Konsortium Bundesbericht Wissenschaftlicher Nachwuchs (2013: 31 and 82) and EFI (2012: 50ff.).
53 Cf. (EFI 2012: 50ff.).
54 Cf. (EFI 2012: 50ff.).
55 Cf. GWK (2015).
56 On several occasions, the Commission of Experts has advocated raising the GDP spending target for R&D to 3.5 percent of the gross domestic product. The state should support such an increase by boosting public funding for R&D. The personnel structure at the universities should be changed in the course of such an increase.
57 Junior research groups (Nachwuchsgruppen) were introduced as early as 1969 by the Max Planck Society (MPG) at its institutes (in this regard and in the following, cf. Böhmer and Hornbostel 2009: 15). About 30 years later, the Volkswagen Foundation (VolkswagenStiftung, in 1996) and the DFG (in 1996, in the form of the Emmy Noether Programme) implemented comparable funding programmes, locating the supported junior research groups at universities. The Helmholtz Association of German Research Centres (HGF) has been funding junior research group leaders since 2002 (also at universities since 2004). The Volkswagen Foundation has discontinued the funding of junior research groups in the meantime.
58 In this regard and in the following, cf. EFI (2012: 58).
59 In this regard, cf. also BMBF (2013) and WR (2011).
60 In 2004, the BMBF set up the German Data Forum (Rat für Sozial- und Wirtschaftsdaten, RatSWD) – an independent body consisting of empirical scientists and representatives of important data producers. The aim is to sustainably improve the research data infrastructure for empirical social, behavioural and economic research and to contribute to its international competitiveness. One of the RatSWD's tasks is to accredit research data centres and data service centres. There are now nearly 30 accredited research data centres and data service centres in Germany (cf. http://www.ratswd.de/forschungsdaten/fdz, last accessed on 5 January 2016). For information on the BMBF's funding of these research data centres and data service centres, cf. BMBF (2013: 6ff.). For information on the funding of the Europe-wide networking of data infrastructures, cf. BMBF (2013: 16).
61 In 2012, the association DHd – Digital Humanities was founded in German-speaking countries as a platform and special interest group for activities in the field of digital humanities (cf. http://www.dig-hum.de/, last accessed on 5 January 2016). For information on the funding of the digital research infrastructure in the field of humanities, cf. BMBF (2013: 20ff.).
62 The Commission of Experts already referred to the potential of MOOCs in its 2015 Report (cf. EFI 2015: Chapter B 2).
63 For example, the Technical University of Munich offers specific technologies on its homepage (cf. http://www.forte.tum.de/technologietransfer/techno-logie-angebote/#pharma, last accessed on 5 January 2016), and the Centre for School Collaborations (Zentrum für Schulkooperationen) of the Freie Universität Berlin, offers courses and lectures for school students and teachers (cf. http://www.fu-berlin.de/sites/zfs/angebote/, last accessed on 5 January 2016).
64 In a recent survey conducted by the Donors' Association for the Promotion of Sciences and Humanities in Germany (Stifterverband für die Deutsche Wissenschaft), 77 percent of university heads stated that in five years digitisation would be of fundamental importance for implementing their respective university's internationalisation strategy. Currently, however, less than half of university heads consider digitisation important for the implementation of their internationalisation strategies (cf. Hetze and Mostovova 2015: 33).
65 Digital solutions can be used to get citizens involved in research (citizen science) (cf. e.g. http://www.artigo.org/about.html;jsessionid=EA481982116FDCA65FAB6E0CF5A80413.www6, last accessed on 5 January 2016).
66 For information on open access, cf. EFI (2013: Chapter A 2).
67 Issues relating to the digitisation of university teaching are currently being comprehensively processed in the Higher Education Forum on Digitisation (cf. http://www.hochschulforumdigitalisierung.de/, last accessed on 5 January 2016), a joint, BMBF-funded initiative of the Donors' Association for German Science, the CHE Centre for Higher Education and the German Rectors' Conference (HRK). The Forum develops recommendations for the administrations of tertiary education institutions, educators and political decision-makers, and identifies outstanding examples of best practice.
68 In this regard, cf. also EEA (2015) and http://www.hrk.de/themen/internationales/arbeitsfelder/fluechtlinge/ (last accessed on 5 January 2016).
69 For example, the German Institutes of Technology (TU9) are promoting the integration of refugees with various projects and programmes, cf. TU9 (2015). The HRK provides a collection of links on the topic of tertiary education and refugees, cf. http://www.hrk.de/themen/internationales/arbeitsfelder/fluechtlinge/linksammlung/ (last accessed on 5 January 2016).
70 The Friedrich Ebert Foundation conducted a survey in August 2015 on the rules governing university admission for refugees in the Länder, cf. https://www.fes.de/de/presse/aktuelle-pressehinweise/hochschulzugang-fuer-fluechtlinge-umfrage-zu-aktuellen-regelungen-in-den-bundeslaendern/ (last accessed on 5 January 2016), and Borgwardt et al. (2015).
71 Cf. KMK (2015).
72 In this regard and in the following, cf. https://kiron.university/, http://www.rwth-aachen.de/cms/root/Die-RWTH/Aktuell/Pressemitteilungen/September/~jdlc/Akademische-Fluechtlingshilfe/, https://www.hs-heilbronn.de/-7981891/920_Kiron_University (last accessed on 5 January 2016) and http://www.hnee.de/de/Aktuelles/Presseportal/Pressemitteilungen/Studium-fuer-Gefluechtete-in-Eberswalde-Kooperation-mit-der-Kiron-E8302.htm (last accessed on 5 January 2016).

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73 Cf. Simon (1990).

74 This information is based on a list compiled by Simon (2012). Cf. Rammer et al. (2016: 194).

75 The innovation behaviour of the German economy is examined by the Mannheim Innovation Panel (MIP), a survey conducted every year. It covers companies with at least five employees in the manufacturing industry and predominantly business-oriented services. Data from the MIP represent the German contribution to the Europe-wide Community Innovation Survey (CIS), which are carried out every two years. On the basis of the methodology drawn up by Eurostat, the CIS only include companies with ten or more employees and cover fewer sectors in the service industry (only wholesale, transport and post office, banks and insurance, IT and telecommunications, technical service providers).

76 The threshold values for the market share to be reached are defined depending on the total volume of demand in the market: in small markets with less than 200 million euros turnover per year, the market share must be at least 10 percent; in markets with 200 to 500 million euros annual turnover at least 7 percent; in markets with 0.5 to 1 billion euros annual turnover at least 3 percent; and in large-volume markets with an annual turnover of over a billion euros at least 1 percent. Cf. Rammer et al. (2016: 195).

77 Cf. http://www.ifm-bonn.org/mittelstandsdefinition/ (last accessed on 5 January 2016).

78 Cf. http://www.ifm-bonn.org/mittelstandsdefinition/definition-kmu-des-ifm-bonn/ (last accessed on 5 January 2016).

79 Based on analyses of the 2012 Community Innovation Survey. Cf. Rammer et al. (2016).

80 According to written information provided by the ZEW.

81 On behalf of the Commission of Experts, the ZEW evaluated the MIP and CIS data, as well as other data, with regard to the role of SMEs in research and innovation in Germany. Unless otherwise stated, the analyses in this chapter are based on this study. Cf. Rammer et al. (2016).

82 Cf. OECD (2015b).

83 Cf. OECD and Eurostat (2005).

84 Cf. Rammer et al. (2015: 4).

85 Innovation-active companies are companies that have carried out innovation activities during the previous three-year period, regardless of whether or not this led to the market launch of new products or the implementation of new processes. Cf. Rammer et al. (2016).

86 The ranking hardly changes, even when calculations are based on the average innovation expenditure of all SMEs in the CIS. Only France is much lower in the ranking when this indicator is used. Average innovation expenditures relative to all SMEs in CIS: Finland 179,000 euros, Sweden 177,000 euros, Netherlands 170,000 euros, France 159,000 euros, Austria 137,000 euros, United Kingdom 110,000 euros, Germany 90,000 euros, Italy 85,000 euros. Own calculation based on Rammer et al. (2016).

87 In the following, cf. Rammer et al. (2016: 53ff.).

88 Cf. Figure C 5-2.

89 Cf. Lazear et al. (2014).

90 SMEs with continuous internal R&D are systematically involved in generating new (technological) knowledge. For the group of SMEs with occasional internal R&D, it can be assumed that they also have skills and resources to drive technological developments of their own. However, these are only used non-systematically, i.e. usually if there is a specific reason. This enables the companies to save fixed costs; at the same time, the technological sophistication level of their innovation activities is likely to be lower. The group of SMEs with innovation activities without R&D operations of their own is made up of SMEs that develop and launch innovations without themselves investing in the generation of new knowledge. Cf. Rammer et al. (2016: 77).

91 In the context of the patent analysis, SMEs are defined as enterprises with fewer than 500 employees.

92 Transnational patent applications are defined as applications to the European Patent Office (EPO) and, via the Patent Cooperation Treaty (PCT) process, to the World Intellectual Property Organisation (WIPO) in Geneva. Cf. Rammer et al. (2016: 71).

93 Germany's performance was also about average according to this indicator in 2008.

94 In the following, cf. Rammer et al. (2016: 105ff.) and written information provided by the ZEW.

95 In the following, cf. Schneider and Stenke (2015).

96 In the following, cf. Rammer et al. (2016: 105ff.) and written information provided by the ZEW.

97 In the following, cf. Rammer et al. (2016: 105ff.) and written information provided by the ZEW.

98 In this regard and in the following, cf. Rammer et al. (2016: 114ff.).

99 In this regard and in the following, cf. Rammer et al. (2016: 112ff., 114ff.).

100 In addition, it suggests that the additional financial resources required to mobilise innovation potential are much lower than the figure of 10 percent of annual turnover assumed in the survey – after all, with such a large volume of funds, significantly more SMEs would implement more innovation ideas than just those that have been restricting their innovation activities due to a lack of funding. It should be noted here that an additional profit of 10 percent of annual turnover corresponds to twice the average profit-turnover ratio of innovation-active SMEs.

101 Own resources play a much more important role in financing innovations than loans. Cf. Rammer et al. (2016: 109ff.). According to the results of the 2014 German Innovation Survey, 83 percent of innovation-active companies used internal financial resources (cash flow) to finance innovation activities in the period from 2011 to 2013. By contrast, only 16 percent of the innovation-active SMEs used overdraft facilities; 14 percent used earmarked bank loans. Own resources become more important in innovation financing, the riskier the innovation activities are and the lower the collateral procured in the context of innovation projects, e.g. in the form of physical capital procurement (cf. Rammer 2009: 63).

102 In the following, cf. Rammer et al. (2016: 135ff.).

103 Cf. http://www.foerderinfo.bund.de/de/ZIM-777.php (last accessed on 5 January 2016).

104 Cf. Rammer et al. (2016: 136) and http://www.foerderinfo.bund.de/de/KMU-innovativ-761.php (last accessed on 5 January 2016).
105 Cf. http://www.bmwi.de/DE/Themen/Technologie/Innovationsfoerderung-Mittelstand/technologieoffene-projektfoerderung,did=502118.html (last accessed on 5 January 2016).
106 Cf. http://www.foerderinfo.bund.de/de/IGF-830.php (last accessed on 5 January 2016).
107 Cf. http://www.foerderinfo.bund.de/de/INNO-KOM-Ost-820.php (last accessed on 5 January 2016).
108 Cf. http://www.foerderinfo.bund.de/de/Beratung-212.php (last accessed on 5 January 2016).
109 http://www.foerderinfo.bund.de/de/Schutzrechte-210.php (last accessed on 5 January 2016).
110 Cf. https://www.kfw.de/inlandsfoerderung/Unternehmen/Gr%C3%BCnden-Erweitern/Finanzierungsangebote/ERP-Startfonds-(136)/ (last accessed on 5 January 2016).
111 Cf. http://www.bmwi.de/DE/Themen/Mittelstand/Mittelstandsfinanzierung/innovationsfinanzierung,did=649698.html (last accessed on 5 January 2016).
112 Cf. http://www.bmwi.de/DE/Themen/Mittelstand/Mittelstandsfinanzierung/gruendungsfinanzierung,did=508044.html and http://high-tech-gruenderfonds.de/de/#gruender (last accessed on 5 January 2016).
113 Cf. http://www.bmwi.de/DE/Themen/Mittelstand/Mittelstandsfinanzierung/invest,did=655264.html (last accessed on 5 January 2016).
114 Cf. http://www.foerderinfo.bund.de/de/Gruendung-211.php (last accessed on 5 January 2016).
115 Cf. http://www.horizont2020.de/(last accessed on 5 January 2016).
116 Cf. http://www.horizont2020.de/einstieg-neuerungen.htm (last accessed on 5 January 2016).
117 Cf. http://eurostars.dlr.de/de/1332.php (last accessed on 5 January 2016).
118 Cf. http://eurostars.dlr.de/de/1307.php and http://www.foerderinfo.bund.de/de/Eurostars-971.php (last accessed on 5 January 2016).
119 In this regard and in the following, cf. Rammer et al. (2016: 144).
120 Cf. Rammer et al. (2016: 144).
121 International statistics do not contain figures on indirect public R&D funding of companies. Therefore, the percentage of R&D expenditures that can be refinanced via indirect support measures was calculated in order to make international comparisons of the attractiveness and extent of indirect R&D funding. This percentage can vary according to company size, the nature of R&D activities conducted, and the companies' profit or loss situation; it depends not only on the design of the indirect R&D support measures, but also on the rate of tax or duty to which the indirect support measure relates. Assuming that all eligible companies actually use the indirect support measures (and that R&D expenditure that has already received direct state funding cannot be supported a second time by an indirect measure), the percentage of indirect state funding of R&D can be calculated. In the case of different percentages of funding in the case of a profit or loss, it was assumed that profitable companies account for 90 percent of corporate R&D expenditure and loss-making firms for 10 percent.
122 Other indirect measures, for example, are linked to social expenditure or other components of the wage costs of R&D personnel.
123 In the following, cf. Rammer et al. (2016: 149ff. and 152ff.).
124 The Commission of Experts is of the opinion that the differences in rates cannot be explained only by different practices in the declaration of the R&D expenditure.
125 Cf. BMBF (2016).
126 The programme targets four areas for action. Their aims are: (i) To strengthen SMEs in key sectors of the German economy. For this purpose the KMU-innovativ funding programme is supplemented by the areas Digital Economy, Healthy Living and Sustainable Development. (ii) To improve SMEs' collaborations and partnerships with tertiary education institutions and non-university research institutions within the framework of regional networks and cross-border projects. (iii) To ensure the availability of a sufficient number of skilled workers for SMEs. (iv) To ease SMEs' access to support programmes. In addition to these four action areas, feasibility studies, pilot projects, reference plants, etc. are to be given greater support. Cf. BMBF (2016).
127 Cf. EFI (2010: 9).
128 Cf. EFI (2013: 24).
129 Cf. Ernst & Young (2015) and Rammer et al. (2016: 208).
130 For information on the framework conditions for venture capital in Germany, cf. EFI (2015: Chapter A 5).
131 For information on the shortage of skilled personnel and innovation, cf. EFI (2012: Chapter B 2); on the potential of women in the research and innovation system, cf. EFI (2013: Chapter B 4); on the international mobility of scientists and inventors, cf. EFI (2014: Chapter B 2).
132 A survey of SMEs conducted on behalf of the BMWi showed that three quarters of the companies asked said they were not well informed about the legal framework. More recent information sources from the BMWi, the BMAS or the Confederation of German Employers' Associations were largely unknown. Only the information from the International Placement Services of the Federal Employment Agency was relatively well known and also used. Cf. BMWi (2014a: 77ff.).

B 2

133 The term 'robots' has become established for collaborative lightweight robots.
134 Robots like the 'Sawyer' system from the company Rethink Robotics often consist only of a single robotic arm.
135 Man-machine cooperation and man-machine interaction are generally used interchangeably.
136 In addition, augmented reality is often also a topic in the context of man-machine interaction. However, this refers primarily to data glasses for enhancing human perception with virtual object information and does not describe a technical robotic functionality.

137 For information on labour costs in manufacturing in 2013 by international comparison, cf. Schröder (2014) and http://www.nzz.ch/digital/die-befreiung-der-roboter-1.18546014 (last accessed on 5 January 2016).

138 Cf. Beckert et al. (2016: 74).

139 According to the IFR's estimates, more than 3.3 million robots for domestic tasks (vacuum cleaning, lawn mowing, window cleaning and others) were sold worldwide in 2014 alone. This corresponded to an increase of 24 percent compared to 2013. The actual figure could even be much higher, since the underlying IFR survey cannot guarantee comprehensive coverage of the market segment. The turnover amounted to about 1.2 billion US dollars, an increase of 53 percent over 2013, cf. IFR (2015b: 22).

140 The robot 'Pepper' was developed in a collaboration between Aldebaran Robotics from France and the Japanese company SoftBank Mobile.

141 Aldebaran is working with developers from IBM to further improve interactivity. A cognitive system called 'Watson' developed by IBM processes natural language, uses machine-learning methods, and independently generates and evaluates hypotheses from the data obtained. Cf. http://www-05.ibm.com/de/watson/ (last accessed on 5 January 2016).

142 Apart from its entertainment and information routines, the robot 'Pepper' is limited in its functionality. SoftBank has released a user interface to expand capabilities to allow software engineers to program new functionalities.

143 Pepper's offer price in January 2015 was 198,000 yen, or about 1,500 euros. Cf. http://www.bloomberg.com/news/articles/2015-06-18/softbank-to-sell-pepper-robot-to-consumers-from-june-20 (last accessed on 5 January 2016).

144 Cf. http://www.campaignlive.co.uk/article/softbank-invests-android-data-collection/1364933 (last accessed on 5 January 2016).

145 Google acquired eight robotics firms in 2013 alone – although none of the robotics companies taken over had previously sold an appreciable number of robotic systems. Experts believe that Google primarily regards modern robot assistants as the data collectors of the future. Intuitive operating systems and the 'crowdsourcing' of complex issues on the internet seem to be playing an important role in improving robotic skills. The foundation is laid by robotic systems that 'learn' by interacting both with their environment and with their users and share the accumulated experience-based knowledge in clouds.

146 The definition of a robot follows the ISO 8373:2012 standard, especially sections 2.6-2.12. The definition given there explicitly states that it must be "programmable in three or more axes". Since some service robots do not meet these requirements, this Report does not follow this very strict interpretation. A vacuum-cleaning robot, for example, only has two axes (longitudinal axis for forward motion, vertical axis for orientation in space).

147 Service robots for industrial use are frequently defined by the fact that they are operated by a trained person, while untrained people control robots used privately. This distinction, too, can rarely be made with absolute certainty. For example, a cleaning robot can be used not only privately, but also in industry, and still be operated by untrained people.

148 Most actuators convert control signals into movement, but some convert them into pressure or temperature, for example. In actuatorics, which is regarded as a subfield of drive engineering, distinctions are made between mechanical, pneumatic, electromechanical, biological, optical and thermal actuators.

149 Cf. IFR (2015a: 17).

150 All unit figures given in this Report exclude software, peripherals and related plant and systems engineering.

151 Own evaluations and descriptions are based on the IFR's World Robotics Database. The figures for the number of robots given or shown in Table B 2-2, Figure B 2-3 and Figure B 2-4 refer exclusively to the manufacturing sector. By contrast, the IFR's written reports often show all industrial robots – including those that are used outside of the manufacturing sector. As a result, the global numbers given by the IFR in its reports are approximately 15 percent higher on average. The IFR reports nevertheless arrive at the same ranking of the most important countries. Furthermore, the IFR aggregates the data of some countries in its reports; for example, the number of robots in the USA, Canada and Mexico are subsumed under the term 'North America' in some descriptions. Cf. for example IFR (2015a) and the reports of the previous years. However, the figures for robots in the USA are given separately in this Report.

152 Cf. IFR (2015a: 422). Canada, Mexico and the USA are aggregated as North America in the forecast mentioned there with a predicted inventory of 280,000 industrial robots at the end of 2016. The disaggregated data on the last few years, which are available in the IFR database, show that the USA has by far the largest share of industrial robot stocks in North America with over 90 percent. It is thus plausible to assume that the USA, considered separately, will exceed Germany's 191,300 units predicted for the end of 2016.

153 The delimitation of the individual industries follows the classification of economic sectors used by the IFR. This is based on the International Standard Industrial Classification ISIC Rev. 4 – but is not completely identical to ISIC Rev. 4 (cf. IFR 2015a). Figure B 2-3 examines the sectors with the most intensive use of robots in Germany's manufacturing industry and compares them with the corresponding sectors in the reference countries. Some substantially similar classes and subclasses were aggregated to make this possible. For example, the metal industry (excluding mechanical engineering) is made up of the following IFR classes from D-Manufacturing: 24 basic metals, 25 metal products (non-automotive) and 289 metal, unspecified.

154 For Germany alone, robot density can also be determined in the individual sectors of the manufacturing industry in 2014. Vehicle construction is the only sector with figures above the average of manufacturing as a whole. The other sectors are at a significantly lower level.

155 The unit prices of service robots vary considerably according to the area of application. Medical robots are the most expensive with an average price of about one

million US dollars (including accessories and services); exoskeletons for humans, on the other hand, cost an average of about $50,000 US dollars, and professional cleaning systems just under $24,000. Cf. IFR (2015b). Service robots for private use have a significantly lower mean value. Looking at unit numbers alone is therefore not very informative in assessing the economic importance of service robotics. Turnover forecasts are used instead.

156 Cf. IFR (2015a, 2015b).

157 Cf. BCG (2014).

158 Cf. IFR (2015b).

159 These forecasts are subject to various difficulties. In service robotics, data availability is very heterogeneous due to the different application areas and national statistics. Furthermore, not all figures are published, especially in the field of defence. Because of the different periods of use of the individual models, it is difficult to estimate current stocks and, as a result, replacement needs. The average period of use of an industrial robot is usually calculated at twelve years. An underwater robot can be used for about ten years, whereas the useful life of defence robots is often considerably shorter.

160 Above all the automotive industries in the emerging markets can be identified as further growth drivers for industrial robotics. Apart from this, the regular modernisation of production under the influence of global competitive pressure ensures a continuously high demand for robots, also in the countries and sectors that already have a high degree of automation and are further intensifying robot use. Cf. Beckert et al. (2016).

161 For information on further prospects of service robotics, cf. also Ott (2012).

162 A potential driver of future demand for service robots could be the growing shortage of labour in ageing societies. As early as the 1980s, the Japanese government recognised that the country would have a shortage of nursing staff due to the ageing of the population. Japan reacted by intensifying research efforts to develop nursing robots.

163 In 2011, President Obama launched a programme called Advanced Manufacturing Partnership, in which the government, together with industry and universities, invested in newly emerging technologies to create jobs and improve competitiveness in manufacturing. Cf.: https://www.whitehouse.gov/the-press-office/2011/06/24/president-obama-launches-advanced-manufacturing-partnership (last accessed on 5 January 2016).

164 Cf. http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=503641&org=CISE (last accessed on 5 January 2016).

165 Cf. https://www.whitehouse.gov/blog/2011/06/24/developing-next-generation-robots (last accessed on 5 January 2016).

166 Cf. DLR – Strategies and funding activities of the USA in the field of Autonomics 4.0: http://autonomik4.pt-dlr.de/_media/Strategien_und_Foerderaktivitaeten_der_USA_im_Umfeld_von_Autonomik_4.0.pdf (last accessed on 5 January 2016).

167 Cf. https://robotics-vo.us/sites/default/files/2013%20Robotics%20Roadmap-rs.pdf (last accessed on 5 January 2016).

168 Cf. summary of the speech by Mr Wang Weiming (Equipment Department at the Ministry of Industry and Information Technology of the People's Republic of China) in IFR (2015a: 446ff.).

169 Cf. IFR (2015a).

170 In its World Economic Outlook Database for April 2014, the International Monetary Fund (IMF) puts Japan in 3rd place among the countries with the highest gross domestic product (characteristics GDPD and NGDP_RPCH). If purchasing power parities (PPP) are incorporated, Japan still reaches 4th place behind India (characteristic PPPGDP). Cf. https://www.imf.org/external/pubs/ft/weo/2014/01/weodata/index.aspx (last accessed on 5 January 2016).

171 Japan's R&D intensity has always been well over 3 percent in the last ten years. In 2013, private firms accounted for 77 percent of Japanese gross domestic expenditure on R&D. Cf. Schasse et al. (2015) and EFI (2015: 94ff.).

172 Cf. http://www.auswaertiges-amt.de/sid_7ED3757F9EC6C2962F0E48F996A7164A/DE/Aussenpolitik/Laender/Laenderinfos/Japan/Wirtschaft_node.html (last accessed on 5 January 2016).

173 More than 25 percent of Japanese were 65 years of age or older in 2015. By comparison, the figure for Germany was 17 percent. In 2012, Japanese expenditure on the social systems exceeded 30 percent of gross domestic product. Cf. www.meti.go.jp/english/press/2015/pdf/0123_01b.pdf and http://de.statista.com/statistik/daten/studie/1365/umfrage/bevoelkerung-deutschlands-nach-altersgruppen/ (last accessed at the 5 January 2016).

174 Cf. https://www.kantei.go.jp/jp/singi/keizaisaisei/pdf/honbunEN.pdf (last accessed on 5 January 2016).

175 Cf. www.meti.go.jp/english/press/2015/pdf/0123_01b.pdf (last accessed on 5 January 2016).

176 For decades, Japan has been the country with the highest use of industrial robots and the highest exports of industrial robots in the world. Cf. IFR (2015a).

177 Development was not even sustainably impeded by the 1997/1998 'Asian Crisis', during which South Korea had to ask the IMF for assistance. In the meantime, the country ranks 12th among the biggest economies in the world (gross domestic product by purchasing power parity, characteristic PPPGDP). Cf. https://www.imf.org/external/pubs/ft/weo/2014/01/weodata/index.aspx (last accessed on 5 January 2016). According to information provided by the Korea Institute of Science and Technology (KIST), South Korea sees the reason for its success in the strong R&D efforts of an innovation system based on the German model.

178 Cf. Schasse et al. (2015) and EFI (2015: 94ff.).

179 To achieve this, the aim is to increase the number of South Korean robotics firms from approx. 400 at present to 600 in 2018. Another target is to raise average turnover from currently about 6.0 to 11.7 million US dollars.

180 In international comparisons, several of the observed indicators have weaknesses that should be borne in mind. To begin with, there is a language bias in favour of English-speaking countries in the Web of Science. Cf. for example Beckert et al. (2016: 11). Moreover, there are differences in patenting propensity between different countries.

181 The results are based on data from the Fraunhofer ISI from December 2015. The basic search method used here captures 'robot' documents according to the category code of the same name for publications in the Web of Science, or according to the IPC subclass B25J in the World Patent Index (WPI, STN) for patents (only European or PCT applications). All patent and publication documents that contain the keyword 'robot' (with open masking) in the title or abstract are added – in the case of patents with the exception of all documents belonging to the patent subclass A63H. Cf. Beckert et al. (2016). The division into industrial and service robotics shown here is carried out in a second step using lexical search terms. Korzinov and Kreuchauff propose an alternative method of subdivision according to patents for industrial and service robotics using a support-vector-machine classifier (2015).

182 Cf. Kreuchauff and Bälz (2016).

183 The following remarks relate to the funding landscape in Germany. The SPARC programme has existed at the EU level since 2014; here, the European Commission intends to spend a total of 700 million euros up to 2020 to fund over 180 companies and research institutions – in particular public-private partnerships in the field of robotics. The SPARC programme is embedded in Horizon 2020. The European Commission calls it the world's most comprehensive funding programme for civilian robotics. However, total funding is spread across all EU member countries. In addition to industrial robotics, SPARC also stresses the relevance of service robotics with its potentially disruptive effects on the competitiveness of industries outside of manufacturing, such as agriculture, transport, health, security and logistics. Cf. Kreuchauff and Bälz (2016).

184 Examples include the ENTERN and LIMES projects, for which the BMWi is distributing almost 4.2 million (ENTERN) and 3.7 million euros (LIMES) to the respective network partners DFKI and the University of Bremen between 2014 and 2017. Cf. Kreuchauff and Bälz (2016).

185 Examples of cross-section functions include projects on man-robot interaction and general methods of software development (example: D-Rock project). Cf. Kreuchauff and Bälz (2016).

186 The measure is running from 2013 to 2016. The funding volume is being distributed among several sub-projects and totals approx. 24.7 million euros. The average funding per project is under two million euros. Cf. Kreuchauff and Bälz (2016).

187 Also especially important are man-machine interaction and a high degree of autonomy. The programme aims to also make progress in the field of software engineering for service robotics.

188 In this regard, cf. pioneering work by Brynjolfsson and McAfee (2011. 2014).

189 The observed polarisation of the labour market is not a purely US phenomenon. Several studies have also revealed this development in a number of EU countries. Cf. Goos and Manning (2007), Goos et al. (2009, 2014), Machin (1996), Machin and van Reenen (2007).

190 Cf. for the first time Autor et al. (2003).

191 This hypothesis is known as the 'routinisation hypothesis' or 'routine-biased technical change'.

192 192 Cf. the author and Dorn (2013); the author et al. (2006, 2008); Bartel et al. (2007); Black and Spitz-Oener (2010); Firpo et al. (2011).

193 Cf. Dustmann et al. (2009), Spitz-Oener (2006).

194 Cf. Antonczyk et al. (2009) and Antonczyk et al. (2010). Dustmann et al. (2009) argue that the routinisation of work was the main driver of polarisation from 1980 to 2000. However, this applied primarily to the upper limit of the distribution scale. The main driver at the bottom limit was the decline in collective bargaining coverage. The authors also find that routine tasks are used particularly below the 20th percentile and around the 80th percentile of wage distribution. This pattern does not match the pattern in English-speaking countries, in which routine activities dominate in the middle. Antonczyk et al. (2009) and Antonczyk et al. (2010) point out that although some of the developments of employment distribution in Germany could be explained by a reduction in routine activities, there were major differences between the developments in the USA and Germany. The routinisation hypothesis alone could not, therefore, explain the empirical results for Germany.

195 Cf. Eichhorst et al. (2015), Rinawi and Backes-Gellner (2015), as well as the results of the German Council of Economic Experts (Sachverständigenrat zur Begutachtung der gesamtwirtschaftlichen Entwicklung, 2015). Although the study by Rinawi and Backes-Gellner (2015) focuses on wage developments among employees with vocational training, they also link their results to the development of wages in the population as a whole. Here, they come to a similar result as Eichhorst et al. (2015), namely that the middle remains stable.

196 It should be noted that early studies did not explicitly take training differences into account. In early studies, 'occupations' are typically grouped simply according to the average income and not according to their content. Low-wage occupations are then simply classified as occupations of low-skilled workers, and high-wage occupations as occupations of highly skilled workers (although the qualifications are not studied per se). However, this categorisation does not allow conclusions to be drawn on which kinds of training prepare employees better or worse for technological change.

197 In this regard, cf. also EFI (2014: 58: Chapter A 3)

198 Cf. Backes-Gellner (1996), Rupietta and Backes-Gellner (2012), as well as Backes-Gellner and Rupietta (2014).

199 Cf. Backes-Gellner (1996), Ewers et al. (1990) and Sorge (1985, 1990).

200 Cf. Janssen and Mohrenweiser (2015). In order to ensure causality, the authors compare the wage developments of employees in the reformed occupations with those of employees in similar occupations that have not been reformed (machining versus non-machining mechanics). Because the curricula of these two occupations are largely congruent, the employees work in the same factory, manufacture the same products, and are represented by the same trade union, both employee groups encounter the same labour-market institutions and economic conditions.

201 Initiated by the work of Frey and Osborne (2013), the importance of robotics for the labour markets is currently at the focus of many political and scientific discussions. Based on expert assessments, the authors examine the likelihood of occupations in the USA being automated, and come to the conclusion that approximately 47 percent of occupations are highly likely to be automated over the next ten to twenty years. Bonin et al. (2015) transfer this study to Germany and come to a rather more moderate assessment (42 percent). At the same time, they point out that great care should be taken when interpreting the respective results.
202 Cf. Bonin et al. (2015), Eichhorst and Buhlmann (2015), Möller (2015), as well as Rinawi and Backes-Gellner (2015).
203 Cf. Autor et al. (2006, 2008).
204 Cf. Rinawi and Backes-Gellner (2015).
205 Cf. Janssen and Backes-Gellner (2009).

B 3

206 Cf. Box B 3-13 for detailed definitions of big data and cloud computing.
207 Cf. EFI (2014: Chapter B 3). Other studies also show that the percentage of total value added and employment attributable to the ICT industry in Germany has been stagnating since the turn of the millennium and fell below the average of the OECD member states in 2013 (OECD 2015c).
208 The Commission of Experts interprets the introduction of an ancillary copyright law for print products, and the hesitant attempts by political decision-makers to improve the framework conditions for start-ups and venture capital, as indications of a structurally conservative policy on the part of the current, but also previous federal governments.
209 According to Osterwalder and Pigneur (2010), "a business model describes the rationale of how an organisation creates, delivers, and captures value."
210 Cf. Baden-Fuller and Morgan (2010).
211 Cf. Waldrop (2015). Whereas operating systems were also already integrated in previous vehicle generations, today operating-system providers are also seeking control over the graphical user interface, i.e. the communication interface with the end customer (cf. http://www.zdnet.com/pictures/microsoft-shows-off-windows-for-cars-concept/, last accessed on 5 January 2016), e.g. with Apple Car Play, Android Auto or Windows for Cars. If the vehicle operating concepts (e.g. in the case of the Tesla Model S) are geared more towards tablet computers, the major operating-system providers can apply their extensive experience with these technologies directly in automobiles. Such a development is also anticipated by experts of the German automotive industry. For example, Luca De Meo, Member of the Board of Management for Sales and Marketing at Audi AG, expects the proportion of applications, electronic systems and digital services to rise to 50 percent of value added in the automotive industry (cf. http://www.autonews.com/article/20150526/OEM06/150529909/audi-expects-in-carelectronics-to-become-as-valuable-as-horsepower, last accessed on 5 January 2016).
212 Cf. Bründl et al. (2015).
213 Cf. EFI (2013: Chapter A 4).
214 The ICT industry comprises the ICT hardware manufacturers and the ICT service providers (including software development). It does not include repairs of data-processing and telecommunications equipment or the ICT retail trade. Cf. BMWi (2014b: 108).
215 Cf. BMWi (2014b: 13).
216 From the perspective of households, businesses and the state, internet-based consumption and investment comprises hardware, e-commerce (B2B and B2C), data services, internet-based IT services, online advertising, online content (gambling and video games, video streaming and digital music products). In terms of foreign trade, the internet economy covers ICT hardware, telecommunications services and IT services. In this context, the ICT industry overlaps with the internet economy. This circumstance is taken into account by using correction factors. For example, only 5 percent of turnover from B2C (business-to-consumer) e-commerce is posted. Cf. BMWi (2014b: 110ff.).
217 Cf. BVDW (2012).
218 "The digital economy is a cross-sectional industry essentially comprising all economic sectors in which an IP address is used to implement business processes. I.e. these include, on the one hand, companies that operate ‘pure’ internet services and virtual goods, and, on the other, parts of ‘classic’ industries in which business processes or transactions are supported by internet technologies." Cf. BVDW (2012: 6).
219 Cf. Accenture (2014: 9). The degree of digitisation in a company can be assessed in an exemplary way by looking at business activities in the fields of digital strategy, digital range and digital processes within the company (communication, production etc.). However, no viable concept has yet been presented for measuring the degree of networking ‘things, data and services’ in companies and their environments.
220 For information on the classification of the two sectors by means of different industry classifications, and on the analysis of market capitalisation, cf. Müller et al. (2016).
221 A comparison by market capitalisation could cause distorted results if the economic potential of unlisted companies in Germany is significantly larger than in the USA. The Commission of Experts does not expect this, since particularly start-ups financed specifically by venture capital are currently widespread in the USA.
222 If software providers are added to the classification of the internet economy – and not, as hitherto, included under the ICT industry – then e.g. SAP SE must be classified under the internet economy (market capitalisation in 2015: approx. 70 billion euros). Such a classification would increase the total market capitalisation of the internet economy in Germany from 34 to more than 100 billion euros. However, even according to this extremely conservative perspective, the US companies remain dominant overall.
223 The Commission of Experts has already referred in the past to the growing importance of ‘user capital’ for the value of internet-based business. Cf. EFI (2015: Chapter B 3).

224 Cf. BVDW (2014).
225 Cf. http://blogs.wsj.com/corporate-intelligence/2014/02/19/facebooks-whatsapp-price-tag-19-billion/ (last accessed on 5 January 2016).
226 Cf. http://www.globalwebindex.net/blog/top-global-smartphone-apps (last accessed on 5 January 2016).
227 Cf. Roland Berger Strategy Consultants (2013).
228 Cf. Bloching et al. (2015).
229 The company value is determined within the framework of a business appraisal and covers the company's ability to make distributable surpluses. An evaluation of innovative start-ups, especially in such a relatively new and dynamic field as the digital economy, can prove difficult, since start-ups are not (yet) listed on the stock exchanges and therefore not yet valued on the market. Venture-capital investors already appraise the market potential of such start-ups at an early stage. In order to arrive at a valuation of the enterprise, the value of a digital-economy start-up is approximated, among other methods, via the (expected) number of internet users.
230 Cf. Jetter (2011).
231 Cf. Bain (2012).
232 Cf. D'Emidio et al. (2014).
233 Cf. Müller et al. (2016).
234 Cf. http://blogs.wsj.com/venturecapital/2015/08/20/zocdoc-valued-at-1-8b-in-new-funding-round/ (last accessed on 5 January 2016).
235 Cf. http://www.cnbc.com/2014/06/17/ (last accessed on 5 January 2016).
236 Cf. Steidl (2015).
237 Cf. http://www.utilitydive.com/news/the-future-of-googles-nest/257068/ (last accessed on 5 January 2016).
238 Results of a workshop on IT start-ups at the German Institute for Japanese Studies on 25 September 2015 in Tokyo.
239 Cf. EFI (2013: Chapter A 4).
240 This applies above all to the series A and B rounds of financing for growth-oriented business start-ups. In principle, these rounds continue the seed financing of these business start-ups and are usually carried out by professional venture capitalists. The scale of these financing rounds is usually above the mid-six-digit investment range.
241 Cf. EFI (2015: Chapter A 5).
242 Both in Europe and the USA, a further approx. 20 percent of the funds was invested in the other areas relevant to the digital economy, such as communications services and internet technologies. Cf. OECD (2015b).
243 Cf. OECD (2015d).
244 Cf. https://digitalcityindex.eu/ (last accessed on 5 January 2016).
245 In another renowned ranking, the Regional Entrepreneurship and Development Index (REDI), Germany's top city (Berlin) is also only in 11th place. Here, too, the leading regions are mostly in northern Europe. Cf. http://blogs.lse.ac.uk/redi/best-and-worst/ (last accessed on 5 January 2016).
246 Augmented reality is defined as a computer-based extension of reality perception and can in principal be geared to all human sensory modalities, not only to visual perception.
247 Cf. Müller et al. (2016).
248 Cf. Müller et al. (2016: 46ff.).
249 Cf. Müller et al. (2016: 75).
250 Cf. Müller et al. (2016: 47).
251 Note: the buyer companies were chosen on the basis of selected industry-classification codes of the ICT industry and the internet economy (cf. Müller et al. 2016). This definition was not used exclusively to determine the industry affiliations of the target companies (data source: Crunchbase).
252 Cf. Müller et al. (2016: 10ff.).
253 Cf. Füller (2010).
254 Cf. Erler et al. (2009).
255 Cf. Lakhani et al. (2013).
256 Cf. Müller et al. (2016).
257 Cf. Müller et al. (2016: 13).
258 Cf. Gumsheimer et al. (2015). The authors define digital maturity based on digitisation in the following four areas: interface to the customer, impact on innovation, business processes/business areas, and IT platforms.
259 Cf. GFK (2014: 7).
260 Cf. Li and Chen (2012), as well as Lycett (2013).
261 Cf. Brynjolfsson and McAfee (2012).
262 Cf. Bundesamt für Sicherheit in der Informationstechnik (Federal Office for Information Security, 2015). Other definitions, e.g. by the National Institute of Standards and Technology (NIST), describe cloud computing as "[…] a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g. networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction." Cf. Mell and Grance (2011).
263 Fundamentally, three different categories of service models can be distinguished: Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS). Cf. Federal Office for Information Security (2015).
264 This is also confirmed by the results of the business survey on the 'Information Economy' conducted by the ZEW in 2014. There is a lot of overlap between the industries of the digital economy and the information economy as defined by the ZEW. Cf. Rammer et al. (2016: 123ff.).
265 Cf. BITKOM (2014). The study is based on a survey of approx. 500 companies.
266 In the BITKOM study (2014), SMEs are defined as companies with more than 50 and fewer than 500 employees. Companies with more than 500 employees are counted among large-scale companies.
267 Cf. TCS (2013). In the survey of more than 1,200 companies worldwide, big data was defined as "the collection, processing and usage of large volumes of digitised data to improve how companies make important decisions and operate the business." The survey was conducted at the end of 2012 in nine different countries.
268 Cf. http://ec.europa.eu/eurostat/statistics-explained/index.php/Cloud_computing_-_statistics_on_the_use_by_enterprises (last accessed on 5 January 2016).
269 Cf. i.a. Monopolkommission (2015: 13, 192). For example, a working group has been constituted at the

GRUR (German Association for the Protection of Intellectual Property) to discuss issues of data ownership in the context of new business models. It also considers the benefits and costs of creating new property rights.

270 Market abuse proceedings against Alphabet are pending both at the European Commission's Directorate General for Competition and at the Federal Trade Commission (FTC) in the USA. They relate in particular to Alphabet Inc. shopping portals and the Android operating system, among other things for discrimination against the apps of other manufacturers in the company's own sales portal.

271 Cf. Monopolkommission (2015) and Münchner Kreis e.V. (2014).

272 Cf. Initiative D21 (2015).

273 For example, the General Data Protection Regulation both strengthens the rights of the consumer and tightens up the accountability obligations of companies in the context of data collection and exploitation. Cf. http://deutschland.taylorwessing.com/de/eu-datenschutz-grundverordnung-ds-gvo-steht (last accessed on 5 January 2016).

274 For example, Microsoft intends to set up its own European locations in the wake of the changed regulatory situation.

275 Cf. http://europa.eu/rapid/press-release_IP-15-4919_en.htm (last accessed on 5 January 2016).

276 Cf. http://blog.cebit.de/2015/03/16/industrial-data-space-sicherer-datenraum-fuer-kleine-und-grosse-unternehmen/ (last accessed on 5 January 2016).

277 Cf. Haucap and Heimeshoff (2013). Multihoming is a form of behaviour in which users with heterogeneous preferences are active online on several competing platforms at the same time.

278 A current ranking by the European Commission puts Germany only in 10th place among the member states. A different ranking of leading global economies has Germany only in 9th position. Cf. inter alia https://www.accenture.com/de-de/company-newsroom-germany-may-miss-digitization-connection.aspx and http://europa.eu/rapid/press-release_IP-15-4475_de.htm (last accessed on 5 January 2016).

279 A recent study estimates the global economic potential of the Internet of Things at between 3.9 and 11.1 trillion US dollars in 2025. The potential of the sub-areas that are emerging in the context of Industry 4.0 amounts to only about half of the total potential of the Internet of Things, i.e. to a target corridor of approximately 2.0 to 5.6 trillion US dollars. Cf. McKinsey & Company (2015a).

280 The Commission of Experts is not alone in this assessment. Cf. Reiss (2015).

281 Cf. http://www.plattform-i40.de/I40/Navigation/DE/Home/home.html (last accessed on 5 January 2016). The Federal Government has promised funds totalling 200 million euros for Industry 4.0. 120 million euros of this is to come from BMBF funds. The priorities of the funding are the realignment of microelectronics, reference architectures for Industry 4.0, support for the implementation of Industry 4.0 in SMEs, and the creation of reference projects on IT security. Cf. https://www.bmbf.de/de/bdi-forschungsfruehstueck-1255.html (last accessed on 5 January 2016).

282 The BMBF will provide funding for the new research framework programme for IT security amounting to around 180 million euros up to 2020. Cf. https://www.bmbf.de/de/sicher-in-der-digitalen-welt-849.html (last accessed on 5 January 2016).

283 In the first four years, the BMBF is to provide almost 100 million euros in funding within the framework of the funding concept for medical informatics. Cf. https://www.bmbf.de/pub/Medizininformatik.pdf (last accessed on 5 January 2016).

284 Cf. http://www.bmwi.de/BMWi/Redaktion/PDF/I/infopapier-fortschritte-umsetzung-digitale-agenda,property=pdf,bereich=bmwi2012,sprache=de,rwb=true.pdf (last accessed on 5 January 2016).

285 The BMBF is supporting the initiative with three years of funding promotion. Cf. http://www.fraunhofer.de/de/forschung/fraunhofer-initiativen/industrial-data-space.html# (last accessed on 5 January 2016).

286 The BMBF is providing up to 50 million euros for this purpose over the next five years. Cf. https://www.bmbf.de/de/startschuss-fuer-das-neue-internet-institut-1336.html (last accessed on 5 January 2016).

287 According to the planning, the BMBF will increase its total funding for SMEs by about 30 percent to approximately 320 million euros per year by 2017. Cf. https://www.bmbf.de/files/KMU-Konzept_Vorfahrt_fuer_den_Mittelstand_final.pdf (last accessed on 5 January 2016).

288 Cf. EFI (2015: Chapter A 5).

289 For example, surveys conducted by Eurostat in 2012 and 2013 show that German users are at best about average by European comparison when it comes to computing skills (such as unpacking files, installing software or using programming languages) and lower down the table on the subject of internet skills (e.g. creating a website and using internet telephony or file-sharing services). Cf. http://digital-agenda-data.eu/ (last accessed on 5 January 2016).

B 4

290 Speyer definition on e-government.

291 Cf. McKinsey & Company (2015b).

292 According to a study by the Local Government Joint Office for Administrative Management (KGSt), about 70 percent of core processes in Germany's cities and municipalities show potential for optimisation by e-government. Costs could be cut by about 20 to 40 percent. Cf. KGSt (2011).

293 Cf. http://www.vemags.de/ (last accessed on 5 January 2016).

294 Cf. Ministry of Government Administration and Home Affairs (no date).

295 Cf. Bahrke et al. (2016), Slapio et al. (2013) and Bundesregierung (2001).

296 Examples from: McKinsey & Company (2014).

297 Example of South Korea: e-participation portal http://www.epeople.go.kr/ (last accessed on 5 January 2016) or Ministry of Government Administration and Home Affairs (no date).

298 Effective e-government (i.e. optimising the 60 most important administrative services) ideally requires initial

investment of at least 1.7 billion euros for development and five subsequent years of operation. According to the study, in view of annual IT costs amounting to 13 billion euros, the amount could be financed without problems from the current budget. Cf. Fromm et al. (2015: 3ff.).

299 Cf. Bahrke et al. (2016).

300 Example of South Korea: a research project used open government-data principles to examine to what extent experience with corporate start-ups influences the likelihood of start-ups surviving. Cf. lecture by Prof. Ryu at a workshop at Seoul National University on 22 September 2015. Example of Denmark: the internet-based Danish Healthcare Data Network, set up as part of Denmark's e-health programme, allows a structured exchange of information between all players in the health sector and provides data for research. Cf. Danish Government et al. (2013).

301 According to the UN Web Measure Index, Germany is ranked 21st behind Estonia (15th), Finland (10th), the USA (7th) and South Korea (1st). Cf. United Nations (2014b: 195). This means that Germany's position has worsened over the last few years. Germany was still ranked 15th in 2010. Cf. OECD (2015e: 151ff.), European Commission (2015a), European Commission (2015b), European Commission (2015c).

302 Cf. IT-Planungsrat (2010: 2).

303 Every two years since 2001, the United Nations has been publishing its United Nations E-Government Survey, which tracks the e-government status of 193 states on the basis of the so-called E-Government Development Index (EGDI). This index is made up of three equally weighted sub-indices: (i) the Web Measure Index, (ii) the Telecommunications Infrastructure Index, and (iii) the Human Capital Index. While Germany shows no significant deficits in (ii) and (iii) compared to the reference countries, its performance is poor in (i). Cf. United Nations (2014b: 195).

304 Cf. United Nations (2014b).

305 In Stage 2, forms can be downloaded as e-documents and requests made for documents that are not available or for more information.

306 Examples of Stage 4 services: services specifically tailored to certain groups and individuals, apps for online ballots, citizen surveys and discussion forums, apps for online voting at elections.

307 "Particularly worthy of mention is South Korea's completely digital administration with advanced government-to-citizens (G2C) and government-to-business services (G2B). Furthermore, there is a multi-channel communication and transaction system to serve the diverse needs of citizens and businesses in the best way possible. (…) This system is based primarily on sophisticated central e-government portals like the ones that Finland and Estonia are also increasingly developing" (Bahrke et al. 2016).

308 For information on methodology, cf. United Nations (2014b: 191ff.).

309 Cf. European Commission (2015a), European Commission (2015b), European Commission (2015c).

310 The term transparency covers the following meanings: transparency of processing processes and transparency with regard to access to data and the use and forwarding of data.

311 Cf. Slapio et al. (2013: 128ff.).

312 The E-Government Monitor is a study published by the Initiative D21 and the Institute for Public Information Management (IPIMA). Since 2010, the E-Government Monitor has been providing a comprehensive, annual picture of the use and acceptance of e-government services in Germany, comparing them with Austria, Switzerland and Sweden. In the 2015 edition, the focus is on the population's expectations for specific online citizen services. The E-Government Monitor polls people who use the internet about whether they use e-government services and, if so, which ones. The results of the survey show that although many people use e-government services, they do not regard them as a component part of e-government. This leads to the paradoxical situation that only 39 percent of the respondents say they used e-government services in the previous year, while at the same time 71 percent state that they have already accessed the services mentioned in a prescribed list. Cf. Initiative D21 and Institute for Public Information Management (2015).

313 Cf. http://ec.europa.eu/digital-agenda/en/news/eu-egovernment-report-2014-shows-usability-online-public-services-improving-not-fast (last accessed on 5 January 2016).

314 Written statement by M. Bahrke (IW Consult) dated 23 October 2015.

315 Cf. www.bund.de (last accessed on 5 January 2016).

316 Together with the EU member states, the European Commission defines 20 services that are of key importance for citizens and businesses in its E-Service Initiative.
Citizens: tax declaration, job seeking by the employment office, social security benefits, personal documents, car registration and de-registration, building permits, police reports, certificates/documents, university enrolment, registering a change of residence, health services, public libraries.
Companies: social security contributions for employees, corporation tax declaration, business start-up and registration, transfer of data to statistical offices, customs declaration, environmental permits, public procurement. Cf. European Commission (2001).

317 Only 30 percent are satisfied with the transparency of e-government services, compared to 63 percent in Finland, 75 percent in Estonia and an EU average of 48 percent. In the surveys, transparency covers the following dimensions: "transparency indicates to what extent governments are transparent regarding: a) their own responsibilities and performance, b) the process of service delivery and c) personal data involved." Cf. European Commission (2014).

318 Vodafone Institut für Gesellschaft und Kommunikation GmbH (2014: 11).

319 Cf. Slapio et al. (2013: 117ff.).

320 Cf. Slapio et al. (2013: 128ff.). According to a survey by the Bearing Point business consultancy, 85 percent

of the companies asked said that a lack of knowledge of e-government services represented a medium to very large challenge. Cf. Schmid et. al (2014).

321 While the approval rate for user centricity in regular business operations is 90 percent in Finland, 95 percent in Estonia and 80 percent on average across the EU, it is only 66 percent in Germany. Cf. European Commission (2014).

322 Utilisation rates by companies and citizens in Germany are below the OECD average. Cf. Bahrke et al. (2016).

323 The international comparative analysis shows that use of online services is highest in countries that provide a comprehensive, fully digitised service that is structured in a user-friendly way. Cf. Bahrke et al. (2016).

324 Information on e-government services in Germany: Medical treatment costs are paid out automatically; no application is necessary. Student loan: online forms for an application must be downloaded and be filled in online, but then handed in to the corresponding institution. Passport and ID: applications are made to an authority in the respective federal state; the applicant must appear in person, online applications are not possible; minors require their parents' application, which must be downloaded. University enrolment: applications are mostly available via online platforms, but often still need to be sent in by post (for example at the BTU Cottbus). The ZVS, too, has no central portal. Registering a change of residence: the responsibility is at the Länder level. Although many have online application services, applicants must still appear in person. Certificates/documents: here, too, the responsibility is at the Länder level. Although many have online application services, applicants must still appear in person. Information on e-government services in Finland: Child allowance is paid automatically as soon as the child is born. The responsible office receives a corresponding notification from the hospital; no action is required by the parents. Sick pay: applications that can be filled in and printed out online are available on the website. Passport/ID: applications are made at the police station, where the application can be made online. Certificates/documents: not relevant, not customary; everything can be viewed online. Health services: mainly serve information purposes; many municipalities also offer online services. Written information from M. Bahrke (IW Consult) dated 3 December 2015, as well as European Commission (2015a), European Commission (2015b), European Commission (2015c).

325 Cf. BMI (2014). Data that are subject to data-protection regulations or sensitive for security reasons include personal data – i.e. data containing information about individual people – and trade and business secrets. Cf. http://daten.berlin.de/glossar (last accessed on 5 January 2016).

326 Bundesregierung (2014: 19).

327 The following principles are laid down in the G8's Open Data Charter:
– Releasing high-quality, up-to-date and well described open data;
– Releasing as much data as possible in as many open formats as possible;
– Releasing data for improved, responsible governance;
– Sharing expertise and creation of transparency on data collection, standards and publishing processes;
– Releasing data for innovation;
– User consultation and support for future generations of people with ideas. Cf. BMI (2014: 4).

328 The Action Plan names concrete commitments to be implemented step by step by the end of 2015. The Action Plan also serves the implementation of the Coalition Agreement, according to which the federal administration is supposed to become a pioneer in the provision of open data. As a measure implementing the E-Government Act, it is part of the government's Digital Management 2020 programme. Cf. http://www.bmi.bund.de/DE/Themen/Moderne-Verwaltung/Open-Government/Regierungs-Verwaltungshandeln/regierungs-verwaltungshandeln_node.html (last accessed on 5 January 2016).

329 The GovData data portal is a multi-level metadata portal where the administrative data of the Federal Government, Länder and municipalities can easily be found and re-used. The data include geodata, as well as statistical and environmental data. Cf. http://www.bmi.bund.de/SharedDocs/Pressemitteilungen/DE/2015/01/datenportal-govdata-auf-dem-weg-in-den-regelbetrieb.html (last accessed on 5 January 2016).

330 In order for data, especially administrative data, to be really open, a number of different criteria need to be met. The criteria normally used are: completeness, primary sources, proximity in time, easy access, machine interpretability, non-discrimination, use of open standards, licensing, durability, usage costs. Cf. Klessmann et al. (2012: 36) and https://netzpolitik.org/2013/konsequent-kein-open-data-portal-im-bund/ (last accessed on 5 January 2016).

331 In order to facilitate the use of public information – also for commercial purposes – in May 2015 the Bundestag passed an amendment to the Act on the Re-Use of Public Sector Information in accordance with European legislation on the re-use of public sector information (PSI Directive). The latter states that information that citizens have received under the information access laws – such as the Environmental or Consumer Information Act (UIG, VIG) or the federal (IFG) and Länder freedom-of-information acts – can now also be used freely and, for example, published on the internet. The commercial use of such data is also expressly allowed and, in future, will no longer require permission from the authorities, unlike the previous Act on the Re-Use of Public Sector Information (IWG). Cf. http://www.heise.de/newsticker/meldung/Bundestag-ebnet-Weg-fuer-Verwendung-oeffentlicher-Informationen-2638583.html and http://www.bundesregierung.de/Content/DE/Artikel/2015/02/2015-02-11-kabinett-informationsweiterverwendungsgesetz.html (last accessed at the 5 January 2016).

332 Joint declaration: finally setting the standard to 'open'! Cf. http://not-your-govdata.de/ (last accessed on 5 January 2016). A comprehensive manual and partially automated analysis commissioned by the BMI makes it possible to assess the quality of the German open-data portal and to check compliance with the above-mentioned standards.

D

The evaluation showed, among other things, that only 1,759 of the 4,539 data sets found can really be classified as 'open'; 2,780 have the potential to be classified as 'open', but not are sufficiently machine-interpretable, or are not re-usable at least for non-commercial – at best for commercial – purposes free of charge. Cf. Klessmann et al. (2012).

333 The great majority, around 80 percent, of the data sets at the federal level and 90 percent at the Länder level are only available in PDF format. Cf. Klessmann et al. (2012: 384 and 402).

334 Cf. Bahrke et al. (2016) and the 17th session of the IT Planning Council, decision no. 2015/19: 'GovData – Dealing with regional and local authorities that do not participate in funding', http://www.it-planungsrat.de/SharedDocs/Sitzungen/DE/2015/Sitzung_17.html?pos=6 (last accessed on 5 January 2016).

335 Bahrke et al. (2016).

336 As early as 2000, the Federal Government undertook to put all internet-enabled services of the federal administration online by 2005. Cf. Bundesregierung (2001). Because Germany's federal structure requires such complex coordination, the IT Interstate Treaty (IT-Staatsvertrag) was passed in 2010 to set up an IT Planning Council, a central body designed to coordinate cooperation between the Federal Government, the Länder and the municipalities in the field of information technology. The foundation for the development of e-government in Germany was laid by the National E-Government Strategy, adopted by the IT Planning Council in September 2010, which lays down plans for forging ahead with the digital processing of administrative affairs and strengthening division of labour between the Länder and interdisciplinary cooperation. The E-Government Strategy is based on the EU's Malmö Declaration, which states that citizens and companies shall by 2015 receive e-government services which are user-centred, raise the transparency of government actions, facilitate information about and participation in government action, and enhance the level of mobility in the European internal market. Cf. Deutscher Bundestag (2012). The specific legal form was finalised with the E-Government Act, which came into force on 1 August 2013. The law commits the administration, among other things, to opening an electronic channel (of communication), and in addition commits the federal administration to open De-Mail access. It also makes it easier to furnish electronic proof and to make electronic payments in administrative procedures. Furthermore, it includes principles on electronic file management as well as rules on the provision of machine-readable data sets by the administration (open data). Cf. http://www.bmi.bund.de/DE/Themen/IT-Netzpolitik/E-Government/E-Government-Gesetz/e-government-gesetz_node.html (last accessed on 5 January 2016). Measures for the implementation of the E-Government Act and the framework for the 'administration of the future' were formulated in the Digital Administration 2020 government programme in September 2014. These measures include the commitment to set up digital access to the administration, to keep digital files, and to provide public data in machine-readable form (open data). In addition, in its Digital Agenda 2014-2017 the Federal Government formulated a framework for its actions in the context of the digitisation of all areas of life and the economy by again emphatically embracing the development of e-government and open data. Cf. Bundesregierung (2014: 19ff.).

337 Cf. European Commission (2015a), European Commission (2015b), European Commission (2015c); OECD (2015); Initiative D21 and Institute for Public Information Management (2015), as well as United Nations (2014a).

338 Cf. Deutscher Bundestag (2012: 59).

339 Cf. http://www.it-planungsrat.de/DE/ITPlanungsrat/RechtlicheGrundlagen/rechtliche_grundlagen_node.html (last accessed on 5 January 2016).

340 The task of fleshing out the laws in detail is carried out at the Länder level, for example by adjusting laws on administrative procedure. The Länder governments formulate the rules for the development of e-government at the Länder, district and municipal levels. Cf. Bahrke et al. (2016).

341 Cf. http://www.it-planungsrat.de/DE/ITPlanungsrat/RechtlicheGrundlagen/rechtliche_grundlagen_node.html (last accessed on 5 January 2016).

342 Cf. http://www.it-planungsrat.de/DE/Projekte/Ma%C3%9Fnahmen/eGovernment_Gesetz/egovernment_gesetz.html?nn=2708422 (last accessed on 5 January 2016).

343 Cf. http://www.lvstein.uni-kiel.de/t3/index.php?id=82&no_cache=1 (last accessed on 5 January 2016).

344 Bahrke et al. (2016).

345 "In addition, the joint organisation shall provide services for IT collaborations of the IT Planning Council. In particular, it shall make it possible for Federal and Länder governments to perform tasks together, wherever this is expedient and in line with needs." Cf. Die Beauftragte der Bundesregierung für Informationstechnik et al. (2015).

346 IT-Planungsrat (2010: 2).

347 Cf. http://www.bundesregierung.de/Content/DE/Artikel/2015/11/2015-11-02-merkel-vdz-publishers-summit.html (last accessed on 5 January 2016).

348 The Federal Government refers in this context to a study commissioned by the European Commission, which quantifies the economic potential of open data in the EU at up to 40 billion euros per annum. Cf. http://www.verwaltung-innovativ.de/DE/E_Government/Open_Government/Open_Government_node.html (last accessed on 5 January 2016).

C

349 The systematic selection of international reference countries is based i.a. on the size of the economies and national R&D intensity in the OECD and BRICS countries.

C 1

350 Cf. Cordes and Kerst (2016).

C 2

351 Cf. https://www.destatis.de/DE/ZahlenFakten/GesellschaftStaat/BildungForschungKultur/ForschungEntwicklung/ForschungEntwicklung.html (last accessed on 5 January 2016).
352 Cf. Schasse et al. (2016).

C 3

353 In this regard and in the following, cf. Rammer and Hünermund (2013).
354 In this regard and in the following, cf. Rammer and Hünermund (2016: 6f.).
355 Cf. Blind (2002).

C 4

356 For a detailed discussion of the justification and effects of public R&D funding, cf. Chapter B 4 on the Economic Assessment of Public R&D Funding in the 2012 Report.

C 5

357 Chapter C 5 is based on a study prepared for the Commission of Experts by the ZEW. Cf. Bersch et al. (2016).
358 However, the data from the individual countries are not fully comparable. For more details on this, cf. Müller et al. (2014).
359 In this regard and on individual points, cf. Müller et al. (2013).
360 An original, newly formed company is created when a business activity not exercised before is begun and provides at least one person with their main source of income. A company closure is when a company no longer exercises a business activity and no longer offers products on the market.
361 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

362 Cf. Gruber et al. (2016).
363 Cf. Gruber et al. (2016: 17ff.).

C 8

364 This section and the following figures are based on Gehrke and Schiersch (2016).
365 For a methodical explanation of the RCA indicator, cf. Gehrke and Schiersch (2014: 74).

D

366 Cf. Gehrke et al. (2013).
367 Cf. Simon (1990).

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