

RESEARCH, INNOVATION
AND TECHNOLOGICAL
PERFORMANCE IN GERMANY

COMMISSION OF EXPERTS
FOR RESEARCH
AND INNOVATION

EFI

REPORT

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AND TECHNOLOGICAL
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REPORT 2015

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Foreword

There is little controversy in public debate about the importance of research, innovation and science for employment and prosperity. However, the cause-and-effect relationships are complex, and there is generally a time lag before the results of research and innovation policy can be measured. This makes it all the more important to keep looking at the concrete challenges of research and innovation policy and their long-term implications – even when other tasks seem more urgent in the short term.

As in previous years, the 2015 Report of the Commission of Experts for Research and Innovation is divided into three parts. The A chapters discuss topical issues of R&I policy. Focused analyses are presented in the B chapters. And in the C section, the Report documents the development and status quo in Germany by international comparison using eight particularly relevant groups of indicators.

In Chapter A 1, the Commission of Experts outlines the need for action on policies to secure and advance the results of the Higher Education Pact, the Excellence Initiative and the Pact for Research and Innovation. The lifting of the cooperation ban in the field of higher education was a major success for the Federal Government. The task now will be to make wise use of the new leeway this has created. In Chapter A 2, the Commission of Experts comments on the latest development of R&D expenditure and draws attention to weaknesses in the innovation activities of small and medium-sized enterprises (SMEs). With its new High-Tech Strategy, the Federal Government is further enhancing the overall framework for innovation policy – the Commission of Experts discusses this concept in Chapter A 3. The Federal Government's plans for the Digital Agenda are examined in Chapter A 4. In Chapter A 5, the Commission of Experts again calls for improvements in the framework conditions for venture capital in Germany; this would particularly benefit start-ups in the field of digital technologies.

In the B chapters, the Commission of Experts addresses key challenges for German R&I policy. In Chapter B 1, the Commission of Experts begins by analysing cluster concepts, which have dominated R&I policy in Germany over the past few years. The Expert Committee's review of important German cluster measures comes to a generally positive assessment; however, the review also reveals the limits of cluster funding and advises against a continuation of the Leading-Edge Cluster competition. It urges an evaluation of these measures, including their medium- and long-term effects.

Digitisation and connectedness have a growing impact on the education sector, too, creating new opportunities for teaching courses. In Chapter B 2, the Commission of Experts investigates the potential of MOOCs (Massive Open Online Courses). In its analysis, the Commission of Experts concludes that such courses should in future be perceived with respect to the opportunities they can offer Germany as a location for education. They can represent an important and meaningful complement to existing teaching and research options and an interesting instrument for improving the profile of tertiary education institutions.

In Chapter B 3, the Commission of Experts examines the interaction between copyright law and innovation. Here too, digitisation and connectedness are key drivers of innovative change: productivity and product variety are increasing in the copyright-based industries, and new innovation actors – e.g. user innovators – are entering the market. Up to now, the existing legal framework has not sufficiently taken these developments into account. The regulations on copyright enforcement have not proved their worth. Against this background, the Commission of Experts recommends, for example, facilitating access to information in science and education domains. In addition, the creative redesign and remixing of works should be permissible under certain conditions.

In Chapter B 4, the Commission of Experts analyses the potential of Additive Manufacturing (AM), often also called 3D printing. Today, AM is already an important technological basis for innovation and production processes in industry and has the potential to strengthen industrial production in Germany. In order to make optimum use of AM's potential in Germany, the support measures for AM should be embedded into a stringent overall framework.

The analyses conducted by the Commission of Experts indicate that R&I policy faces numerous challenges. The increased application of digital technologies is having an especially significant impact in several contexts. The Commission of Experts had already drawn attention to the weakness of the German innovation system in this field in its 2014 Report. In order to avoid a situation in which digitisation and connectedness become an Achilles heel of the German economy, the Federal Government must now energetically tackle the objectives it has identified.

Berlin, 25 February 2015



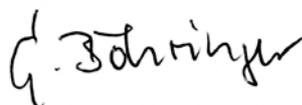
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SUMMARY

Summary

A Current developments and challenges

A 1 Recent trends in science and research policies

In 2014, important strategic steps have been taken in the area of science and research policies.

In the tertiary education sector, the cooperation ban has been lifted. While the Commission of Experts expressly welcomes this step, it stresses that the rule of unanimity, which is anchored in the German Constitution, in fact gives a right of veto to each of the Länder.

The Federal Government has now taken full financial responsibility for BAföG, Germany's student loan and grant scheme. The Länder governments need to make use of their newly won financial leeway to ensure adequate basic funding for their tertiary education institutions.

The Higher Education Pact, the DFG programme allowance, as well as the Pact for Research and Innovation are being continued further. The Commission of Experts recommends that the Federal and Länder governments agree on a clear and transparent division of tasks with regard to the future financing of teaching. In the medium term, the DFG programme allowance should be aligned more closely with the actual overhead costs incurred. The Commission of Experts further recommends redesigning the current financing model for non-university research organisations by standardising the relevant funding formulas.

The Federal and Länder governments have taken the decision in principle for a new initiative to follow the Excellence Initiative. The Commission of Experts points out that, in continuing the Excellence Initiative, the level of funding for top-level research must remain at least constant. At the same time, institutional funding of Germany's best-performing universities will also have to be maintained.

A 2 Germany's R&D intensity and innovation activities of SMEs

Germany's R&D intensity, i.e., expenditures for internal research and development (R&D) in relation to gross domestic product (GDP), decreased from 2.98 percent in 2012 to 2.85 percent in 2013. While this trend is partially owing to slow growth in the business sector, the decrease is largely attributable to purely statistical effects and should therefore not be overrated. Yet, the Commission of Experts also notes that in order to close the gap on leading innovative nations in the long term Germany will have to commit to a more ambitious target for the year 2020: 3.5 percent of GDP for R&D.

The long-term development of innovation activities of German SMEs is a cause for concern. Although German SMEs recorded growth in terms of employment of engineers and natural scientists, growth rates did not keep pace with those recorded by large companies in the past decade. What is more, between 1995 and 2012, innovation expenditures in relation to turnover decreased considerably among SMEs. The reasons for this have yet to be resolved, and thus it is still unclear how policies should respond. Given the important role of SMEs for employment and economic growth, the Commission of Experts expresses general concern regarding these trends in innovation activities of SMEs. Against this background, the Commission of Experts will address this subject in more detail in upcoming Annual Reports.

A 3 The new High-Tech Strategy – innovations for Germany

On 3 September 2014, Germany's new High-Tech Strategy was adopted by the Federal Cabinet and presented to the public. To put the new High-Tech Strategy into practice, permanent milestones will have to be set swiftly and communicated to the public in a transparent way. A counter-productive overlap with measures from other policy fields has to be avoided. The Commission of Experts urges the Federal Government to continue its path of bundling topic-related support measures – an approach that was introduced at the start of the Strategy's second phase. The Commission of Experts further recommends defining a clear hierarchy of targets also within the priority challenges.

The new High-Tech Strategy places special emphasis on transparency and participatory processes. For this to be achieved, the relevant ministries should experiment, e.g., with internet-based instruments, such as online platforms as tools for gathering ideas and forming opinions.

To identify and rectify any undesirable developments, mechanisms for a systematic monitoring of the High-Tech Strategy should be developed.

A 4 The Federal Government's Digital Agenda

With its "Digital Agenda 2014–2017", the Federal Government has been attaching great importance to the opportunities and challenges emerging from digital change. The Commission of Experts welcomes this commitment.

The Federal Government should swiftly implement the policy goal of providing 50 Mbits/s broadband coverage area-wide. To ensure that Germany's network infrastructure can compete internationally, the supply of a digital infrastructure has to be regularly monitored and adapted according to the changing needs of the business sector. Furthermore, the Commission of Experts believes that it is essential to swiftly develop a consistent package of measures, which should specify how and over which period of time other initiatives from the Digital Agenda are to be implemented and financed. In addition, the Commission of Experts urges the Federal Government to provide legal certainty with regard to data protection; make non-sensitive personal data collected by the public sector accessible for academic research; make stronger use of open standards in public administration; take a leading role in terms of safe transfer of sensitive data, and, finally, advance the development of the Industry 4.0 concept. The implementation of the Digital Agenda requires transparent modes of documentation.

A 5 Framework conditions for venture capital in Germany

Venture capital is an important source of financing for young innovative enterprises. Yet, Germany's venture capital market is far less developed than markets in the United States and many European countries. Germany is an innovation-based economy and thus squanders potential for growth and productivity. Against this background, the Commission of Experts welcomes the fact that the Federal Government is planning several measures to improve the international competitiveness of the framework conditions for venture capital in Germany.

The Commission of Experts particularly welcomes the Federal Government's announcement to revise the restrictive tax regulations for the treatment of carried-over losses. The Federal Government should refrain from introducing a general taxation on capital gains realised upon the sales of free floating shares – a measure that has been called for by various stakeholders. Neither should the Federal Government give in to demands to increase the tax rate on carried interest. Each of these measures would reduce incentives to invest in young innovative firms. In addition, conditions for anchor investors have to be designed in an investment-friendly way. New restrictions regarding the investment opportunities for insurance companies and pension funds must be avoided. The Federal Government's plan to create a fund for growth financing of German start-up businesses via the European Investment Fund (EIF) should be implemented without delay.

B Core topics 2015

B 1 Promoting innovation through cluster policy

Over the past 20 years, a number of cluster initiatives have been launched in both Germany and Europe. The goal of cluster policies is generally twofold: spatial concentration and networking effects. Cluster policies aim to correct market and coordination failures that might hinder the genesis of a cluster and its early development. The great diversity of policy measures in terms of goals, design and implementation makes it difficult to compare and assess the effectiveness of these measures. The choice of appropriate policy measures requires detailed knowledge of externalities and of complementarities in the innovation system.

Against this background, the Commission of Experts recommends the following:

- As the organisational form of a multi-staged technology-open competition has proven successful, future policy initiatives should adopt this organisational form.
- The carefully executed initial evaluation of the Federal Government's Leading-Edge Cluster Competition should be used as a benchmark for also systematically evaluating the great number of regional cluster initiatives.
- The evaluation of the Leading-Edge Cluster Competition has demonstrated the great innovation potential emerging from financing R&D cooperation projects between large companies and SMEs. Such collaborations should therefore also be supported as part of other measures, i.e. beyond cluster policies.
- The Commission of Experts welcomes the introduction of different exchange formats, which will give policy-makers at federal and regional levels and cluster managers the opportunity to share their experience and to learn from each other. These new opportunities should be fully exploited.
- With regard to the clusters supported, the Federal and Länder governments should aim to avoid an excessive focus on regional partners and potential isolation from external stimuli. Cluster initiatives at state level should aim to create transregional net-

works. Against this background, the support programme for the internationalisation of clusters, which was announced by the Federal Ministry of Education and Research (BMBF), advances and complements the Leading-Edge Cluster Competition in a consistent manner.

- If the Leading-Edge Cluster Competition were to be continued further, one can expect that its positive effects will weaken considerably. The Commission of Experts therefore advises against continuing the Leading-Edge Cluster Competition beyond the third funding round.
- The Commission of Experts further calls for an evaluation of the medium- and long-term effects of the Leading-Edge Cluster Competition. To assess the effects of funding in an objective manner, systematic monitoring should be implemented. This will also require the collection of data beyond the funding period.

B 2 MOOCs: an innovator in the educational sector

Since 2013, the risks of Massive Open Online Courses (MOOCs) have been the subject of lively debate in Germany, while the potential has been largely disregarded. Looking forward, the potentials of MOOCs should be taken into account to a greater extent. MOOCs are an important, valuable supplement to the teaching and research instruments currently used in Germany's colleges and universities.

MOOCs could lower the burden of colleges and universities in supplying standard knowledge and create leeway for more research-related teaching. The use of externally created MOOCs provides small colleges and universities in particular with opportunities for improving their study programmes. MOOCs can create positive reputation effects for the colleges and universities producing them and for Germany as a location for education and research.

MOOCs can facilitate students in organising their studies. What is more, MOOCs provide easier access for working professionals involved in life-long learning and for secondary school students seeking orientation. The broad range of goals MOOC participants pursue sheds new light on the debate on low graduation rates for MOOCs; a debate that has been highly critical at times. In fact, many MOOC participants do not aim at obtaining a course certificate at the very start but rather focus on other objectives such as guidance in their choice of studies or acquiring the relevant German terminology in their given field.

The Commission of Experts wishes to make the following recommendations:

- All tertiary education institutions should examine new models of combining different forms of learning and teaching in depth.
- It might not make sense for every college and university to create its own MOOCs. Those engaging in their own MOOC production should do this as part of an overall strategy with clearly defined objectives.
- Public funding for the creation and use of MOOCs can be useful in cases where an increase in expenditure can be justified by quality improvements.
- The ministries in charge of financing tertiary education institutions should not use the integration of MOOCs as a justification for depriving tertiary education institutions of their financial resources for teaching.
- The public sector should create a legal framework that allows individual colleges and universities to experiment with MOOCs. This may include areas such as admission to studies, development of study programmes, financing keys, copyright, teaching loads, remuneration, credit points and financing of universities.

B 3 Digital innovation and the need for reform of copyright law

Literary, scientific and artistic works are protected by copyright law. Activities relating to copyright have economic and societal relevance. Copyright protection granted for a relatively short term generates incentives for innovation as evidenced in the economic literature. While the use of digital technologies facilitates illegal copying of existing works, it also reduces the costs of creating and disseminating new creative works: productivity and product diversity in the copyright industries increases, and new innovation actors, among them user innovators, enter the market. The current legal framework does not adequately account for these developments, and regulations for the enforcement of copyright have not proven successful.

The Commission of Experts therefore recommends the following:

- The creative redesign of works should be permitted in order to set incentives for user innovations. Redesigns should be permissible based on an exemption from law, provided that an inherent difference from the original work is maintained, and provided that the redesign is non-commercial.
- Access to scientific findings should be simplified. To achieve this, a general exemption to copyright for scientific and education purposes should be introduced, thereby providing practicable regulations for the broadest possible access to the stock of knowledge. This exemption from law should be complemented by compulsory compensation. The current complex rules of German copyright for the domain of science have to be simplified.
- The current copyright regulations are very complex and therefore oppose a greater public acceptance of the law. The Commission of Experts therefore urges the Federal Government to simplify the copyright provisions as part of their ongoing reform efforts. These steps should also be flanked by policy measures that improve awareness among users and increase the transparency of copyright law.
- Sending violation alerts is a useful alternative to the common practice of issuing formal warnings. Violation alerts can help inform about rights violations and create transparency. A legal claim for reimbursement of the costs of a formal warning should be tied to the condition that a prior violation alert has been sent via the internet service provider to the infringer.

B 4 Additive manufacturing (“3D printing”)

Due to its versatile applications, additive manufacturing (AM) is a much-debated technology that is thought to have a disruptive potential. Even at this stage, AM provides an essential technological basis for innovation and production processes in industry. AM can strengthen Germany as an industrial location, limit the shift of added value and employment to other countries and even relocate added value processes to Germany.

To fully harness the potential of AM in Germany, the Commission of Experts recommends the following:

- Interdisciplinary research collaboration (e.g. with material sciences and nanotechnology) at higher education institutions and non-university research institutions should be strengthened via appropriate measures, and technology transfer to businesses should be supported further.
- In the context of promoting Industry 4.0, the potential of AM should also be pursued further.
- To reduce information costs and to overcome lock-in effects, the diffusion of AM technologies may require support on the demand side. This may include a stronger focus on AM in best practice examples for Industry 4.0 and Smart Services to be showcased

in the competence centres, which have been announced by the Federal Government as part of the Digital Agenda.

- Support measures for AM should be embedded in a consistent overall framework. Current support measures for AM are being provided detached from each other and not in a systematic way.
- Unresolved legal issues relating to AM, such as liability, have to be clarified without delay in order to increase legal certainty for innovators.
- The Federal Government should set stronger incentives for developing quality standards and for testing and certification activities in the area of AM designs, materials and products.
- European and non-European cooperation in the fields of AM research and standardisation should be promoted to a greater extent.
- Skills in the use of AM should be taught across the vocational education and training system. AM technologies should be broadly employed not only in the higher education sector, but also in vocational training and in schools. Teaching staff and vocational trainers should receive relevant training in parallel.

CURRENT
DEVELOPMENTS
AND
CHALLENGES



A 1 Recent trends in science and research policies

In its 2014 Report, the Commission of Experts submitted recommendations on funding tertiary education institutions and further developing the reform initiatives.¹ Since then, important decisions have been taken in the field of science and research policies. In this context, the Commission of Experts sees progress in some areas, but also the risk of undesirable developments in others.

Cooperation ban lifted in the tertiary education sector

The two German houses of parliament have decided to lift the cooperation ban in the tertiary education sector that was introduced in the context of Federalism Reform I. Federal funding is currently restricted to projects with strictly defined content and a time limit. The new Article 91b, paragraph 1 of the German constitution (Basic Law) stipulates that “the Federation and the Länder may mutually agree to cooperate in cases of supraregional importance in the promotion of science, research and teaching”. This makes it possible for the Federal Government to provide long-term institutional funding for tertiary education institutions, individual institutes and institute associations.² According to the Federal Government, corresponding agreements between the Federal and Länder governments aim to “set common priorities and cultivate profiles with which to improve the performance and excellence of the German knowledge landscape, both overall and at the leading edge”.³ Each agreement requires the consent of all the Länder.

The Commission of Experts expressly welcomes the lifting of the cooperation ban, a measure it had repeatedly called for in past reports.⁴ This will create new opportunities for advancing the development of the German science system. However, the Commission also stresses that the rule of unanimity, which is anchored in the German Constitution, in fact gives a right of veto to each of the Länder.

Federal Government takes full financial responsibility for BAföG

As from 1 January 2015, the Federal Government has taken full financial responsibility for BAföG, Germany’s student loan and grant scheme, which had until then been financed jointly by the Federal and Länder governments. According to the Federal Government’s calculations, this will reduce Länder expenditure by approximately EUR 1.17 billion per annum. In May 2014, Federal and Länder representatives agreed that the Länder should use the freed-up funds to finance expenditure on education in the fields of higher education and schools.⁵

The Commission of Experts proposes dividing the freed-up funds between tertiary education institutions and schools according to the amounts of assistance currently paid out to tertiary and secondary-school students. This would mean that over two-thirds of the freed-up funds would go to tertiary education institutions.⁶ In September 2014, the Institute for Education and Socio-Economic Research and Consulting (FiBS) analysed current planning in the 16 Länder. One of the study’s findings indicates that many Länder have a lower estimate than the Federal Government of the sums that will be released and must be spent on tertiary education institutions and schools. Furthermore, few of the Länder intended to allocate the majority of the funds to the higher education sector.⁷ Individual Länder also planned to use the freed-up funds for early childhood education.⁸ However, this would violate the agreements between the Federal Government and the Länder to use the funds for higher education and schools.

The Commission of Experts is concerned that individual Länder governments will be governed by considerations of election strategy and might not permanently allocate enough of the freed-up resources to the urgently needed improvement of basic funding for tertiary education institutions.

Higher Education Pact and Pact for Research and Innovation to be continued

In December 2014, the Federal Government and the Länder decided to continue the Higher Education Pact, the DFG programme allowance and the Pact for Research and Innovation.⁹

The new agreement between the Federal and Länder governments on the Higher Education Pact plans to finance places for 760,000 more first-year tertiary students in the 2016–2020 programme phase compared to the 2005 level.¹⁰ Another aim here is to give a larger number of qualified professionals access to higher education. The Federal and Länder governments are earmarking about EUR 19 billion for this programme phase. 10 percent of this sum is to be spent on measures designed to reduce university drop-out rates.

The Commission of Experts welcomes the Federal Government's financial participation in teaching at tertiary education institutions. In addition to this, a clear and transparent division of tasks should be agreed between the Federal and Länder governments. The Federal Government should concentrate in particular on tasks that are of nationwide interest. One such task, for example, might be training foreign students for the German labour market in order to counteract the effects of demographic change. The Federal Government could therefore co-finance training costs for foreign students.¹¹ The Swiss model is also of interest in this context. There, the central government pays a certain amount for each foreign student in the context of the contributions made by the government to the operating costs of cantons with a university.¹²

The Commission of Experts had proposed a package of measures to reduce the drop-out rate in its 2010 Report,¹³ and drew up measures for improving access to degree courses for people with vocational qualifications in its 2012 and 2014 reports.¹⁴

The DFG programme allowance, which represents the second pillar of the Higher Education Pact, will also be granted during the 2016–2020 period, and increased by two percentage points to 22 percent of the direct project costs.¹⁵ The Federal Government will continue to finance 20 percentage points of this 22 percent; the Länder will co-fund the DFG programme allowance for the first time, providing the additional two percentage points.

The Commission of Experts initially welcomes the fact that the DFG programme allowance will continue

beyond 2015. However, it still considers an increase of two percentage points to be insufficient to cover the actual overhead costs.¹⁶

The Pact for Research and Innovation is also to continue in the period from 2016 to 2020.¹⁷ During this phase, the allocations to the DFG and the four large non-university research organisations – FhG, HGF, MPG and WGL – will be increased by three percent per annum. This financial growth totalling EUR 3.9 billion will be financed by the Federal Government alone. The Pact for Research and Innovation lays down research-policy goals – e.g. networking within the science system, deeper international and European cooperation, more exchanges between science on the one hand and the private sector and society on the other, and the task of winning the best minds for German science. The Commission of Experts' assessment is that the continuation of the Pact for Research and Innovation ensures that the science and research organisations will receive the planning certainty they urgently need. Because the increase is being paid exclusively by the Federal Government, this will mean a shift in the percentages funded by the Federal and Länder governments. The Commission of Experts again calls for the standardisation of funding formulas for the non-university research organisations.¹⁸ This would make it easier to achieve a further increase in collaborations, both among the non-university research organisations and between non-university research organisations and tertiary education institutions.

Plans for a programme to succeed the expiring Initiative for Excellence

In December 2014, the Federal and Länder governments took a decision in principle for a new initiative to follow the Excellence Initiative; the aim was to “sustainably strengthen Germany as a centre for research, improve its international competitiveness and continue the successful development aimed at training top performers in research and raising the broad-based quality of Germany as a location for higher education and science”.¹⁹ The Federal and Länder governments plan to use the new constitutional leeway in the implementation of the new initiative.²⁰ In addition to promoting novel projects, the aim is to open up future prospects for successful Excellence Initiative projects. Furthermore, projects that have only been receiving funds since 2012 under the Excellence Initiative are to be given a chance of a second funding phase. As early as September 2014, a commission of

international experts was set up by the Federal Government and the Länder to evaluate the Excellence Initiative, which expires at the end of 2017.²¹ This body will present its findings at the beginning of 2016. The basis for the evaluation will be a data-based report on the Excellence Initiative's progress to be prepared by June 2015 by the DFG and the German Council of Science and Humanities (Wissenschaftsrat). The Joint Science Conference (GWK) will then submit a concept for the detailed design of a new initiative in June 2016.²² The aim is for this initiative to be launched by the end of 2016 and to be fully operational as from 2018.

According to the decision in principle made by the Federal and Länder governments, the new initiative aims to offer a range of differentiated funding opportunities that will help the tertiary education institutions to develop technical and strategic profiles, strengthen cooperation between higher-education institutions in regional associations, networks or new institutional forms, and promote cutting-edge research in universities.²³ The Commission of Experts has already spoken out on several occasions in favour of greater horizontal and vertical differentiation of tertiary education institutions; it therefore welcomes the promotion of enhanced profiling by Federal Government and the Länder.²⁴ In principle, the Commission of Experts also supports the promotion of the above-mentioned forms of cooperation. However, support for such cooperation must be limited in time and only be given if considerable synergy and efficiency potential is achieved and internationally outstanding research findings are to be expected. Furthermore, the planned promotion of cutting-edge research in universities is essential in order to strengthen Germany's competitive and innovative capacity and to ensure a high level of visibility for the German research system. The Commission of Experts therefore urges that the level of funding for top-level research must remain at least constant.²⁵ At the same time, an internationally visible science system will not be able to get by without "lighthouses". Institutional funding of Germany's best-performing universities will therefore also have to be maintained. As a general principle for all measures, funding should be based on a competitive process.

Recommendations

The Commission of Experts lauds the repeal of the cooperation ban in the tertiary education sector as a major success for science policy that will open up new organisational possibilities. The continuation of the Higher Education Pact and the Pact for Research and innovation, as well as the decision in principle for a new initiative to follow the Excellence Initiative, also represent important steps towards further boosting Germany's performance as a location for research and innovation. Building on these developments, the Commission of Experts formulates the following recommendations:

- Having been relieved of having to pay student loans under the BAföG scheme, the Länder governments need to make use of their newly won financial leeway to ensure adequate basic funding for their tertiary education institutions. The Commission of Experts proposes dividing the freed-up funds between tertiary education institutions and schools according to the amounts of assistance currently paid out to tertiary and secondary-school students, so that over two-thirds of the funds go to tertiary education institutions.
- The Commission of Experts refers to the package of measures recommended in its 2010 Report aimed at reducing student drop-out rates.²⁶
- A clear and transparent division of tasks should be agreed between the Federal and Länder governments with regard to the future financing of teaching at tertiary education institutions. The Federal Government should concentrate on tasks of nationwide interest. For example, it could make a financial contribution to foreign students' training costs.
- In the medium term, the DFG programme allowance should be adjusted to bring it more into line with the actual overhead costs. The BMBF project allowance should be adjusted in a similar way.
- The Federal and Länder governments should support non-university research organisations by standardising funding formulas.
- The level of funding for top-level research must remain at least constant if the Excellence Initiative is continued. At the same time, institutional funding of Germany's best-performing universities must also be maintained.

Germany's R&D intensity and innovation activities of SMEs

A 2

Stagnating R&D intensity

Overall economic R&D intensity – i.e. expenditure on research and development (R&D) in relation to gross domestic product (GDP) – represents an important measure for assessing national innovation systems. R&D intensity in Germany fell from 2.98 percent in 2012 to 2.85 percent in 2013. Most of the decline in R&D intensity was attributable to statistical effects. On the one hand, the system of national accounts was changed. Expenditures on R&D are now treated as investment and no longer as pure expenditure; this leads to an increase in GDP and therefore in the denominator for calculating R&D intensity. Using the new national accounts method of calculating GDP, R&D intensity would have been only 2.88 percent (instead of 2.98 percent) in 2012. On the other hand, the figure reported for internal R&D expenditure is lower, due to a change in reporting in the private sector. Without these purely statistical effects, R&D intensity would have remained approximately constant.

After years of continuously rising R&D intensity in Germany, temporary stagnation is not a cause for alarm. Nevertheless, the development is a warning to politicians to continue making a major effort to support research and innovation.

Differences in the development of R&D expenditure in different industries

In addition to the change in R&D intensity, shifts can also be observed in internal R&D expenditure within the private sector: different industries are developing differently. In mechanical and electrical engineering, as in the previous years, R&D expenditure rose (by 4.6 and 3.6 percent respectively). However, it stagnated in pharmaceuticals and in the ICT sector. In the chemical industry, spending on R&D actually fell by 3.7 percent. It also declined in automotive engineering (by 4.6 percent). However, the above-mentioned

changes in reporting had an impact here, so that, in fact, R&D expenditure is only stagnating in this latter sector. Even so, to date the positive development of the last few years has not continued since 2012.

Shift from internal to external R&D

There was a relatively large increase in R&D expenditure in the sphere of professional, scientific and technical services: 13.3 percent between 2012 and 2013. The development in the number of R&D personnel employed in these sectors followed a similar course: between 2012 and 2013, employment in R&D rose by 16.1 percent – from approx. 29,900 to approx. 34,700 in terms of full-time equivalents. Parallel to this, there was a shift from internal to external R&D activities in many industries. This development was mainly due to the fact that many companies do less R&D internally, preferring to commission it to specialized companies, R&D service providers or public research institutions.

Innovation dynamics weakening in SMEs?

Innovations by SMEs are particularly important for growth and employment in Germany.²⁷ In previous reports, therefore, the Commission of Experts already recommended that political decision-makers should pay particular attention to supporting the R&D activities of SMEs.²⁸ The long-term development of innovation activities by German SMEs is a cause for concern.

Analyses conducted on the basis of the Mannheim Innovation Panel (MIP) show that innovation intensity in SMEs,²⁹ i.e. the percentage of a company's turnover that is spent on innovation, almost halved from 2.7 percent in 1995 to 1.6 percent in 2012. Over the same period, innovation intensity in large German corporations rose from 3.0 to 4.5 percent.³⁰ In absolute terms, innovation expenditure by SMEs has only

risen slightly since 1995 and cannot keep pace with the expenditure dynamics of the large corporations.³¹ One of the drivers of this decline is the lower overall level of innovation expenditure by those SMEs that only conduct research occasionally. By contrast, expenditure by SMEs that are continuously engaged in R&D has remained stable over the years.

In order to further analyse this development, the Commission of Experts had commissioned the Institute for Employment Research (IAB) to study trends in German corporate employment relevant to innovation.³² This analysis shows that, on average, the percentage of highly qualified engineers and scientists among the staff of small businesses (with fewer than 100 employees) fell slightly from approximately 2.7 to 2.6 percent between 1999 and 2010. During the same period, the percentage of highly qualified staff rose slightly (from 3.8 to 4.2 percent) in medium-sized companies (100 to 500 employees) and strongly (from 6.0 to 7.1 percent) in large companies (500+ employees).³³ Knowledge intensification in the economy was thus concentrated mainly in large corporations.³⁴

Recommendations

The current decline in R&D intensity should not be over-interpreted. However, it must not be taken too lightly either, because even after adjusting for the statistical effects, private-sector R&D expenditure is no longer following the growth trend of the past years of continuous growth. Nevertheless, the Federal Government's three-percent target for R&D intensity by 2015 in Germany (according to the new statistical method) can still be achieved. However, the Commission of Experts points out, as in its 2012 and 2013 reports, that this is an unambitious target. Other countries like Sweden, Japan and Korea left the three-percent mark behind them a long time ago.

Germany considers itself one of the leading economic and innovative nations and should therefore set its sights in future not on the three-percent target, or on average R&D spending by the OECD countries, but on the R&D intensity of the global leaders. In order to close the gap on leading innovative nations in the long term, Germany will have to commit to a more ambitious target for the year 2020: the Commission of Experts regards 3.5 percent of GDP for R&D as both appropriate and necessary.

The growth rates in the number of engineers and natural scientists employed by SMEs in Germany have not kept pace with those recorded by large companies in the past decade. What is more, innovation expenditures in relation to turnover decreased considerably among SMEs between 1995 and 2012. The reasons for this have yet to be resolved, and thus it is still unclear how policies should respond.³⁵ One possible explanation is that the effects of skilled-labour shortages are much stronger for SMEs than for large corporations. Whatever the reasons, the Commission of Experts expresses general concern regarding these trends and will therefore address this subject in more detail in upcoming Annual Reports.

The new High-Tech Strategy – Innovations for Germany

The new High-Tech Strategy – cutting across ministries and policy areas

On 3 September 2014, Germany's new High-Tech Strategy was adopted by the Federal Cabinet and presented to the public. The strategy process in the field of research and innovation policy (R&I policy), initiated in 2006, is thus entering its third phase.

Overarching policy coordination across ministries and policy areas was a distinctive element of the High-Tech Strategy from the outset and is to be continued in the coming years. In its 2008 and 2010 reports, the Commission of Experts already welcomed the fact that the Federal Government was pursuing the approach of intensifying policy coordination. Inter-ministerial cooperation in the drafting of the R&I policy has been considerably intensified in recent years.³⁶

In the first phase of the High-Tech Strategy (2006 to 2009), the main focus was on key technologies and lead markets.³⁷ Yet even here, reference was made to the need to use new technologies to overcome major societal challenges. These became a priority in the High-Tech Strategy's second phase (2010 to 2013).³⁸ Science has coined the term "new mission orientation" to describe an R&I policy that is geared towards the great societal challenges and thus intends to specifically exert influence on the direction of technological change.³⁹

According to the Federal Government, the new High-Tech Strategy aims to merge the "threads" of the first two phases.⁴⁰ The new High-Tech Strategy is to be further developed into a "comprehensive inter-ministerial innovation strategy".⁴¹ The concept of innovation has been extended and now also includes social innovations.

The new High-Tech Strategy contains five core elements:

- I. Priority challenges with regard to value creation and quality of life
- II. Networking and transfer
- III. The pace of innovation in industry
- IV. Innovation-friendly framework
- V. Transparency and participation.

Priority challenges set policy guidelines

In the new High-Tech Strategy, the policy guidelines associated with the new mission orientation can be found in the core element "priority challenges".

A total of six priority challenges have been defined:

1. The digital economy and society
2. Sustainable economy and energy
3. Innovative world of work
4. Healthy living
5. Intelligent mobility
6. Civil security.

The Federal Government regards the priority challenges as areas "that feature especially dynamic innovation and hold potential for economic growth and prosperity", and as areas "in which we can help address global challenges and thereby enhance the quality of life for everyone".⁴² The priority challenges link up closely with the fields of action of the High-Tech Strategy's second phase. The priority challenge entitled "Innovative world of work", which introduces a new emphasis within the High-Tech Strategy, represents an exception here.

Each of the six priority challenges contain three to eight main points. Against the background of limited financial resources, the question is whether positive effects of relevant magnitude can be achieved in all the main points. The Commission of Experts urges the Federal Government to continue its path of

bundling topic-related support measures – an approach that was introduced at the start of the Strategy’s second phase. The Commission of Experts further recommends defining a clear hierarchy of targets also within the priority challenges.

New funding approaches in the field of networking and transfer

The new High-Tech Strategy targets not only the supply side of knowledge production, but also a rapid demand-side dissemination and application of technologies. A swift transfer of research findings to applications was already an important objective in the first two phases of the High-Tech Strategy.⁴³ In the new High-Tech Strategy, the “Networking and transfer” core element addresses the non-university research institutions and tertiary education institutions as well as companies.⁴⁴ Two new support approaches are announced. The first aims to promote the internationalisation of leading-edge clusters, forward-looking projects and comparable networks. The funds earmarked for this purpose will not, however, be anything like as big as the budget of the Leading-Edge Cluster Competition, which expires in 2017. Another aim is to help tertiary education institutions to try out novel cooperation strategies in their regions and to develop innovative cooperation formats. The first funds are expected start flowing in 2017. As yet, no draft plans for the new measures have been made public.

Broad-based innovation incentives for industry

Unlike the priority challenges, the support approaches of the new High-Tech Strategy bundled in the “Pace of innovation dynamics in industry” core element does not aim to influence the direction of the innovation process. In the sense of an open funding concept, the Commission of Experts welcomes, for example, the fact that the use of the key technologies is no longer geared primarily towards the solution of specific problems within the great societal challenges, as was the case in the second phase of the High-Tech Strategy. Rather, it is a matter of creating broad-based innovation incentives for industry – especially in small and medium-sized enterprises (SMEs). The funding measures here include, for example, the Central Innovation Programme for SMEs (ZIM) and the promotion of innovative start-ups.⁴⁵

Improving the framework conditions for innovation

Incentives for innovation are created not only by launching funding programmes, but also by reducing – often bureaucratic – obstacles that inhibit the development of existing innovation potential. The Commission of Experts is therefore in favour of including the element “Innovation-friendly framework” in the five core elements of the new High-Tech Strategy. In concrete terms, the Federal Government plans the creation of innovation-friendly framework conditions in the fields of public procurement, professionals, innovation funding, technical legal framework and standards, intellectual property rights, open innovation, open access and copyright.⁴⁶ The Commission of Experts regards these fields as highly relevant to social policy; however, it regrets that the Federal Government is not making provisions for improving the overall conditions for funding innovations by introducing R&D tax credits.

Growing importance of transparency and participation

When setting funding priorities, it is important to weigh up the social costs against the benefits of innovations. This involves the problem of coordinating and merging decentrally distributed knowledge of preferences, costs and prices. In principle, this can be achieved by encouraging greater participation by citizens and civil-society actor groups, who have hardly been involved in the formulation of funding priorities or the design of funding policy up to now. Exceptions include the BMBF’s citizen dialogues,⁴⁷ BMG’s and BMBF’s cooperation with the German Alliance of Chronic Rare Diseases (ACHSE) in the development of the National Action Plan for People with Rare Diseases, which was presented to the public in August 2013,⁴⁸ and the development of the Green Economy research agenda, presented in November 2014, which was drawn up in a dialogue process with the main business associations, trade unions, consumer organisations and NGOs.⁴⁹

The new High-Tech Strategy places more emphasis on participatory processes with the core element “Transparency and participation”. The Commission of Experts welcomes the inclusion of further societal groups. In its 2013 Report it had also already come out in favour of resolutely continuing to pursue greater citizen participation in the development of R&I policies.⁵⁰ To date, it is still unclear which would be

the best procedure to reach this objective. As shown by US, European and German examples, the participation of citizens and civil-society actor groups in political processes is increasingly being facilitated by internet-based systems (see Box 1).

Neutral information and transparent processes are necessary to optimise the ability of citizens and affected actor groups to assess the effects of policies and technologies. The Federal Government has begun systematically examining the opportunities and risks of new societal developments and extending the analyses of innovation and technology. In addition, it is planning to further pursue scientific trend research and to develop a comprehensive communication strategy.⁵¹ In the Commission of Experts' view, the aim of these initiatives should be to provide impartial and scientifically founded information on the possible impact of innovations, and on the measures of R&I policy, including its potential effects.

Late launch of the High-Tech Forum

The Science and Industry Research Union (Forschungsunion Wirtschaft-Wissenschaft), in which actors from science and industry were represented, served as an advisory body during the first two phases of the High-Tech Strategy. The Strategy's third phase will also be accompanied by an advisory body – the High-Tech Forum, which is supposed to be made up of civil-society representatives alongside stakeholders from academia and business. The Commission of Experts points out that the Forum's constituent meeting will not be held before spring 2015, leaving only about two years for the body's active work during this legislative term. The opportunity for this body to provide stimuli from an early stage has thus been missed.

Examples of internet-based participation in political processes

USA: Crowdsourcing Ideas to Accelerate Economic Growth and Prosperity through a Strategy for American Innovation

During the process of updating the Strategy for American Innovation, the White House's Office of Science and Technology Policy invited citizens to suggest new initiatives or name areas where there was a need for investment.⁵² Among other things, questions were published on an online platform relating to R&D priorities, developing a well-qualified labour-force potential, and intellectual property rights. Answers could be sent in by a cut-off date in September 2014.

EU: European Commission's consultation processes

The European Commission hosts internet-based consultation processes when it is planning to launch new political initiatives or revise existing pieces of legislation.⁵³ The consultation processes – there have been over 370 since 2001 – are initiated via the "Your Voice in Europe" website.⁵⁴ Citizens, businesses, organisations and government agencies can answer the questions asked within a deadline of at least eight weeks using an online form or by e-mail. The European Commission is supposed to actively seek the participation of the parties affected.⁵⁵ After the deadline has passed, the Commission evaluates the answers and publishes the results either in full or as summaries.⁵⁶

Germany: E-participation as part of the Open Government Strategy

In May 2014, the cabinet of the federal state of North Rhine-Westphalia adopted the Open Government Strategy that had been drawn up by an inter-ministerial working group called "Open NRW".⁵⁷ A key element of this strategy is the increasing public participation, particularly using electronic participatory processes. A standard e-participation software tool has been procured for this purpose.

Box 01

Recommendations

- Unlike the first phase of the High-Tech Strategy, there was a failure to define milestones when formulating the new High-Tech Strategy. To put the new High-Tech Strategy into practice, permanent milestones will have to be set swiftly and communicated to the public in a transparent way.
- The new High-Tech Strategy's innovation concept is extended by the addition of social innovations. The Commission of Experts welcomes this extension. A political clarification of the concept is urgently needed, however, to make it possible to draw up support measures in line with criteria.⁵⁸
- A counter-productive overlap with measures from other policy fields must be avoided in the implementation of the new High-Tech Strategy. For example, the Federal Government's R&I policy should not pursue regional-policy objectives. On the other hand, it may well be desirable for regional policy to develop regional innovation potential.
- The Commission of Experts urges the Federal Government to continue its path of bundling topic-related support measures – an approach that was introduced at the start of the Strategy's second phase. The Commission further recommends defining a clear hierarchy of targets also within the priority challenges. Moreover, despite policy guidelines, the advantages of entrepreneurial competition should be used as a discovery procedure. Even if goals are laid down by the priority challenges, the methods for reaching those goals should be left as open as possible. For example, research-funding policy in the field of alternative drive technologies in the automotive industry should not discriminate between research on high-performance batteries on the one hand, and fuel cells on the other.⁵⁹
- The new High-Tech Strategy provides for an instrument that helps tertiary education institutions to try out novel cooperation strategies within regions and to develop innovative cooperation formats. This instrument should be designed in such a way that it complements the instruments of the Excellence Initiative and its successor initiatives.
- In order to increase transparency and participation, processes should be developed that help citizens and societal groups to express their preferences in an informed manner. For this to be achieved, the relevant ministries should experiment, for example, with such internet-based instruments as online platforms for gathering ideas and forming opinions, since these represent an inexpensive and effective form of communication.
- To identify and rectify any undesirable developments, mechanisms for systematically monitoring the High-Tech Strategy should be developed. In this context, it is necessary to lay down success criteria, evaluation methods, and a concept for possible changes of policy. Among other things, unsuccessful programmes or instruments should be prevented from harming the careers of open-minded and adventurous decision-makers.
- Evaluation processes must also be considered on principle when designing future R&I-policy measures. It is crucial to already collect the data required for evaluation while the measure is being implemented. In addition, not only short-term, but also long-term effects of the funding should be studied.

The Federal Government's Digital Agenda

A 4

The Federal Government's "Digital Agenda 2014–2017" aims to lay the foundations for a successful digital transformation of the economy, science and society. In order to achieve the three core objectives – growth and employment; access and participation; confidence and security – the Federal Government has identified seven key areas for action to meet the challenges of the next few years. These action areas are: (i) Digital infrastructure, (ii) Digital economy and digital workplace, (iii) Innovative public administration, (iv) Shaping digital environments in society, (v) Education, science, research, culture and media, (vi) Building security, protection and trust within society and the economy, and (vii) European and international dimensions of the Digital Agenda. The following three ministries are responsible for implementation: the Federal Ministry for Economic Affairs and Energy (BMWi), the Federal Ministry of Transport and Digital Infrastructure (BMVI) and the Federal Ministry of the Interior (BMI).

The growing digitisation of the knowledge and information society creates permanently high demands regarding the availability and efficiency of internet connections. In its Digital Agenda, the Federal Government formulates the target of using "an efficient mix of technologies to provide ubiquitous broadband infrastructure delivering download speeds of at least 50 Mb per second by 2018", and in this way to "lay the foundation for equal standards of living in rural and urban areas."⁶⁰

The Commission of Experts welcomes the fact that, with its Digital Agenda, the Federal Government is attaching great importance to the opportunities and challenges emerging from digital change. Furthermore, the Commission of Experts agrees with the policy of attaching a high priority not only to the above-mentioned expansion target, but also to interoperability, to strict demands on data security, and to internationally agreed rules on the protection of data privacy. However, its statements lack concrete

implementation plans either on financing the nationwide expansion of broadband access or on a range of regulation issues. In addition, the expansion targets are not ambitious enough, especially with regard to international comparisons: a dynamic adjustment of the expansion target is essential, also in relation to transmission speeds.

High-performance broadband infrastructure is an indispensable determinant of growth

Similar to physical infrastructure, broadband expansion functions as an important determinant of growth in modern economies. The internet enables and complements private-sector activities, and is key to blazing a trail for innovation in industry, in the public sector, and in services. Access to a powerful internet connection is of key importance for many companies when it comes to their present or future choice of location; this applies especially to medium-sized firms, which are often located in rural areas. In other fields, too – be it decentralised healthcare or a politically desired increase in the population's participation in societal decision-making processes – potential depends on a reliable internet connection, regardless of where the people live. One unclear aspect in the Digital Agenda is how the expansion is to be implemented in rural areas, where private-sector financing models are not profitable. The high costs of a politically desirable full provision must be seen in the context of the need to carefully weigh up the benefits and costs of state support measures.⁶¹ In the planned development of a premium fund for broadband network expansion (Premiumförderung Netzausbau),⁶² it is important to ensure that the funding is open to all technologies and that private incentives for investment are not restricted, let alone squeezed out.

Furthermore, the Digital Agenda's objective of nationwide provision with connection speeds of at least 50 Mb per second can only be regarded as an inter-

mediate step to secure Germany's long-term international competitiveness.⁶³ In recent surveys, many companies are already stating that broadband speeds of 50 Mb per second will no longer be fast enough in the foreseeable future.⁶⁴ At the same time, Germany is currently far behind internationally when it comes to last-mile connections (i.e. all the way to a building or a user's home) with the currently most efficient connections: fibre optic cables.⁶⁵ Yet, high-performance internet is an essential basis for Industry 4.0 and innovative online business models.

Challenges caused by the rapid growth of datasets: innovation potential versus data privacy

Growing connectedness in industry, service companies, research and private households is generating ever-larger amounts of data. This current trend is often discussed under the label Big Data. Suitable statistical processes already make it possible today to evaluate huge amounts of data, e.g. to examine their structural features or to forecast trends. Intelligent merging, linking and evaluation can also open up new approaches in research.⁶⁶ At the same time, comprehensive personal profiles can be created.

In this context, however, rights of disposal and exploitation of the stored information have not yet been finally clarified. It is also unclear what a suitable regulation might look like in the international context. The Federal Government has announced its intention to establish a modern "regulatory framework for ensuring freedom, transparency, data protection and security, and also for preserving competition in the digital world".⁶⁷

Strict demands on data security create confidence and are a fundamental prerequisite for international competitiveness – also for companies outside the field of data encryption.⁶⁸ At the same time, the state should set an example by the way it deals with the citizens' data. When it comes to the protection of data privacy, the great potential of digital technologies and business models come up against understandable concerns from citizens. On the other hand, excessively strict demands on data protection can impede or even prevent innovations and efficiency gains. Comparatively restrictive national laws in particular can lead to disadvantages in international competition. The aim must therefore be to work towards uniform international standards in data protection. One possibility would be to extend the applicability of European

Data protection versus data security

While the term data protection covers the entirety of statutory and corporate measures to protect the rights of people from breaches of confidentiality,⁶⁹ the aim of data security is to protect data from loss or manipulation. Data security is thus the basic prerequisite for the development of robust business processes.

Examples like positioning services for mobile terminal devices illustrate the current challenges facing data protection; here, there is a potential conflict between the right to informational self-determination and overarching goals such as public security. Mobile devices are able to collect and store positioning data, which can then be used, for example, for navigation, advertising or as tourist information. In emergency situations, positioning services can offer enhanced security. However, when mobile terminal devices are positioned, the location data can also be used to assemble extensive movement profiles, and these can be used to infer relationships and habits – and thus make predictions on the future behaviour of the people concerned. The potential for improved security is therefore possibly offset by the risk that the monitoring might breach principles of informational self-determination without the parties involved noticing.⁷⁰

data protection law to also cover companies that offer their services within the EU, even though they are not domiciled in the EU and therefore process their data outside of the EU (*lex loci solutionis*).⁷¹ This is the aim of the EU-wide General Data Protection Regulation,⁷² which should be implemented swiftly.

Interoperability through open standards

Open standards are digital formats or protocols whose content can be reviewed, used and further developed at any time by the public.⁷² They have many advantages over proprietary solutions. The involvement of many actors makes it possible to identify and eliminate security vulnerabilities quickly. Furthermore, the economic importance of open standards comes from the fact that they create the basis for interoperability,

i.e. compatibility between the interfaces of heterogeneous, often locally organised cross-company and cross-industry systems and components.⁷³ This reduces the risk of inefficient parallel developments, without at the same time promoting lock-in effects vis-à-vis individual providers or technologies. The elimination of market-entry barriers makes the overall economy more competitive and prevents monopolies. Furthermore, the continuous advancement of interacting systems by independent developers lays the foundation for a wide range of innovations, e.g. in the context of Industry 4.0.

The Committee of Inquiry (Enquete-Kommission) on "Internet and Digital Society" is already calling for a consistent use of open standards across different levels in public administration.⁷⁴ The Commission of Experts supports this call. The aim formulated in the Digital Agenda of eliminating practical obstacles to open-source software in the federal administration⁷⁵ is not sufficient in this respect.

Lack of reference models for Industry 4.0

The Digital Agenda calls the growing networking of production processes using ICT systems an opportunity to consolidate and further improve Germany's leading competitive positions in plant construction and mechanical engineering, the automotive industry, electrical engineering and medical technology in the long term. The Commission of Experts already expressly welcomed the Federal Government's Industry 4.0 Initiative in its last report.⁷⁶ In the context of Industry 4.0, however, there is a need for more research on suitable reference architectures and standards, as well as in the context of platforms. The uncertainty about developing industry standards in particular leads to a reluctance, especially among medium-sized companies, to invest in systems that may later become incompatible.⁷⁸

The Commission of Experts welcomes initial efforts towards suitable reference models in which partners from industry and science will work together on the future core fields of digitisation.⁷⁹

Recommendations

The Commission of Experts calls for action especially in the following areas:

- The targets laid down in the Digital Agenda for nationwide provision of bandwidth speeds of

50 Mb per second must be swiftly implemented. Potential measures should be designed in a way that is open to all technologies.

- To ensure that Germany's network infrastructure can compete internationally, the supply of a digital infrastructure has to be regularly monitored and adapted according to the changing needs of the digital sector.
- Overall, the Commission of Experts believes that it is essential to develop a consistent package of measures in the next few months specifying how and over which period of time the projects referred to in the Digital Agenda are to be implemented and how individual cases are to be financed. The implementation of the Digital Agenda requires transparent modes of documentation.
- The federal structure of data-protection supervision leads to a coexistence of many sector-specific regulations which partly overlap with the Federal Data Protection Act. The Commission of Experts recommends subjecting the many special regulations to a critical review. At the European level, legal certainty and comparable competitive conditions relating to data protection must be created as soon as possible. The Federal Government should act to make sure that the EU quickly enacts the General Data Protection Regulation.
- Both the Federal Government and the Bundestag have been intensively studying the impact of digital change on society and the economy for years. When the details of the Digital Agenda are worked out, the Commission of Experts expressly recommends taking into account the recommendations that were jointly drawn up and adopted in 2010 by the Enquete-Kommission on "Internet and Digital Society" in a process that incorporated the parliamentary parties and heard the views of external experts and the public.⁸⁰ One example of this is the use of open standards in public administration.
- The state has a pioneering role to play in the secure communication of sensitive data, e.g. between citizens, companies and administrative institutions. It is of paramount importance to safeguard transparency and openness, and to take measures to guarantee data security.⁸¹
- Non-sensitive personal data collected by the public sector should be made more easily accessible for academic research. The Commission of Experts therefore welcomes the Federal Government's National Action Plan to implement the G8 Open Data Charter.⁸²

- The Industry 4.0 concept must be advanced in relation to reference architectures and standards. The implementation of the concept must gain momentum, especially since Germany intends to take a decisive role in the future in shaping international ICT standards for production and automation technologies.

Framework conditions for venture capital in Germany

A 5

Venture capital is an important source of financing for young innovative enterprises. Yet, Germany's venture capital market is much smaller than markets in the United States and many European countries (cf. C 4-2). If young innovative companies do not have access to enough capital, they cannot realise and market their innovative products or business models. Germany as an innovation-based economy thus squanders potential for growth and productivity.

An analysis of venture-capital investments in Germany over the last few years (cf. Figure 1) shows that it has been stagnating and is relatively low compared to innovation pioneers like Finland and Sweden.

Against this background, the Commission of Experts welcomes the intention stated in the Federal Government's coalition agreement to "make the legal and fiscal framework conditions for venture

Development of venture-capital investment as a percentage of national gross domestic product, 2009 to 2013

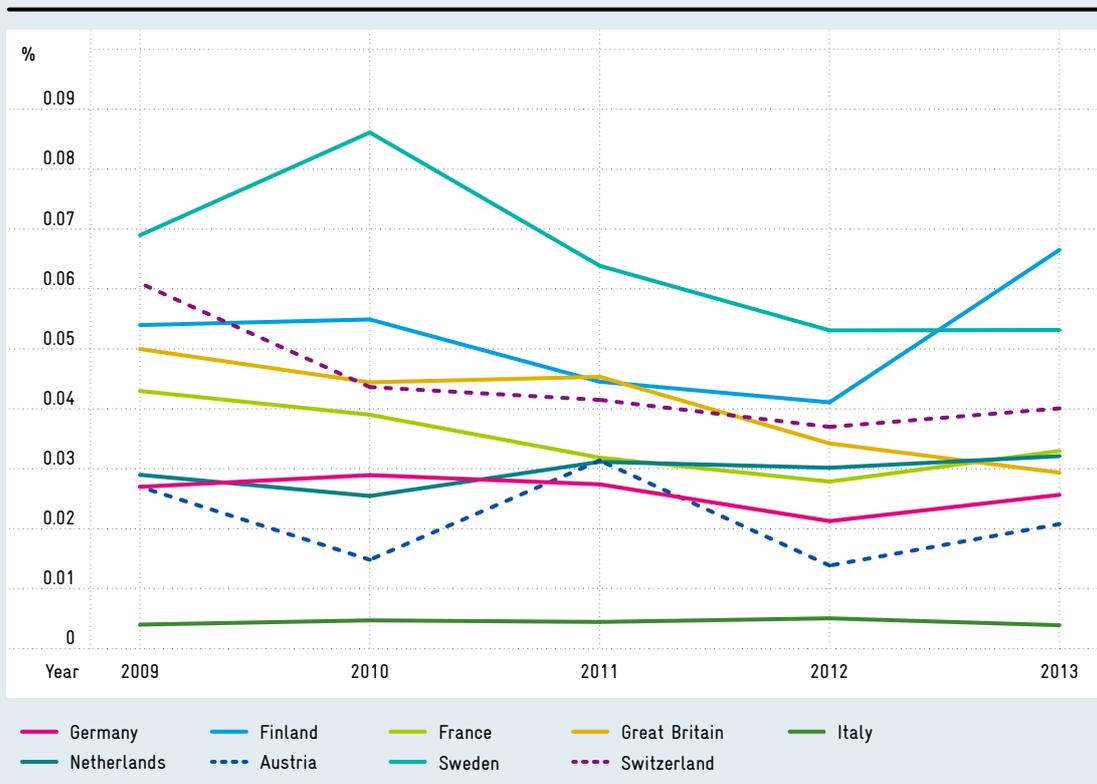


Fig 01

Data
Download

Investments according to registered office of the portfolio companies.
Source: EVCA, Eurostat. Own calculations.

capital in Germany internationally competitive [...]. This requires a separate set of rules. Similarly, new forms of financing, such as crowdfunding, need a reliable legal framework.”⁸³ Different proposals and measures have been discussed by the Federal Government in recent months and are presented and evaluated here.

Tax exemption for INVEST grant decided

Under the programme entitled “INVEST – grant for venture capital” (INVEST – Zuschuss für Wagniskapital), which was introduced in 2013, 20 percent of equity-capital investments by private investors (business angels) is reimbursed (up to a maximum of EUR 250,000), if they invest at least EUR 10,000 in young innovative enterprises and hold onto their stake for at least three years. More than 1,000 investors applied for subsidies from the start of the programme in May 2013 until December 2014. Grants worth a total of EUR 11.7 million were approved, corresponding to a total investment sum of EUR 58.6 million.⁸⁴

However, only a quarter of the envisaged funds was disbursed in the first two years. The recipients’ uncertainty about the tax treatment of the grant was seen as the biggest obstacle to higher demand for the programme.⁸⁵ For this reason, in September 2014 the Federal Cabinet decided to exempt the subsidy from taxation – also retroactively for 2013.⁸⁶

The Commission of Experts had already called for better conditions for venture-capital funds and business angels in its 2011 and 2012 reports. In view of the growing importance of private investors for financing young companies, the Commission of Experts welcomes the decision on tax exemption.

Easier transfer of carried-over losses needed

In addition, the Federal Government has announced its intention to revise the restrictive tax regulations for the treatment of carried-over losses (section 8 of the corporate tax law KStG).⁸⁷ At present, carried-over losses are lost when an investor acquires shares in a company. Yet, innovative companies in particular spend large sums on research and development (R&D) in the first few years, which can then be posted as carried-over losses. If these carried-over losses for R&D expenditure can no longer be deducted from tax after a takeover, this makes the company less attractive for potential investors. The current restrictive

treatment of carried-over losses therefore has a detrimental effect on the willingness of venture-capital investors to invest in innovative start-ups in Germany.⁸⁸ Yet, the law passed by the Bundestag in 2008 to facilitate the transfer of carried-over losses (Law on the Modernisation of the Framework Conditions for Venture Capital and Equity Investments, MoRaKG) was rejected in Brussels because of concerns relating to state aid; it is currently before the European Court of Justice. Depending on the case’s outcome, it is important to find new solutions quickly here.

Taxation of capital gains and the remuneration of fund initiators in discussion

In the context of tax law, it is not enough to create regulations that explicitly increase incentives for venture-capital investors in Germany; it must also be taken into account that undesirable side effects on venture-capital investment can also be caused by changes in the law that do not actually target venture capital. For example, the Bundesrat initiative entitled “Close Loopholes – Reduce Tax Breaks – Stimulate Investment” (Steuerschlußpföcher schließen – Steuervergünstigungen abbauen – Investitionen ankurbeln) called for a general taxation on capital gains realised upon the sales of free-floating shares.⁸⁹ This would have a negative impact on the start-up scene in Germany, however. Small-scale investment by venture-capital investors and business angels would be affected by this tax liability, making their investments less attractive and reducing incentives to invest in young innovative firms. Therefore, the potential that is generated – in the form of innovative products and business models – by venture-capital investments in young companies should be given precedence over short-term increases in tax revenues.

The repeated calls for higher taxes on the remuneration of fund initiators – known as “carried interest” – have a similarly damaging effect.⁹⁰ The Federal Government has rejected such an increase up to now. Even so, the ongoing discussion reduces long-term planning certainty for the initiators of venture-capital funds. Another obstacle in Germany – unlike many other European countries – is that fund managers’ income from administrative services is subject to value-added tax.⁹¹ This makes it relatively unattractive to build up and administer a venture-capital fund in Germany.

Framework conditions for anchor investors threatening to deteriorate

Yet, more than tax arrangements are needed to revive the market for venture capital in Germany. A class of institutional investors that is important in other countries is missing: the pension fund. In countries with capital funded pension schemes, such funds often have the function of an anchor investor who delivers an important signal to foreign investors. Because the pension system in Germany is largely financed according to the pay-as-you-go principle, these anchor investors are missing. This makes it all the more important that other institutional investors are active in this field.⁹² In this context, the Commission of Experts is critical of a new draft investment ordinance that has been prepared by officials of the Federal Finance Ministry,⁹³ because it restricts the opportunities of insurance companies and pension funds to invest in venture-capital funds, thus reducing their possibilities to act as anchor investors. The absence of private anchor investors has not been offset by public institutional investors over the last few years, either. For example, the KfW Bank Group withdrew from venture-capital funding several years ago. The Commission of Experts therefore welcomes the Federal Government's announcement that it intends to launch a fund with a volume of EUR 500 million via the European Investment Fund (EIF) to finance the growth of German start-ups.

Creation of liquid secondary markets necessary

In the long run, liquid secondary markets are also needed to increase incentives for investors. The availability of flexible exit options increases the incentive for investments in venture-capital funds.⁹⁴ It is therefore regrettable that the stock-market segment for young companies planned by the Federal Government and Deutsche Börse is not implemented because the number of exits is too small. Since the market potential for a national stock-market segment is too small, consideration should be given to whether the creation of a pan-European stock-market segment for growth-oriented companies can achieve a sustainable improvement in the financing possibilities for start-ups.

Recommendations

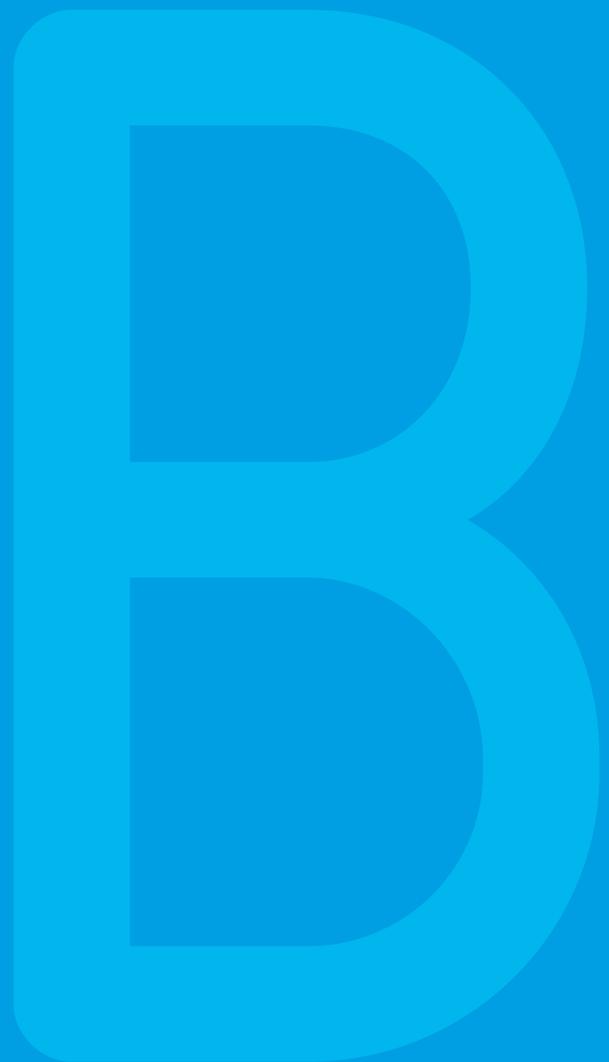
The projects and initiatives mentioned above are steps in the right direction in order to improve incen-

tives for the provision of venture capital in Germany. They should be implemented without delay.

- The Commission of Experts welcomes the Federal Government's announced intention to revise the restrictive tax regulations on the treatment of carried-over losses (section 8 of the corporate tax law KStG). Depending on the outcome of the proceedings relating to the MoRaKG before the European Court of Justice in Brussels, new solutions must be sought quickly.
- The Federal Government should refrain from introducing a general taxation on capital gains realised upon the sales of free floating shares. This would also affect investment by venture-capital investors and business angels in young innovative enterprises and make these investments less attractive.
- Similarly, the Federal Government should not accede to the demands from the Bundesrat initiative for higher taxes on the remuneration of fund initiators, since this would reduce the incentives for investment in young innovative companies.
- Conditions for anchor investors must be designed in an investment-friendly way. New restrictions on investment opportunities for insurance companies and pension funds must be avoided. The Federal Government's plan to launch a fund via the European Investment Fund (EIF) to finance the growth of German start-ups should be implemented without delay.
- Consideration should be given to whether the creation of a pan-European stock-market segment for growth-oriented companies can achieve a sustainable improvement in the financing possibilities for start-ups.



CORE TOPICS 2015

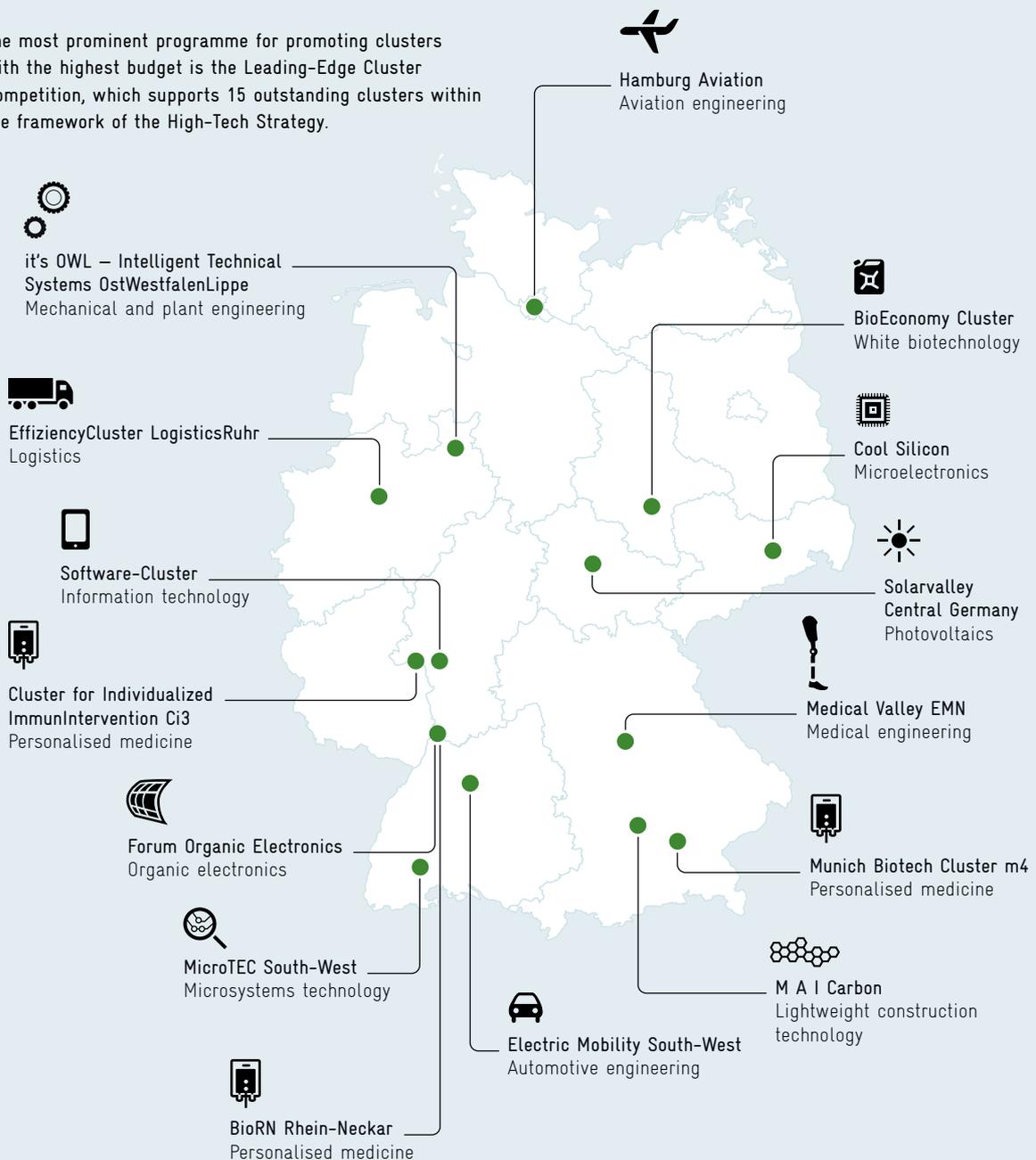


Promoting innovation through cluster policy

Cluster policies aim to connect geographically close actors such as businesses, tertiary education institutions, and public and private research institutions in order to generate and disseminate knowledge and thus increase a region's innovative capacity.

Germany's leading-edge clusters

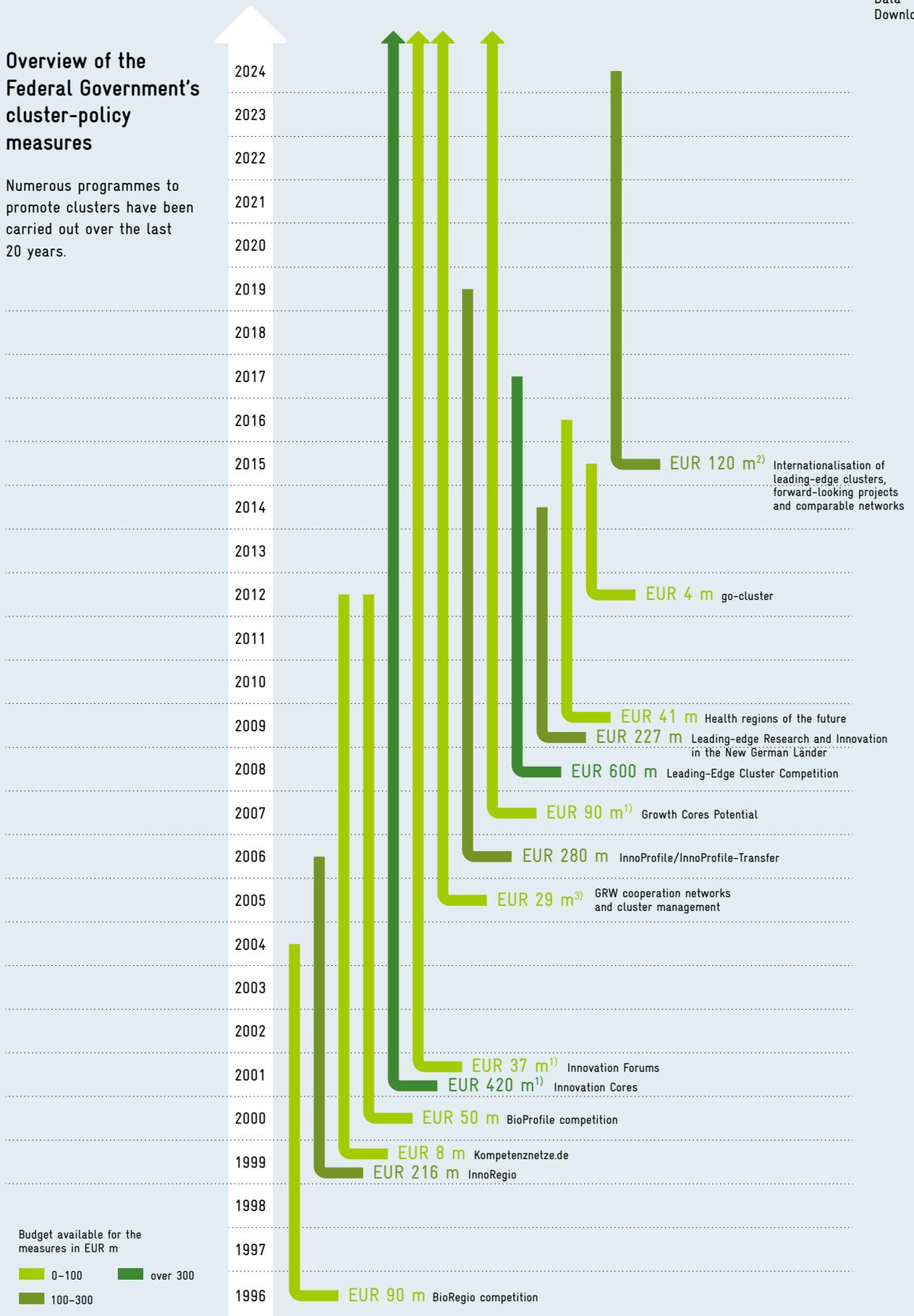
The most prominent programme for promoting clusters with the highest budget is the Leading-Edge Cluster Competition, which supports 15 outstanding clusters within the framework of the High-Tech Strategy.



Source: Own depiction based on BMBF (2012).

Overview of the Federal Government's cluster-policy measures

Numerous programmes to promote clusters have been carried out over the last 20 years.



¹⁾ Projection up to 2019. ²⁾ Projection up to 2024. ³⁾ BMWi's share; approvals until the end of 2014.
 Source: Own depiction based on written information from BMBF and BMWi.

B 1 Promoting innovation through cluster policy

B 1-1 Wide use of cluster policy

Numerous cluster initiatives have been launched in Germany at both federal and state levels during the last 20 years. Clusters can be defined as “geographic concentrations of interconnected companies and institutions in a particular field.”⁹⁵ This understanding of clusters highlights the importance of geographical proximity and local systems of cooperation, competition and knowledge diffusion for the genesis of innovation.

Important cluster programmes at the federal level with a focus on innovation include the Leading-Edge Cluster Competition and the Entrepreneurial Regions initiative (cf. Box 3).⁹⁶ Furthermore, all the 16 German Länder have launched cluster initiatives across all technology sectors.⁹⁷

Parallel to this policy development in Germany, a wave of cluster policies has swept across the rest of Europe (and elsewhere), imposing a certain public intervention model in favour of the constitution of technological clusters, inspired by the works of Michael Porter⁹⁸ and the success stories from Silicon Valley.

In general, the aim of cluster policies is twofold: first, to encourage the spatial agglomeration of firms and other organisations belonging to a particular sectoral or technological field; and second, to support cooperation among firms that are spatially or technologically close in order to generate positive network effects. The European Cluster Observatory has identified more than 2,000 regional clusters which are supported by some kind of policy.⁹⁹ However, under the heading “cluster policy”, one can see a great variety of policies, ranging from intervention from governments to develop a particular science or technology field in a specific region to more generic support of entrepreneurship and innovation at the regional or local level. Moreover, the term cluster has also been applied to networks spanning several regions. This great

Current cluster programmes at the federal level

The “Leading-Edge Cluster Competition – More Innovation. More Growth” (Leading-Edge Cluster Competition) was launched by the Federal Ministry of Education and Research in 2007 as part of the High-Tech Strategy. It addressed high-performance clusters formed by both business and science. Three rounds of competition were held, and in each round up to EUR 200 million was made available to five leading-edge clusters to fund R&D projects and the activities of the cluster management. Funding for the third round ends in 2017.

“Entrepreneurial Regions – The BMBF Innovation Initiative for the New German Länder” (Entrepreneurial Regions) was launched in 2001 with the programme Innovative Regional Growth Cores. So far, EUR 827 million has been spent or budgeted for cluster-oriented measures of the Entrepreneurial Regions initiative.¹⁰⁰ The initiative promotes the creation and expansion of special technological, scientific and economic competencies in East German regions to generate positive effects for innovation, economic growth and employment.

Box 03

diversity of policy in terms of goals, design and implementation makes it difficult to compare and assess the effectiveness of these different policy measures.

In this chapter, the Commission of Experts first reviews the rationale of cluster policies as an innovation driver and then discusses two important cluster policies undertaken in Germany.

B 1-2 Spatial concentration of innovation

Reasons for spatial concentration

Innovation is more geographically concentrated than most other economic activities, e.g. production. This has been a key result from seminal works in innovation geography.¹⁰¹

The tendency towards spatial concentration is due to two essential factors:

First, the resources required to produce innovation are typically not confined to the boundaries of a single firm. Firms frequently contract for external resources. While this can be done at great distance, spatial proximity can generate opportunities for observation, interaction and mutual learning. Moreover, agglomeration strengthens factor markets for labour or specialised services. This process allows for the local development of a rich innovation ecosystem, capable of providing the resources that are needed by innovators.¹⁰² These include well-trained skilled workers, infrastructures for basic and applied research, and specialised technical, legal and financial services. Second, spatial proximity enhances knowledge and information spillovers through lower communication costs and a greater likelihood of chance meetings (serendipity). At the same time, the likelihood of social relationships increases, e.g. between suppliers, buyers and lead users. The importance of positive local knowledge externalities for innovation are widely observed and measured in the empirical literature.¹⁰³ These factors are particularly important when the considered firms are part of the same or related and interconnected industries.¹⁰⁴

Spatial concentration as a dynamic process

The cluster framework is based on the idea that economic performance is the result not only of an individual firm's efforts, but also of a series of factors external to the firm. The spatial concentration of innovation is a dynamic process which exhibits increasing returns.¹⁰⁵ The net benefits to being in a location together with other firms increase with the number of firms in the location. These agglomeration effects provide the rationale for a policy aiming at reaching the "tipping point"; i.e. the size of a cluster above which increasing returns cause a self-reinforcing growth of the cluster.¹⁰⁶

Spatial proximity not sufficient for the development of clusters

Physical proximity among firms alone does not suffice to characterise a cluster. Beyond concentration of similarly specialised firms, other characteristics of a region are important:

- Anchor tenant:¹⁰⁷ A large R&D-intensive company specialised in a given field that creates externalities in the local system. It makes the whole system more innovative, enhances local university research, thickens factor markets, and absorbs research results by universities and smaller firms.
- Universities and public research institutions:¹⁰⁸ They provide skilled labour and innovative ideas. Especially in knowledge-intensive industries, the presence of a strong university or public research institution represents a key asset for a cluster belonging to the same region. It is an instrumental institution that advances knowledge, trains skilled graduates, increases the capacity for problem solving, and spurs the creation of new firms.
- Institutional diversity:¹⁰⁹ This enhances interdisciplinary learning processes and entrepreneurship. For example, scientists in a cluster can acquire management skills if co-located research institutions, business companies, banks and business schools collaborate.
- Openness:¹¹⁰ An open attitude towards foreign skilled workers or companies is an important aspect of clusters. Agents from other regions are often more effective than local agents when introducing disruptive innovations.
- Firm-size diversity:¹¹¹ Start-ups, SMEs and large established enterprises provide different kinds of innovation externalities, which – if recombined within the region – contribute to the genesis and development of a cluster.
- Relational density:¹¹² Frequent communication and the establishment of as many relations as possible between the agents in a cluster increase the potential availability of information and resources. Thus the possibilities for generating and recombining ideas increase.

The studies mentioned in Box 4 document the economic effects of agglomeration and spatial concentration when these phenomena occur naturally, i.e. without policy intervention. They do not allow an assessment of cluster-policy measures. The effect of cluster policies will be discussed in the following.

Box 04

Empirical evidence for the effect of clusters on firm productivity, innovation and industry dynamics

Clusters matter a lot for firm productivity.¹¹³ A recent study has found that the relocation of a plant from an area with no other plant in the same industry to an area with around 1,000 employees of the same industry (excluding the plant itself) will generate significant gains in total factor productivity (TFP). Furthermore, a doubling of employment in neighbouring firms of the same industry increases TFP by 5–6 percent.¹¹⁴ This confirms results of earlier studies that found that a doubling of employment in a region increases labour productivity by 4.5 percent.¹¹⁵ Evidence is even stronger in studies focusing on young firms.¹¹⁶ A possible explanation is that young, and still small, firms may profit more from co-location than large, established firms as a means of accessing complementary capabilities they do not have in-house. Moreover, a number of studies

show that co-location with firms active in related industries is beneficial for firms in the same region.

A recent study analysing the relationship between clusters and industrial dynamics, found that clusters promote firm entry.¹¹⁷ Entry rates also increase with cluster size. Moreover, the current phase in the industry or product life cycles plays an important role for the relationship between a firm's performance and its localisation. Firms in emerging innovative industries profit most from being located in large diversified cities, while firms in mature routinized industries profit more from being in a cluster, typically in smaller specialised cities.

The effects of agglomerations on inventions, entrepreneurship and innovation have been clearly described in the meantime, although

the underlying mechanisms have not yet been fully explored. Agglomeration effects can be studied relatively well with the help of patent data. Patent activities develop especially quickly in agglomerations.¹¹⁸ These results can be considered as confirmation of the theoretical model of agglomeration development.¹¹⁹ Furthermore, it can be proved that entrepreneurial activities are stronger in agglomerations than in less spatially concentrated regions. A recent survey of innovation activities by 1,300 SMEs in the UK finds that SMEs in local economies with a high proportion of creative industries develop completely new products and processes significantly more frequently than SMEs in other regions.¹²⁰ There is also empirical proof that new start-ups in the high-tech sector are particularly common in clusters.¹²¹

B 1-3 Rationale and effects of cluster policies

Economic rationale for cluster policies

Based on the premise that a cluster can provide a platform to organise resources and relationships for innovative activities,¹²² a cluster policy aims to correct market and coordination failures that are likely to impede the formation of a cluster and its early growth. Market failure can take the following forms in this context: i) increasing returns lead to a tipping point, above which the process of agglomeration is likely to be self-reinforcing and which cannot be reached without policy intervention; ii) coordination and collective-action problems among complementary private investments and services; iii) the lack of industry-specific public goods, e.g. skills, basic research, test facilities or marketing infrastructure, that may require specific institutions and public co-funding.

A further reason for cluster intervention can occur at a later stage if clusters suffer from over-specialisation and lock-in. Such effects are likely to narrow down the range of options for the future development of the firms and the cluster as a whole and can generate collective inertia.

From an economics view, one can make a strong case for policy intervention during the emergence and early growth phases of a cluster. By the time a cluster already exists and has reached maturity stage, the argument for subsidies or other interventions are considerably reduced. There is again an economic rationale for policy interventions during the final phase of a cluster's life cycle, during which a renewal process can be supported.

Fixing market failure at reasonable cost

The fact that market failures are identified does not suffice to justify a policy intervention. It has to be possible to fix the market failure at reasonable costs. The choice of appropriate policy tools requires a detailed technical grasp of the externalities and complementarities of the innovation system. Economists have emphasised that the informational requirements at a practical level limit the scope for government policy to correct coordination problems at reasonable cost.¹²³

Effect of cluster policies

The number of academic works devoted to the evaluation of cluster policy is very limited,¹²⁴ and only few studies apply modern techniques of evaluation. The many measurement problems make it very difficult to undertake evaluations that are rigorous enough to satisfy academic standards.¹²⁵ The few methodologically convincing studies deal with Japanese, German and French cluster initiatives respectively.¹²⁶ All these studies find a positive, but rather small impact on regional patenting activities.

An evaluation of the French cluster initiative from 1999, which employs modern econometric methods (difference-in-difference estimation), finds a small and temporary effect on total factor productivity (TFP) growth.¹²⁷ Yet in general, the French cluster initiative did not succeed in reversing the targeted firms' relative decline in productivity. No effect on employment or exports was found. A few other studies focus on the cooperation and networking effects of a cluster policy. In particular, one study on the German Leading-Edge Cluster Competition shows positive and significant cooperation effects – the study is presented below. Very little is known about the long-term effects of cluster policies on innovation. Time lags in realising effects are lengthy and can vary significantly between different fields and programmes. So far, none of the studies has found evidence of significant long-term effects.¹²⁸

Huge variability of policy approaches

There are many ways to help the formation or growth of a cluster, and the specific policy measures vary considerably. There are two policy approaches at the extremes of a continuum of policies: top-down and bottom-up.

The top-down approach is used by national, regional or local governments that aim at promoting the growth of designated fields within a specific location. This approach raises the well-known issues of government failures, policy capture and picking winners by politicians. The bottom-up approach, by contrast, relies more on self-organisation and local entrepreneurial initiatives and limits policy interventions to identifying and correcting a few market failures that are likely to impede market dynamics towards cluster formation and growth.

Cluster policies are implemented in different industries, different time and life-cycle circumstances, and different socioeconomic and development contexts.¹²⁹ This huge heterogeneity may explain why the literature is inconclusive regarding the effect of cluster policy. It is very difficult to know whether a non-positive evaluation merely reflects the inaccuracy of the policy in this particular case or manifests a more general flaw of cluster policy as an instrument of innovation policy.

Cluster policy in Germany: selected measures and their assessment

The forces underlying the emergence of an industrial cluster differ from those needed to ensure its continued growth.¹³⁰ This distinction between the emergence and growth of a cluster provides a useful framework for discussing two policies designed and implemented in Germany. The initiative “Entrepreneurial Regions – The BMBF Innovation Initiative for the New German Länder” (Entrepreneurial Regions), which addresses the problems of cluster emergence, and the Leading-Edge Cluster Competition, which addresses the problems of improving and developing existing clusters.

Entrepreneurial Regions

The Federal Ministry of Education and Research (BMBF) launched the Entrepreneurial Regions initiative to promote the creation and expansion of special technological, scientific and economic competencies in East German regions. The initiative succeeded the InnoRegio programme for the New Länder, which had been in place from 1999 to 2006. Within the scope of this initiative, the BMBF has developed several programmes that address different aspects of regional innovation systems; they are described in Box 5.

B 1-4

Box 05

Programmes included in the Entrepreneurial Regions initiative¹³¹

Entrepreneurial Regions was launched in 2001 by the Innovative Regional Growth Cores programme (since 2007 supplemented by the Growth Cores Potential programme). Until 2019, the programme has a budget of EUR 420 million for the Innovative Regional Growth Cores and EUR 90 million for the Growth Cores Potential. The programmes support alliances of firms, universities and research institutions that have a common technology platform or the potential to develop one. During the three-year support phase, funding is provided for research projects, training measures and innovation consulting for SMEs and entrepreneurs.

The Innovation Forums programme was initiated in 2001 and has a planned budget of EUR 37 million until 2019. It targets regional alliances between the business sector and scientific and research institutions in the early stages of development. The alliances are supported over a six-month period with the aim of triggering an ignition spark. The core of the programme is an innovation forum. This two-day event provides a basis for promoting

knowledge transfer, establishing contacts and determining the position of the alliance in the competitive landscape.

In 2002, the Centres for Innovation Competence programme was launched with a budget of EUR 266 million until 2017. The purpose of this programme is to establish interdisciplinary centres of excellence at universities and research institutes. In these centres, young researchers from Germany and abroad work together with a focus on making commercial use of their results in the medium to long term.

The InnoProfile programme is also directed towards young scientists. Yet, the focus here is on cooperation between a region's young scientists and regional businesses. Since the programme began in 2006, a total of 42 initiatives has been selected for support. With InnoProfile-Transfer, which was introduced in 2010 and has supported 45 initiatives to date, the focus shifted to technology transfer. Overall, the programme has a budget of EUR 280 million until 2019.

Launched in 2007 with a budget of EUR 59 million until 2013, ForMaT – Research for the Market in Teams, aimed at expediting the availability of public research results for businesses. To achieve this, the programme supports interdisciplinary cooperation between science and technology departments and economics or business departments. Partners from the different departments are then encouraged to jointly develop concepts for exploitation and marketing and put them into practice.

In 2012, the new programme Twenty20 – Partnership for Innovation was launched to support national and interdisciplinary cooperation projects. It aims to expand economic and scientific competencies in the New German Länder and create novel innovation structures through new forms of networking and transparent network management. It has a budget of up to EUR 500 million until 2019.

The amounts of public funds earmarked for the programmes described in Box 5 are considerable. As in previous reports, the Commission of Experts therefore underlines its call for systematic evaluations that are planned at an early stage: evaluation processes must always be already considered and planned when new measures are being designed. It is crucial to already collect the data required for evaluation while the measure is being implemented.

Significance of the Entrepreneurial Regions initiative

For almost two decades, this policy and its predecessor programme have addressed the innovation deficit in the new German Länder. Entrepreneurial Regions tries to grasp factors that are central to the genesis and early phase of successful clusters (entrepreneurial projects, fast-growing firms, subsequent spinoffs), as well as to increase the cohesion and coherence of value chains at the regional level. The main policy question, therefore, is how to increase the level and rate of entrepreneurial initiatives and development.

The various programme components of the Entrepreneurial Regions initiative aim to improve framework conditions for entrepreneurship and knowledge transfers between universities and the business sector.

A historical shift in focus can be observed from the initial programme to the subsequent ones: the Innovative Regional Growth Cores programme (launched in 2001) clearly focused on building or improving complete and coherent industrial ecosystems associated with one particular industry. By contrast, the subsequent programmes focus on promoting functional instruments or structures, such as forums or structures for accelerating technology transfer.

Evaluations of the precursor programme of the Entrepreneurial Regions initiative, InnoRegio, and the programmes InnoProfile and Innovation Forums suggest that they had positive effects on several different targets in the supported firms e.g. network development, R&D results and the development of employment.¹³² In the course of these evaluations, interviews were conducted in the supported companies and – in the case of InnoRegio – also in companies that were not supported. However, the Commission of Experts points out that, in addition, a careful evaluation of the medium- and long-term effects of the various programmes using control-group analysis is necessary in order to gather well-founded knowledge to aid the future design of innovation policy.

The Leading-Edge Cluster Competition

The Leading-Edge Cluster Competition was launched by the Federal Ministry of Education and Research in 2007 as part of the High-Tech Strategy. It addressed high-performance clusters formed by business and science. Three rounds of competition have been held based on a two-stage selection process, and in each round five clusters were chosen to become a Leading-Edge Cluster. In each round up to EUR 200 million was made available to five Leading-Edge Clusters (EUR 40 million per cluster) to fund R&D projects and the activities of the cluster management to support young talents and training measures. Firms that receive funding within the framework of the Leading-Edge Cluster Competition are required to match the funding sum with at least the same amount.

After the call for proposals, the applicants had three months to submit project outlines describing the goals, members and projects of the clusters. Based on these outlines, an independent jury selected the

finalists, who were given another three months to develop a more detailed strategy for their clusters and the opportunity to present their strategy to the jury. Finally, the jury chose five Leading-Edge Clusters in each round. The central criteria of the Leading-Edge Cluster Competition were as follows: a high level of technical expertise; a critical mass of internationally operating enterprises and renowned research institutes in the cluster's technology field; the position in the international market and competition; the research dynamic; the potential for increasing competitiveness; and the focus of the profile. Unsuccessful applicants were allowed to re-apply for the next round, a possibility that was used frequently.

The 15 selected clusters cover a wide range of different technology fields (from aeronautics to software, renewable energies and biomedical products).

Assessment of the Leading-Edge Cluster Competition

A first economic evaluation was produced in 2014,¹³³ which allowed an assessment of the short- and medium-term effects of the Leading-Edge Cluster Competition. The policy does not focus on the initiation or early phase of a cluster dynamic. All the winning applicants that have been awarded the title Leading-Edge Cluster are existing clusters which already exhibited strong characteristics of spatial agglomeration – of similar and complementary organisations and performances – prior to receiving support. All the winning clusters already included large and small companies, universities and public research organisations that showed quite a high relational density. This means that the goal of the policy was not to support a process of cluster formation, but rather to improve existing clusters both quantitatively (in terms of their size) and qualitatively (in terms of cooperation, science-industry linkages, internal markets for specialised resources and cluster-management capabilities).

Two aspects of the Leading-Edge Cluster Competition will be discussed here: first, the policy's effects on the agents in the respective regions, and, second, the effect of the organisation of the policy as a competition.

Policy effects on the development and performance of clusters

The recent evaluation of the programme documented several important effects.¹³⁴ There were positive effects on the provision of resources for innovation that all firms in the cluster could draw on. In most cases, the selected clusters improved significantly both the quantity and the quality of supply in terms of human capital, resulting in a thickening of labour markets for specialised and high skilled workers and in the development of new training institutions. Moreover, the selected clusters improved relational density – between firms in general, but especially between small and large firms and, finally, between public research and industries. For instance, an analysis on the impact of the Leading-Edge Cluster Competition on the formation of innovation networks showed a significant effect on the network structure in terms of density, centralisation and geographical reach. On average, more than half of the existing linkages were either initiated or intensified by the cluster policy, leading to an increased density of the network.¹³⁵ According to firm representatives, the cluster policy also offered opportunities to SMEs to connect with large companies.¹³⁶ However, in several cases the cluster policy resulted in too strong a shift in focus towards local networking.¹³⁷ Since it has been shown that extra-regional partners are likely to play a central role in generating radical innovation within a regional cluster,¹³⁸ an excessive focus on the regional network may be detrimental. Finally, the evaluation showed that the selected clusters have become more attractive to researchers and companies from outside the region.¹³⁹

The evidence on the effects of the Leading-Edge Cluster-Competition on R&D and innovation is mixed. In a few cases, the R&D intensity of the companies in the clusters is much higher than R&D intensity in similar companies not located in one of the clusters. However, in most cases the R&D intensity of companies in the clusters is not significantly higher. The effects on product and process innovations are slightly positive with the exception of two clusters. In addition, 36 spin-offs were created during the first and second round – but only two of these were attributable to companies, while the others spun off from universities or research institutes.

Effect of the organisation of the policy as a competition

When designing the Leading-Edge Cluster Competition, the BMBF decided in favour of a competitive organisational form. Although the tightly organised competition procedure only produced a small number of winners, the losers in one competition round were given a chance to re-apply for the next round. Such a mechanism allows a rigorous selection process, while at the same time also motivating the applicants who do not win to improve their application and even implement parts of the project without support. The Leading-Edge Cluster Competition thus had a mobilising effect. The design of the Leading-Edge Cluster Competition proved to be effective in this respect.¹⁴⁰

Cluster policy in Germany and the EU's Smart Specialisation Policy

These different policies¹⁴¹ together with their own cluster policies have enabled the German Länder to gain experience with regional innovation strategies. They have also taken the opportunity to design and implement innovation policies at the regional level. This may explain, why German regions – in contrast to regions in other EU member states – have not experienced the new EU policy approach of smart specialisation as a major cultural change in their policy practices.¹⁴²

Recommendations

At present, the long-term innovation effects of federal cluster policy cannot yet be estimated. However, the accompanying evaluation of the Leading-Edge Cluster Competition suggests that the support measures have had a positive impact in some of the regions supported: e.g. greater availability of skilled workers, a higher network density and size, and greater cooperation between SMEs and large companies. Against this background, the Commission of Experts recommends the following:

- As the organisational form of a multi-staged technology-open competition has proved successful, future policy initiatives should adopt this organisational form.
- The carefully executed initial evaluation of the Federal Government's Leading-Edge Cluster Competition should be used as a benchmark for also systematically evaluating the great number of regional cluster initiatives.

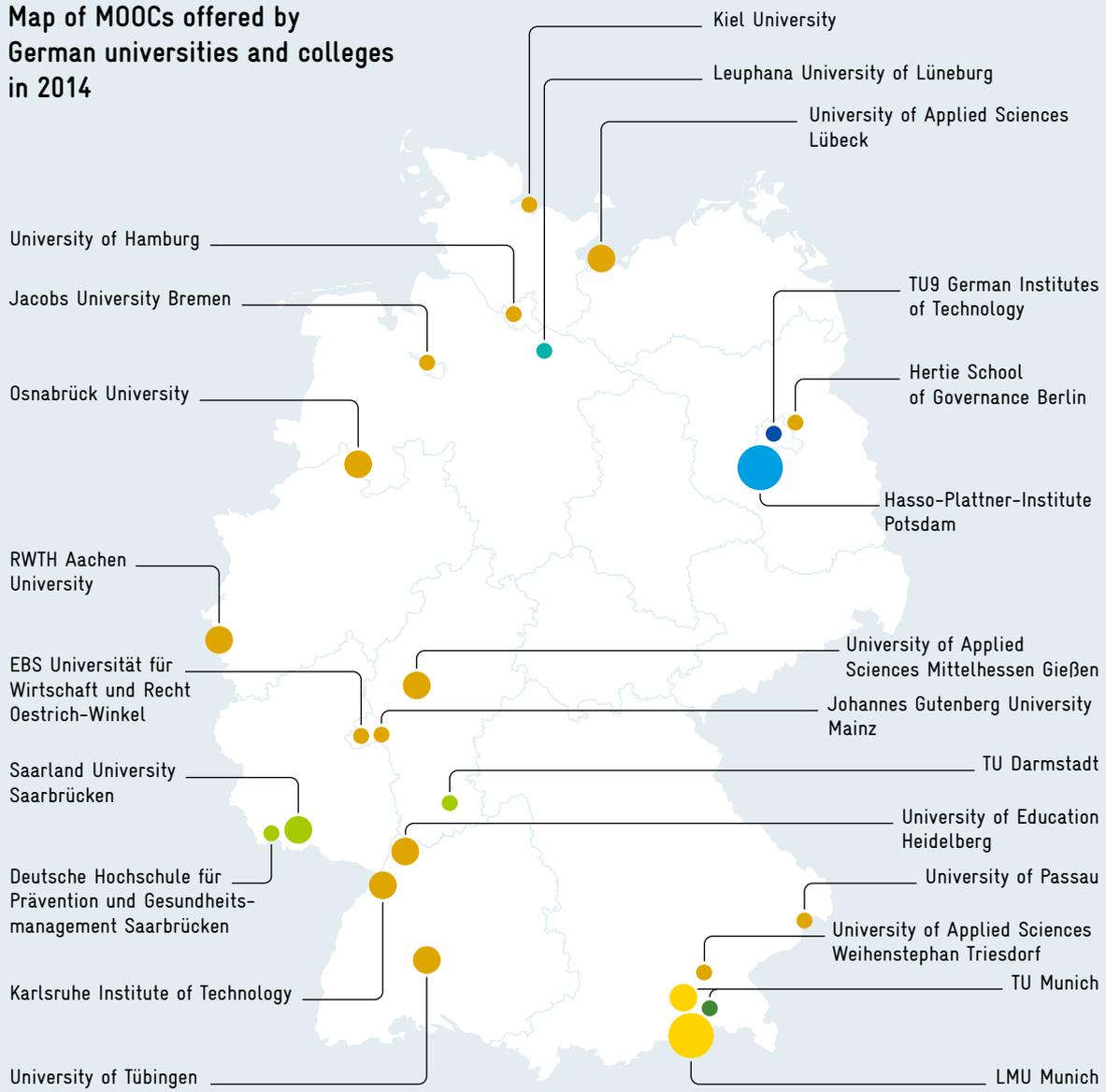
B 1-5

- The evaluation of the Leading-Edge Cluster Competition has demonstrated the great innovation potential emerging from financing R&D cooperation projects between large companies and SMEs. Such collaborations should therefore also be supported as part of other measures, i.e. beyond cluster policies.
- The Commission of Experts welcomes the introduction of different exchange formats, which will give policy-makers at federal and regional levels and cluster managers the opportunity to share their experience and to learn from each other. These new opportunities should be fully exploited.
- With regard to the clusters supported, the Federal and Länder governments should aim to avoid an excessive focus on regional partners and potential isolation from external stimuli. Cluster initiatives at state level should aim to create trans-regional networks. Against this background, the support programme for the internationalisation of clusters announced by the BMBF advances and complements the Leading-Edge Cluster Competition in a consistent manner.
- If the Leading-Edge Cluster Competition were to be continued further, one can expect that its positive effects will weaken considerably. The Commission of Experts therefore advises against continuing the Leading-Edge Cluster Competition beyond the third funding round.
- The Commission of Experts further calls for an evaluation of the medium- and long-term effects of the Leading-Edge Cluster Competition. To assess the effects of funding in an objective manner, systematic monitoring should be implemented. This will also require the collection of data beyond the funding period.

MOCs: an innovator in the education sector

MOCs (Massive Open Online Courses) are offered by universities and colleges on the internet and usually have a very large number of participants. MOCs do not only target students, they are also open to interested users worldwide.

Map of MOCs offered by German universities and colleges in 2014



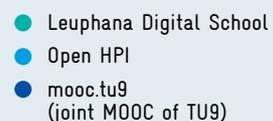
Number of courses offered



Platforms of external providers

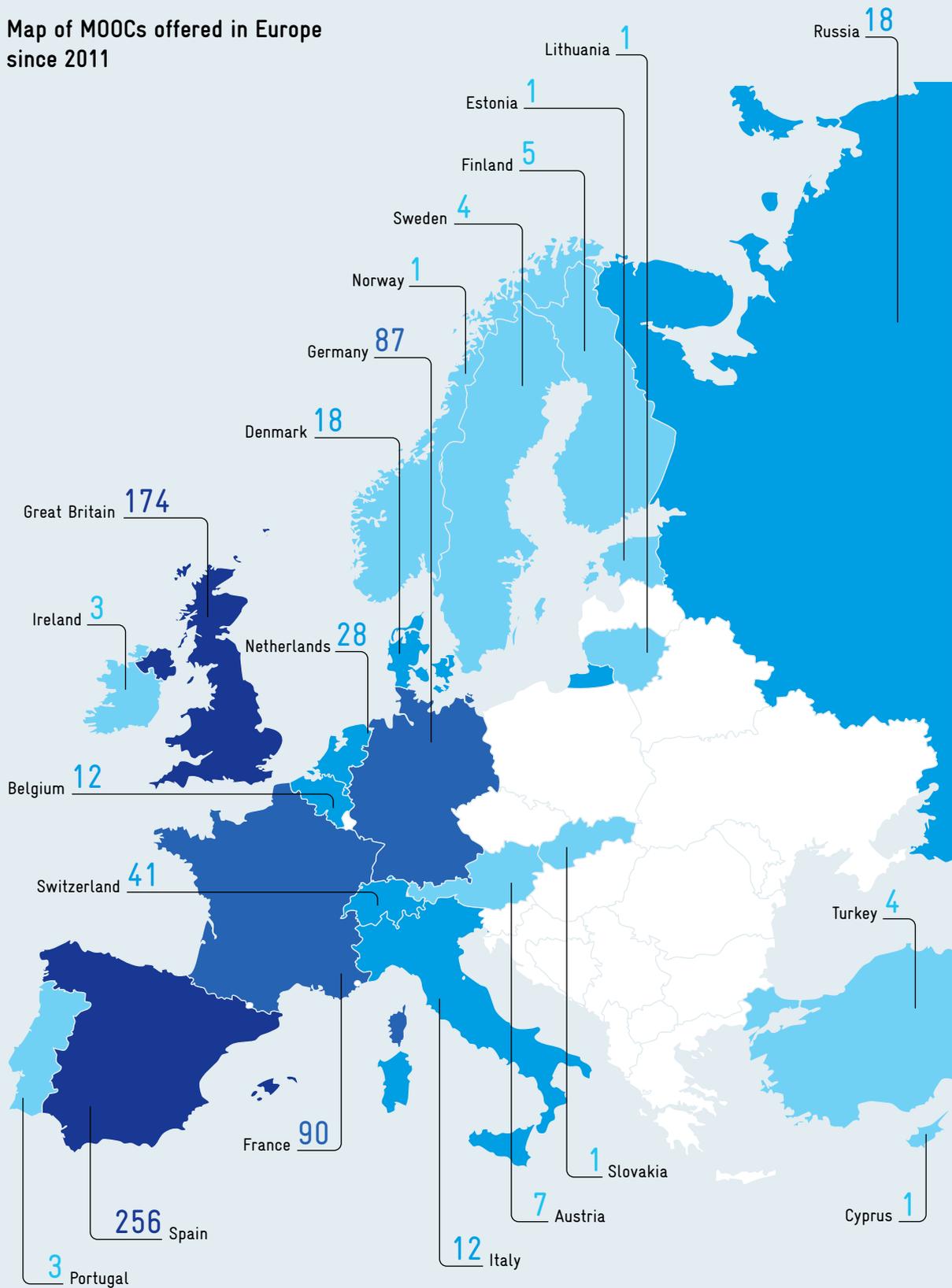


Own platforms

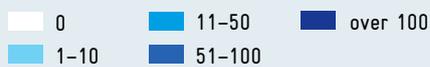


Source: Own depiction based on European MOCs Scoreboard and own research.

Map of MOOCs offered in Europe since 2011



Number of MOOCs



Source: Own depiction based on European MOOCs Scoreboard.

B 2 MOOCs: an innovator in the education sector

MOOCs are one of the most frequently discussed innovations in the tertiary education sector. The abbreviation MOOC stands for Massive Open Online Courses,¹⁴³ i.e. courses that are available online, usually have a very large number of participants, and are open to interested users all over the world.¹⁴⁴ These courses are offered on so-called MOOC platforms (cf. Box 6). The MOOC movement was initiated by lecturers who were keen to experiment and wanted to use the internet to improve teaching and reach a broader target group. MOOCs have been attracting rising media attention in Germany since 2011, when Stanford computer-science professors Sebastian Thrun and Peter Norvig offered a course on “Artificial Intelligence”, which reached more than 160,000 participants. The number of platforms and courses has increased considerably in the meantime.

MOOCs are not new in every respect,¹⁴⁵ but what is new about them is that the best universities in the world (Harvard, Stanford, Massachusetts Institute of Technology – MIT) have become active as pioneers and are now offering their courses free of charge to everyone. Participants with different social, economic or educational backgrounds anywhere in the world can now take part in education from the best universities.¹⁴⁶ By contrast, conventional online university courses or traditional lecture podcasts can typically only be accessed by students; they are not equally open to people of all educational backgrounds from all countries.¹⁴⁷

In the meantime, MOOCs are regarded as a disruptive innovation that can fundamentally change the existing markets and value chains in the education sector. Against this background, the Commission of Experts examines the current dissemination of MOOCs in Germany, the challenges to teaching and learning processes, and the resulting educational opportunities and implications for research and innovation in the education field.

MOOCs at German universities and colleges B 2-1

Few MOOCs offered at German universities and colleges up to now

A controversial discussion on the prospects and risks of MOOCs has been ongoing in Germany since 2013.¹⁴⁸ In order to create an empirical basis for the discussion on MOOCs in Germany, the Commission of Experts commissioned a study from HIS-Hochschulentwicklung (HIS-HE) in the summer of 2014. This study involved broadly based surveys of university and college leaders as well as MOOC lecturers.¹⁴⁹ The survey of vice-presidents and vice-rectors responsible for academic teaching was answered by 169 people (43 percent). On this basis, a second survey of MOOC lecturers was conducted; it was answered by 46 people (46 percent).

The survey of the university and college leaders shows that the dissemination of MOOCs in Germany is still low at present, despite the intensive discussions. Only a sixth of the responding universities and colleges had offered MOOCs in the past or were currently offering such courses. Another sixth intended to do so in the future.¹⁵⁰ The map on page 50 provides an overview of the MOOCs currently offered by German universities and colleges.

Great commitment at individual German universities and colleges

57 percent of the university and college leaders who took part in the survey indicated that they had considered MOOCs in some form; 42 percent said that a committee at their university/college was looking into MOOCs; but only 8 percent of the respondents consider online teaching¹⁵¹ to be strategically important.¹⁵² Few expected an additional benefit for their respective institution as a result of a more distinct profile or improved competitiveness.¹⁵³

MOOCs: history, types and platforms

The first MOOC entitled “Connectivism and Connected Knowledge” was launched by George Siemens and Stephen Downes in 2008 at the University of Manitoba in Canada. Despite its 2,300 participants, the course had a highly interactive component. Such courses later became known as cMOOCs, where the “c” stands for “connectivist”. A characteristic feature of cMOOCs is that the contact and communication between students and lecturers leads to new knowledge networks in which the students generate works or content of their own.¹⁵⁴

Today, the public discourse is more influenced by so-called xMOOCs, where “x” stands for “exponential” and relates to the significantly higher number of participants compared to conventional courses.¹⁵⁵ The first three xMOOCs were offered in 2011 by lecturers at Stanford University; they attracted over 100,000 participants per course.

They subsequently developed into the platforms Coursera and Udacity.¹⁵⁶ The main characteristic of xMOOCs is their almost unlimited scalability. Unlike cMOOCs, their main objective is to teach pre-structured knowledge.¹⁵⁷ In addition, however, they also provide a good basis for what is known as blended learning, i.e. combining online content with other didactic means such as exercises or discussions in the lecture hall. Furthermore, xMOOCs can also be used in the context of so-called flipped-classroom teaching,¹⁵⁸ in which the students acquire the pure knowledge online via video lectures and then practise and apply it together with the lecturers in the university lecture hall.¹⁵⁹

The primary task of so-called MOOC platforms is the technical implementation of the MOOCs, i.e. providing the course software and the necessary server capacity. In addition to this core task,

the different platform operators experiment with additional services for their partner universities and colleges, which are charged membership fees.¹⁶⁰ The MOOC platforms also play a key role in data storage. Depending on MOOC platform, the user data relating to teaching and learning behaviour are also used for research purposes or commercialised. In addition, the leading international platforms¹⁶¹ (Coursera, Udacity, edX) assume a key role in the marketing of the courses by operating as separate brands reaching millions of users.¹⁶² Furthermore, since 2013 edX’s course software has been available as open-source software (openEdX) and forms the basis of several national MOOC platforms. Large platforms in Europe include the French platform FUN and the Spanish Miráda X; there is also a German MOOC platform called iversity (a Berlin-based start-up).

The willingness to consider and implement MOOCs increases with the size of the institution.¹⁶³ Ludwig Maximilians University of Munich (LMU), and Technische Universität München (TUM), are among the leading German universities in the use of MOOCs. The Hasso Plattner Institute at the University of Potsdam and the Lübeck University of Applied Sciences, with its subsidiary company Oncampus, also put a strong emphasis on MOOCs. However, MOOCs play a less strategic role at the institutions mentioned than at leading universities in other European countries or the USA.¹⁶⁴ For example, the École Polytechnique Fédérale de Lausanne (EPFL),¹⁶⁵ Graz University of Technology together with the University of Graz¹⁶⁶, and MIT in the USA¹⁶⁷ all pursue a very proactive strategy (cf. Box 7).

Wide range of participants and course components

The survey of lecturers showed that the numbers of students taking part in the MOOCs offered at German universities and colleges rarely exceed 100,000, a figure often stated in the English-speaking world.¹⁶⁸ Even so, as a rule MOOC participants significantly exceed the number of participants attending regular courses at German universities and colleges.¹⁶⁹ One of the most popular MOOCs from a German-speaking university – with 93,000 participants – was the English-language course “The Future of Storytelling” from the Potsdam University of Applied Sciences.¹⁷⁰ Another example is the English-language course “Competitive Strategy” from LMU with 95,000 participants; a Chinese-language version is now also available.¹⁷¹

Box 07

Examples of the strategic embedding of MOOCs

TUM has developed five MOOCs since 2013 and is planning more. The MOOCs are offered on Coursera or edX.¹⁷² LMU has also developed a total of five MOOCs since summer 2013 and offers them exclusively via Coursera.¹⁷³ Up until December 2014, LMU's courses had a total of 800,000 participants worldwide,¹⁷⁴ a total of more than 50,000 participants had registered for TUM's courses worldwide.¹⁷⁵

The EPFL has a pronounced strategic focus. It was the first European university to offer a MOOC in 2012.¹⁷⁶ Because French is the native language, the EPFL's range of MOOCs is directed mainly at the French-speaking world, including French-speaking developing countries. From summer 2012 until February 2014, it launched a total of 21 MOOCs – 15 on Coursera and six on edX – in French or English; 13 more MOOCs are at the planning stage. Up until November 2014, a total of over 750,000 students took part in the courses worldwide.¹⁷⁷ The EPFL divides its MOOCs into four different types that clearly illustrate the strategic direction. First, there are MOOCs whose aim is to raise the university's global visibility; second, MOOCs for the university's own – and possibly external – students, which create time for flipped classroom situations; third, MOOCs specifically for development aid; and fourth, shorter MOOCs designed specially for the broad Swiss population, but also other interested people.¹⁷⁸ This specific example illustrates changes in learning processes and ways of accessing educational content and potential markets. It also shows that access to markets is partly dependent on the prevalence of the respective national language, a fact that limits possibilities for German-speaking MOOCs.

Based on the above-mentioned survey of lecturers, a review of the components of the MOOCs generally offered at German institutions revealed a wide variety of didactic resources.¹⁷⁹

Unclear role of MOOCs in regular tertiary teaching

The motives most frequently mentioned by the MOOC lecturers surveyed include an interest in new course formats, a desire to participate in the current MOOC development, and an ambition to reach new target groups. However, it is still largely unclear how MOOCs can count towards a regular university degree. At present, only very few universities and colleges in Germany recognise external MOOCs as part of a degree at their university or college.¹⁸⁰ At the present time, therefore, the fast-growing supply of MOOCs in Germany is hardly leading to a systematic broadening of, or improvement in, the quality of typical degree programmes at universities and colleges. Yet, the targeted inclusion and recognition of external MOOCs in regular study programmes could open up great opportunities, especially for smaller universities and colleges or for subjects with smaller numbers of students. Furthermore, MOOCs could create extended opportunities for a form of general studies (*studium generale*); and in smaller subjects they could broaden the range of available internal courses and in this way improve the breadth and quality of the training. MOOCs are thus also influencing the competitive conditions on the education market.

Among MOOC participants, too, there is a wide range of goals. Apart from obtaining a course certificate, this can, for example, be a search for guidance in their choice of studies or a need to acquire the relevant German terminology in their given field.¹⁸¹ This broad range of goals also explains frequently observed low graduation rates. For example, in more than half of the MOOCs offered, the above-mentioned survey of lecturers showed that a maximum of 20 percent of the participants actually completed the course with a certificate of attendance or graduation. Yet, when students terminate a MOOC early, this does not mean that they are dropping out in the classic, negative sense, because they may have already achieved their goal by this time.

Big differences in development costs

To date, hardly any reliable statistical data are available on the costs of creating MOOCs. According to the HIS-HE study,¹⁸² examples vary between 25,000 to 500,000 euros. These big differences stem partly from different demands on the content of the courses and different production methods, some of which involve more work than others. In addition, considerable costs are sometimes caused by developing individual MOOC platforms, which soon leads to higher costs per course if there are only a small number of courses.¹⁸³ However, since the number of potential students can be several times higher than for regular courses, this can sometimes justify the high costs.

MOOC funding differs according to the higher-education system

Up to now, most MOOCs have been financed by the regular higher-education budgets for teaching and research, not by the users (i.e. private individuals or companies). Sporadically, there are funding programmes financed by the Länder, or third-party funds awarded via a competitive system.¹⁸⁴

Neither in Germany nor in the USA are MOOCs currently generating substantial revenue.¹⁸⁵ As far as future income prospects are concerned, however, the starting position in Germany differs systematically from that of the USA and other countries where students tend to bear bigger financial burdens for their university education. A large number of business models are expected to emerge in the USA.¹⁸⁶ In Germany, such business models could become relevant in further education. The kind of profile-building processes among individual universities and colleges recommended in the 2012 Report could lead to opportunities to generate revenue to support this profile-building.

MOOCs are changing competitive dynamics and creating new market structures

Even if some higher-education systems do not use MOOCs to generate new revenue, they can still have considerable positive effects on an institution's reputation. Whenever the huge numbers of students lead to economies of scale, small differences in quality can be reflected in large differences in demand. This results in strong incentives to improve and spend more on promising MOOC courses, because investments in

quality can have a decisive effect, both financially as well as in terms of reputation.

Overall, one can expect a concentration on a small number of especially popular MOOCs.¹⁸⁷ In addition, sophisticated niche products and specialised portals for different market segments are likely to emerge. As long as students can use these offers at virtually zero cost, and subsequently adapt their expectations of content and quality, then even traditional universities and colleges will not remain immune to this development in the long run – even if they do not offer their own MOOCs.

MOOCs: an opportunity for the German academic landscape

B 2-2

Strengthening the unity of research and teaching

MOOCs create new incentives for quality improvements in teaching, although the strength of these effects depends on who receives the revenue generated by MOOCs.¹⁸⁸ The concept of flipped classrooms connected with MOOCs can strengthen the discussion culture. In this context, professors become interpreters of MOOCs, in a similar way to today when text books are used. MOOCs distributed by open access or open source systems are needed to provide the planning security and content freedom needed by universities and colleges and lecturers using external MOOCs.¹⁸⁹ MOOCs should therefore be taken into account in the introduction of the general exemption to copyright for scientific and education purposes announced in the Digital Agenda.¹⁹⁰

However, the use of MOOCs – e.g. for teaching standard course contents – also creates space for teaching research-related content in small, discursive in-class seminars. This would enable universities and colleges to return more closely to Humboldt's ideal. This would require policy-makers to strengthen research-related and specialised teaching methods and not to use MOOCs as an excuse to cut teaching budgets.¹⁹¹ The universities and colleges themselves ought to undergo a radical innovation process to enable them to make use of the available potential and thus simultaneously strengthen the fundamental principles of the unity and freedom of research and teaching.¹⁹² This requires creative concepts from universities and colleges, but also a generous amount of regulatory leeway in order to be able to implement creative ideas, at least experimentally.¹⁹³ Without an assurance of financially stable budgets, such creative and efficiency-

raising ideas could possibly be stifled by worries about budget cuts.

More flexibility for students

Such a strategic use of MOOCs can also make it easier for students to organise their studies, since they can be more flexible as regards timing, adapt courses to their individual learning speeds – and reconcile their studies with their work or child-care responsibilities. Furthermore, MOOCs can already give prospective students an insight into the subject before beginning a degree programme, enabling them to make better-informed educational decisions. In view of the fact that about a third of the first-year bachelor's-degree students do not complete their degree programmes these days at German universities and colleges,¹⁹⁴ innovative solutions must be found to avoid expensive “false starts” in the education system – with all the long-term psychological consequences these involve.¹⁹⁵ One such solution might be to deliberately introduce prospective students to MOOCs.¹⁹⁶

MOOCs can relieve the burden on universities and colleges by taking on some of the pure teaching of standardized knowledge. The resources freed up in this way can be used to improve teaching and promote students' career and personality development, e.g. with targeted activities to support network building between students, lecturers, alumni and potential employers. German universities and colleges in particular, with their strong focus on lecture-style teaching, will have to adapt if they do not want to lose students as they become increasingly mobile.¹⁹⁷

MOOCs can reach new target groups

Furthermore, MOOCs can reach target groups who are in regular employment and in this way support lifelong learning.¹⁹⁸ Already today, over a third of non-traditional first-year students in Germany are enrolled with distance-learning universities and colleges – suggesting that this target group are especially open to online teaching and likely to use MOOCs in the future.¹⁹⁹ MOOCs are easily accessible sources of informal further education that are likely to attract the broad sections of the population who currently have no access to academic training.

In addition, MOOCs can make an important contribution to strengthening education systems in developing countries and emerging economies. EPFL,²⁰⁰ for

example, has declared development cooperation as one of the aims of its overall university MOOC strategy and has already recorded initial successes.²⁰¹

Raising the international visibility of German universities and colleges

MOOCs can also have positive effects as a marketing instrument for universities and colleges.²⁰² High-quality MOOCs that are used worldwide can improve the reputation of individual universities or colleges – and of Germany itself as a location for education and research – thus generating long-term positive effects. Since MOOCs' broad distribution give them a strong reputation effect, universities and colleges should support their best lecturers and outstanding scientists in the development of MOOCs and create suitable decision-making structures and appropriate quality-assurance mechanisms for the MOOCs offered by their lecturers.

Recommendations

B 2-3

In the Commission of Experts' view, MOOCs are an important and useful supplement to the teaching and research instruments currently used in universities and colleges. So far, however, the reception of MOOCs in Germany has been comparatively hesitant.

German universities and colleges should be more active in using the opportunities offered by MOOCs and be given appropriate support by education policy.

Recommendations to universities and colleges

- Universities and colleges should intensively examine new models of combining different forms of learning and teaching, such as MOOCs, blended learning, flipped classroom and other elements.
- It does not make sense for every university and college to create its own MOOCs. Universities and colleges engaging in their own MOOC production should do this as part of an overall strategy with clearly defined objectives. Since the creation of MOOCs can be time-consuming and expensive, it is important that this effort can be justified by improvements in quality, reaching new target groups or an improved market position. In this context, a meaningful MOOC strategy

should go hand-in-hand with the kind of profile-building by universities and colleges already called for in the 2012 Report.

- Universities and colleges that want to produce their own MOOCs should consider joining forces with suitable partners, forming collaborations to produce high-quality MOOCs at low overall costs.

Recommendations for education policy

- Since MOOCs can support quality improvements in higher education, political stakeholders should take a fundamentally positive interest in their development. Public funding for the creation and use of MOOCs can be useful in cases where an increase in expenditure can be justified by quality improvements and where the shared use of MOOCs make up for increased fixed costs. One prerequisite for an effective and efficient use of MOOC funds is that MOOCs are clearly integrated into strategic overall concepts of the universities and colleges. Beneficial funding might therefore include financial incentives to draw up strategic concepts or to create a quality competition, e.g. a MOOC excellence competition. Excellent MOOCs should also be supported to improve Germany's visibility and reputation as a location for research and innovation.
- Additional funding for MOOCs could also be made available to reach new target groups, including younger people with little or no experience of higher education (who have been almost impossible to reach up to now), older employees within the framework of lifelong learning, and talents of all age groups in developing countries who have hitherto had no access to education. This could improve educational equality and the permeability of the education system.
- To ensure that MOOCs produced with public resources can be extensively used and changed – or adapted – they should be made as freely available as possible or shared under open licenses. In chapter A 2, Open Access, of its 2013 Report, the Commission of Experts set out how free access to scientific findings should be organised.²⁰³
- Any support policies should avoid costly duplications of MOOC platforms and give preference to open source infrastructures.
- The ministries in charge of financing universities and colleges should not use the integration of MOOCs as a justification for cutting the financial resources allocated to universities and col-

leges for teaching. Should any financial leeway emerge, it must be left within the universities and colleges to pay for long-overdue quality improvements in teaching.

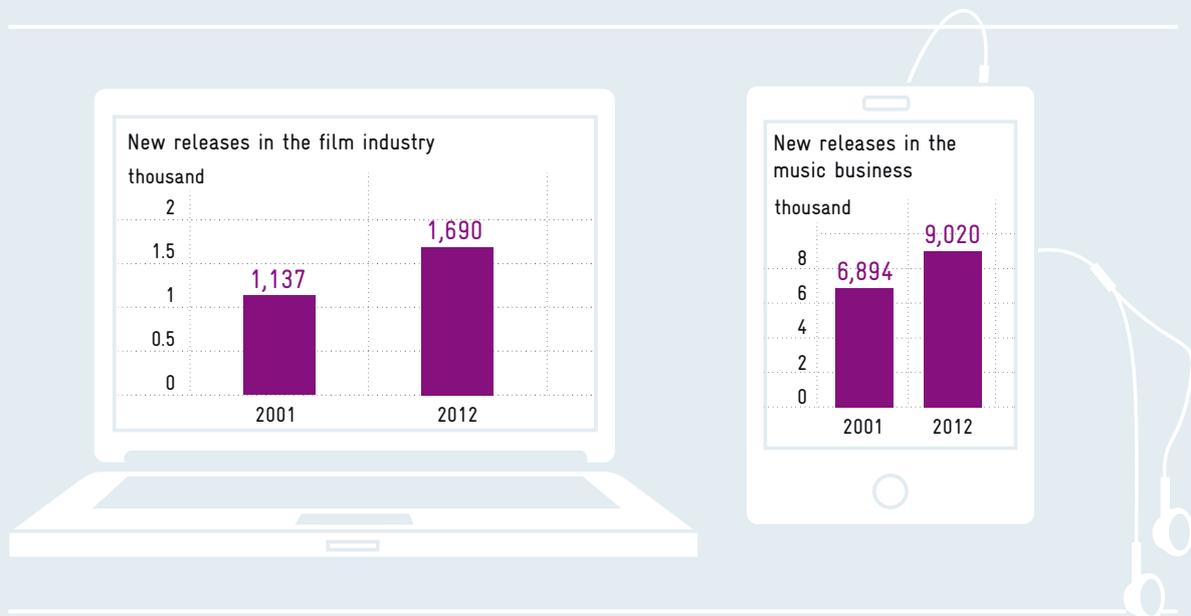
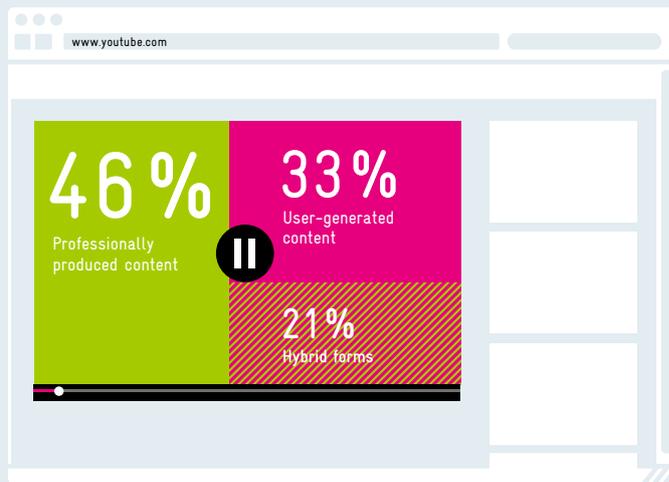
- The public sector should create a legal framework that allows individual universities and colleges to experiment with MOOCs and to develop innovative concepts for improving teaching and strengthening the unity of research and teaching. This may include areas such as admission to studies, development of study programmes, financing keys, copyright, teaching loads, remuneration and higher-education funding.
- Questions of data protection should be clarified at an early stage (cf. on this also chapter A 4). MOOC platforms should ensure that users are clearly and understandably informed about their platform's privacy policy.

Digital innovation and the need for reform of copyright law

Copyright is the societally most important legal instrument for supporting creativity and innovation – it affects citizens to a much greater degree than other legal institutions. The design of copyright law is therefore not only a matter of legal policy, but also of innovation and economic policy.

User-generated content as innovation by new actors

On the basis of a random sample of 500 Videos on YouTube, a recent study comes to the conclusion that many contributions are created by private users.



48.50 EUR

Expenditure per quarter on digital products by users whose conduct is perfectly legal.

112.47 EUR

Expenditure per quarter on digital products by users who buy legal and illegal products.



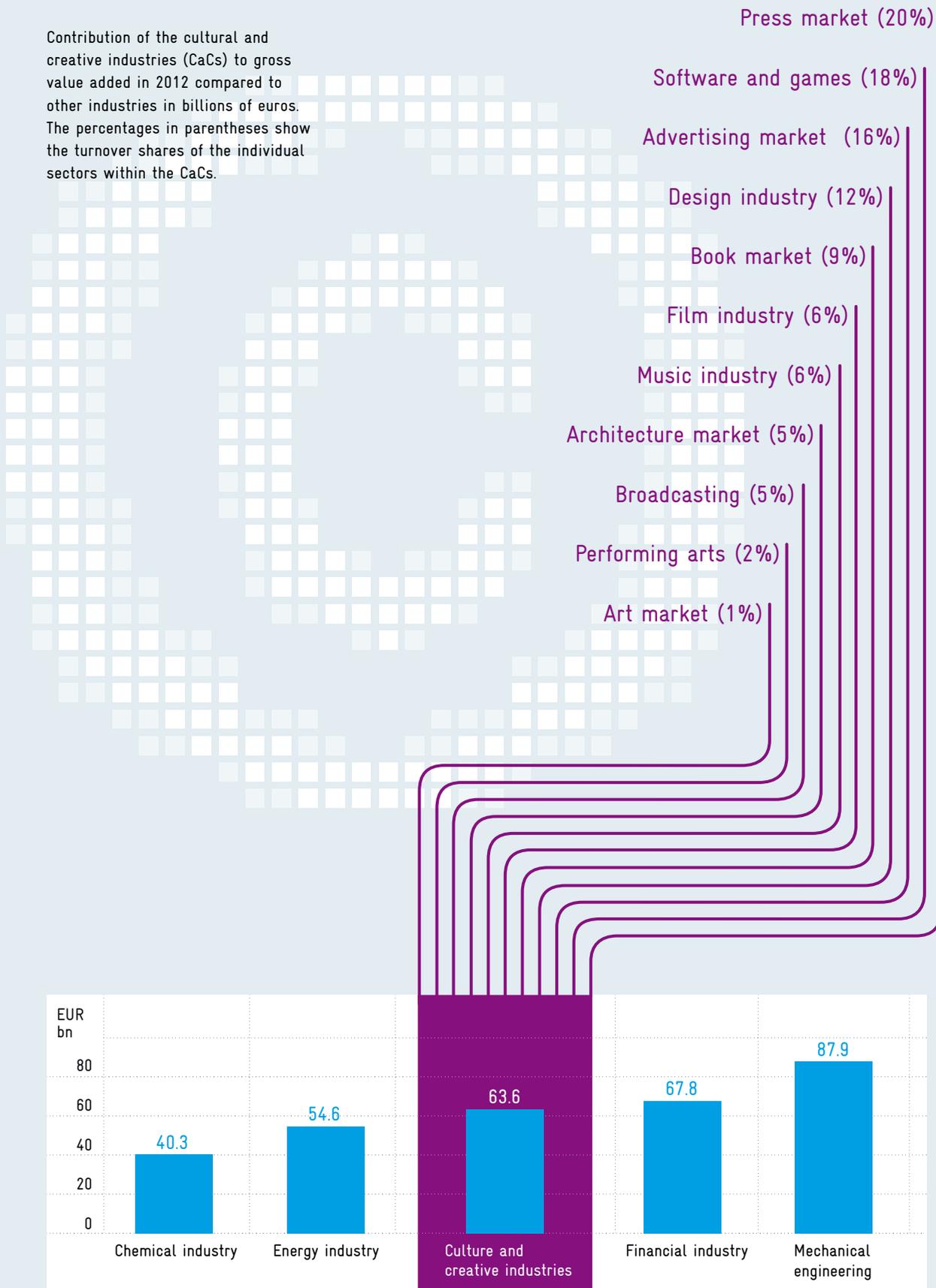
39%

of users don't know which internet channels are legal or illegal.

Source: Own depiction based on Handke et al. (2015) and Ofcom (2013).

Relevant sectors: culture and creative industries

Contribution of the cultural and creative industries (CaCs) to gross value added in 2012 compared to other industries in billions of euros. The percentages in parentheses show the turnover shares of the individual sectors within the CaCs.



Source: Own depiction based on BMWi (2014).

B 3 Digital innovation and the need for reform of copyright law

B 3-1 Aims and importance of copyright law

Copyright law plays an important role in the discussion on the challenges of digitisation and connectedness. The Digital Agenda 2014–2017, which was adopted by the Federal Cabinet on 20 August 2014, is a component of economic and innovation policy. It explicitly refers to copyright and identifies areas where there is a need for reform. The Commission of Experts is examining copyright because it is of fundamental importance for Germany's scientific and economic competitiveness. This complements a discussion that is usually held in the sphere of legal doctrine, adding an economically oriented perspective on copyright and its role in the innovation system.

Great economic and societal importance of copyright law

In Germany the protection of creative works is anchored in the Copyright Act (UrhG), the Law on the Administration of Copyright and Neighbouring Rights (WahrnG) and the Publishing Act (VerlG). Copyright law is part of German civil law. While industrial property law (e.g. patent and trademark law) protects intellectual property in the commercial field, German copyright law aims to protect intellectual property in the cultural field. Literary, scientific and artistic works are protected by copyright law. The first international harmonisation of copyright law was

Box 08

Actors and responsibilities

Copyright law in Germany is subject to a range of different stipulations of international, EU and national constitutional law. The relevant provisions of international law are the Revised Berne Convention (RBC), the Universal Copyright Convention (UCC), the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) and the Treaty on Intellectual Property of the World Intellectual Property Organisation (WIPO).

The international conventions guarantee copyright holders certain minimum rights, such as a period of protection of at least 50 years after the originator's death. Furthermore, any limitations on

protection (exemptions from law) must pass the so-called three-step test.²⁰⁴ Related, albeit weaker rights are granted to performing artists, phonogram producers and broadcasting organisations.²⁰⁵

Stipulations of EU law are generated by the case law of the European Court of Justice. However, there is no general copyright directive in the EU to date – unlike the field of trademark and design law. A relatively far-reaching harmonisation was achieved by the 2001 Directive on Copyright in the Information Society (InfoSoc Directive). Numerous other directives regulate specific areas and the enforcement of legal claims.

Nevertheless, many legal scholars interpret the current situation relating to copyright in the EU as being in need of improvement.²⁰⁶ particularly ambitious approach towards a comprehensive harmonisation would be the creation of an EU Copyright Ordinance. Detailed proposals for such an ordinance have already been developed. For example, a group of European scholars have presented a draft European Copyright Code, which is usually referred to as the "Wittem Code" after its place of origin.²⁰⁷ A less ambitious step forward – but a step forward nevertheless – would be a uniform EU copyright directive.

Box 09

Culture and creative industries

In the “Monitoring of Selected Economic Key Data on the Culture and Creative Industries 2013” (BMWi 2014b), the culture and creative industries are defined as all cultural and creative enterprises that are mainly market-oriented and deal with the creation, production, distribution and/or dissemination through the media of cultural/creative goods and services. The “cultural industries” comprise nine submarkets: music industry, book market, art market, film industry, broadcasting industry, performing arts market, design industry, architecture market and press market. The “creative industries” are made up of the advertising market on the one hand, and the software and games industry on the other. The culture and creative industries thus comprise a total of eleven submarkets.

completed in 1886 with the Berne Convention for the Protection of Literary and Artistic Works (cf. Box 8).

Activities relating to copyright have economic relevance. In its “Monitoring of Selected Economic Key Data on the Culture and Creative Industries 2013” (cf. Box 9) the BMWi states in a comparison of industries that this sector contributed EUR 63.6 billion to gross value added in 2012 – more than the chemical (EUR 40.3 billion) and energy (EUR 54.9 billion) industries and only slightly less than financial service providers (EUR 67.8 billion).²⁰⁸

If the societal importance of property rights is measured by the number of citizens who come into contact with them and whose behaviour is significantly affected, then copyright law is probably the most important public instrument for protecting creativity and innovation – compared to patent or trademark law.

An innovation in the context of the creative and cultural industries is defined as “content generation”, i.e. the first completion of a creative work, e.g. a film or video game.²⁰⁹ Innovations also include technologies and business models that help create, disseminate and further process such works. Moreover, technical or service innovations affect structural change in the copyright industries, e.g. when new media technologies like e-books or MP3 players come onto the market, or new business models – like YouTube or

Spotify – emerge that make digital content available on platforms in the internet.

Excessively long copyright terms are obstacles to innovation

The economic rationale of copyright law is that the copyright owner may exploit his or her own work exclusively and thus exclude other market participants from its use and exploitation for a specific period. Profit expectations from exclusive use generate individual economic incentives for creative output and ensure that the provision of copyright-protected works leads to an increase in societal value added.

Evidence from the economic literature suggests that the law has a positive incentive effect. However, economists tend to be sceptical about the most recent extensions of terms of copyright.²¹⁰ Various historical studies imply that copyright protection generates positive economic effects via higher incomes and a larger number of creative people entering market.²¹¹ However, there is only evidence of positive overall economic effects over short copyright terms of less than about 30 years. The empirical findings support objections to an extension or strengthening of existing copyright protection that have been expressed in recent years.²¹² In particular, cumulative innovation, which is based on the use of existing works, could be impeded, without this effect being offset by stronger incentives for the creative people.

The legal rationale of copyright law in Germany aims to create “an appropriate balance of interests between originators, intermediaries and users” and not to serve “only the personal and economic interests of the originator”.²¹³ In copyright law, legislators distinguish between exploitation rights (e.g. for copying, dissemination and public reproduction) and the originator’s moral rights (e.g. for first publication, attribution and the integrity of the work).

Flexibility through exemptions from law

Exemptions from law are an important instrument for ensuring a fair balance of interests in copyright law. In copyright law, exemptions from law “limit” the exploitation rights of originators in certain situations. For example, the law grants the users of copyright-protected works the freedom for personal reproduction (private copying). In general, exemptions from

law can be coupled with compensation entitlements for the copyright holder.

At the international level there are two legal models for designing exemptions from law. In the US system, a general clause allows the “fair use” of protected works. By contrast, EU law provides for a specific list of exceptions. The US system is said to be more flexible than the European one. On the other hand, it leads to more legal uncertainty, since the grey areas in the definition of “fair use” have to be interpreted in court.²¹⁴

Furthermore, European and German copyright law currently provide for special exemptions from law and other copyright-related regulations in the field of science and research which aim to serve the common interest in open scientific communication. However, exemptions from law – such as reproduction at terminals in libraries – are hardly applied in practice. The exemptions from law created in 2003 – for the public reproduction of small parts of a work and works (section 52a of the UrhG), reproduction at terminals in libraries (section 52b of the UrhG) and for the dispatch of copies (section 53a of the UrhG) have a particularly large number of unresolved interpretation issues and are therefore hardly used in practice.²¹⁵ The introduction of a general exemption to copyright for scientific purposes, by contrast, represents a flexible and practical alternative that goes beyond the privileges for scientists and users under existing law.²¹⁶ At the same time, however, any general exemption to copyright for scientific purposes should meet the requirements of the three-step test and be complemented by compulsory compensation.²¹⁷

B 3–2 Effects of digitisation on the copyright industries

Changed cost structures for the creation and distribution of creative works

Digitisation is greatly influencing cost structures in creative industries. The costs of making copies of creative works fall, and – unlike in the analogue world – the digital copies maintain the quality of the original. In addition, distribution costs also decline because of the greater connectedness of online users. These effects became especially visible with the spread of the internet and the advent of file-sharing networks like Napster and platforms like MySpace or Soundcloud, where owners of digital

music files are (or were) able to network and give each other access to the respective titles.²¹⁸

However, digital technology also reduces the fixed and variable costs of producing creative works. The cost of access to a music studio, to facilities for making audio and video recordings, and to the creative processing of digital works are falling considerably, leading to an increase in the number of people entering creative work domains, be it for recreation or in commercial markets. Another important implication is that creative people are much less dependent on the selection mechanisms of traditional intermediaries. For example, artists who create music can today be successful without having a contract with one of the main publishing companies (“major labels”), because it has become possible for them to disseminate their own works on the internet without intermediaries. Cost reductions induced by digitisation and the lowering of market-entry barriers must in principle be seen as a positive development from an economic perspective, even if this means that the role and importance of classic intermediaries decline.

Participation of new innovation actors

Copyright law is implicitly based on historically grown assumptions on the different roles and activities of artists, copyright holders and users. In the world before digitisation, only artists acted creatively, whereas users only consumed – this was the assumption. Since licensing negotiations between artists and the numerous users would be inefficient due to transaction costs, copyright holders act as intermediaries. The latter sometimes take on further functions, e.g. choosing artists, advertising the works or organising the distribution. The users’ contribution to value added consists only of consuming the work. From this point of view, copyright law primarily aims to control user behaviour or prevent unauthorised reproductions.

In a digital, connected world, however, users increasingly become creative people who make works for their own use, without necessarily substituting services that are commercially offered on the market. In some cases, subsequent market entries also turn creative users into suppliers of works who increase the variety of products available on the market.

In this context, an extension of property rights can be detrimental from an economic perspective, since cumulative innovations are restricted:²¹⁹ when inno-

vations build on each other, excessive protection for the first innovator can reduce the incentives for subsequent innovations (cumulative innovations) or make them more expensive. Creative users could be granted greater freedoms in this context, for example by introducing a corresponding exemption from law. Despite a relaxation of protection, such regulations can remain linked to compensation entitlements for the first innovator.

Ambivalent user behaviour

A detailed and differentiated description and evaluation of user behaviour is an important precondition if copyright law is to be adequately adapted to the developments of digitisation. It will require systematic studies financed by neutral (perhaps public) institutions and conducted by neutral research institutes, like the studies commissioned by the British Office of Communications (Ofcom). Every quarter, Ofcom collects and evaluates data on user behaviour in six categories: music, films, TV programmes, computer software, books and video games. For example, the fourth wave of Ofcom studies comes to the conclusion that one in six users (17 percent) consumed at least one digital product illegally between March and May 2013. Illegal behaviour in the consumption of digital works varies according to product type. It is most pronounced in music, but very low in fields like software, video games and books.²²⁰

Two observations made by the Ofcom studies are particularly interesting. Users who consume digital products via both legal and illegal channels spend much more on digital content per quarter (EUR 112.47 on average) than users who behave perfectly legally (EUR 48.50).²²¹ One possible interpretation is that the first group do a lot of “sampling”: i.e. products are first tested illegally and then bought legally. Furthermore, the findings suggest that a large proportion of users do not know which offers are legal and which are illegal. 39 percent of the respondents²²² state that they are not at all – or not especially – sure about the legality of offers. In other words, overly complex copyright laws could create their own piracy.²²³

Ineffective enforcement procedures

Reports on rising piracy in the digital domain have led to calls for stronger copyright enforcement. Primarily multilevel, escalating procedures are used in this context.²²⁴ In the meantime, however, the success

of such measures (e.g. Hadopi in France, cf. Box 10) is now being critically questioned.²²⁵ A recent empirical analysis of enforcement measures in several countries confirms this sceptical assessment.²²⁶

The formal warning regulation used in Germany is problematic because it involves an inherent risk of abuse and shifts the burden of proof onto the addressees when the legal situation is unclear.²²⁷ The costs of the first warning to private individuals should therefore be borne by the copyright holders themselves. They should not be able to demand reimbursement of their dunning costs unless the internet-access provider has issued a first violation alert at the holder’s request and the infringement has nevertheless continued.²²⁸

Growing importance of user-generated content

The OECD (2007) defines user-generated content on the basis of three central criteria: (i) the content must be distributed on the internet, (ii) the work must involve creative effort and not just be a reproduction of existing content, and (iii) the content must be produced without any direct involvement by established companies in the copyright industries.²²⁹

To date there is no uniform concept of methods or indicators for quantifying the value of user-generated content. Recent economic literature focuses in particular on the importance of user-generated content in the sense of user capital. User capital differs from a company’s other intangible assets – such as human capital or brand value – in that it has no direct relation to tangible corporate assets. Rather, the emergence of user capital is subject to the control of the users, who provide services in this context and bear the costs. One vivid example is internet platforms like Facebook, which generates incentives for users to create and exchange content themselves. The online platforms make most of their profits from advertising revenue, which increases, the more users participate and generate content, and the longer the users remain on websites. Empirical studies on the US media industry indicate that more than 60 percent of the market value of such online businesses stems from user capital.²³⁰

Box 10

Enforcement measures in France

In 2009, the French Government passed the “Haute Autorité pour la diffusion des oeuvres et la protection des droits sur internet”, or Hadopi Act, with the aim of improving the enforcement of rights on the internet; it was modified in 2010 and 2013. A state authority with the same name was created as part of the application of the law. It is to this authority that accredited copyright holders report suspected legal violations by users on the internet, particularly on file-sharing networks. The authority subsequently examines the legal situation and, where appropriate, asks the internet service providers for the infringer’s user data.

The Hadopi authority uses a three-stage enforcement mechanism. In the first step, violation alerts are sent by email drawing the attention of the internet-access owner to the currently illegal use. At the same time the infringer is informed about possible further consequences, the economic

damage being suffered by the copyright holders, and alternative, legal offers. The second step ensues if there is a further infringement within the next six months, in which case the authority again sends the same violation alert by email – plus an official letter with the same contents. If there is a further violation in course of the next year, this can lead to the internet access being blocked – but still paid for – for up to twelve months and a maximum fine of EUR 1,500 being imposed. Even if the owner of an internet connection is demonstrably not the actual infringer, this person is nevertheless liable in the course of the procedure and has to reckon with comparable sanctions and punishments.

After only a year, the authority had already received more than 18 million reports of infringements, i.e. around 25,000 to 50,000 per day, so that only a very small proportion of the reports led to actual court proceedings. In 2011

alone, the public costs of implementing the Hadopi legislation totalled more than EUR 10 million. The copyright holders are not directly involved in financing enforcement, but they do have to invest in the monitoring of the online markets in order to uncover copyright violations which are later reported to the Hadopi authority.

In 2013, the Lescure Commission’s evaluation report on the effectiveness of the Hadopi measures came to the conclusion that the main aims had not been reached. Although there had been an overall decrease in the number of violations in the field of file-sharing networks, the infringers had not increased their use of legal offers; rather, most of them had switched to alternative platforms and technologies with illegal content. The Hadopi law was revoked by the French Government in mid-2013.²³¹

B 3-3 Innovation and structural change in the copyright industries

More innovation despite difficult revenue situation

The German music and film industries have been greatly affected by structural change – at the latest since the turn of the millennium. The music industry in particular has experienced a massive decline in revenue since 2001. To be more specific, annual turnover fell by more than half in the period up to 2011 (cf. Figure 2). In the film industry, by contrast, sales have stabilised again following a slight decline in figures after 2005 (cf. Figure 3).

At the same time, companies of both industries have succeeded in maintaining their innovation dynamics

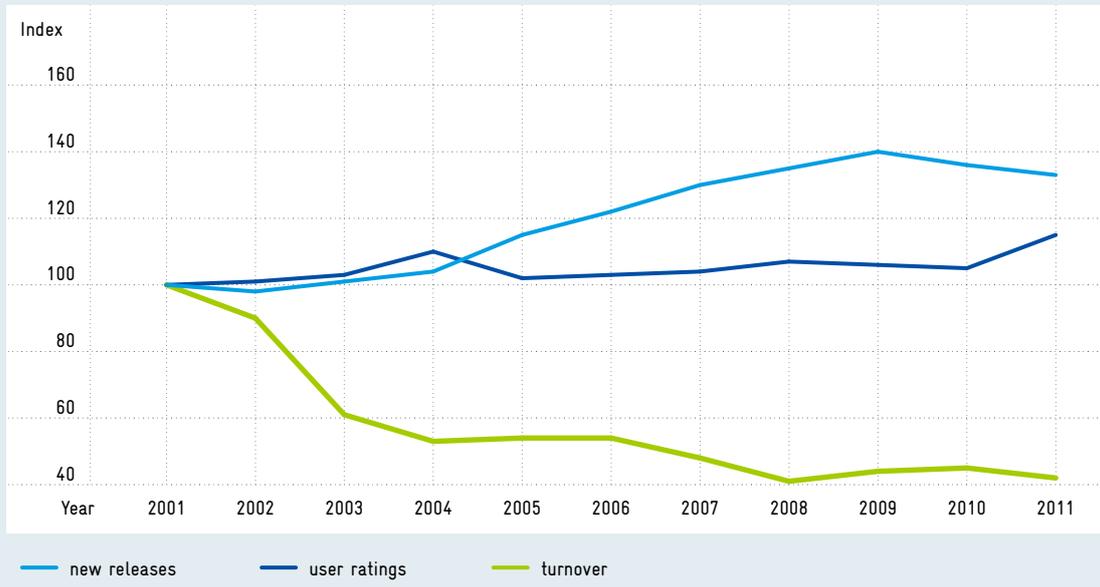
despite this massive structural change: the annual number of new releases in the music industry rose in this period by more than 30 percent compared to the 2001 baseline year (cf. Figure 2); new releases in the film sector grew by more than 50 percent in the same period (cf. Figure 3). This has led to a marked increase in the overall diversity of supply in both industries. At the same time, trends in average user ratings²³² of music and movie titles currently provide no evidence of a reduction in the quality of the fast-growing supply of works.²³³

Additional innovations by creative users

A much publicised development in the culture and creative industries is the increased participation of

German music industry: new releases, user ratings, turnover, 2001 to 2011

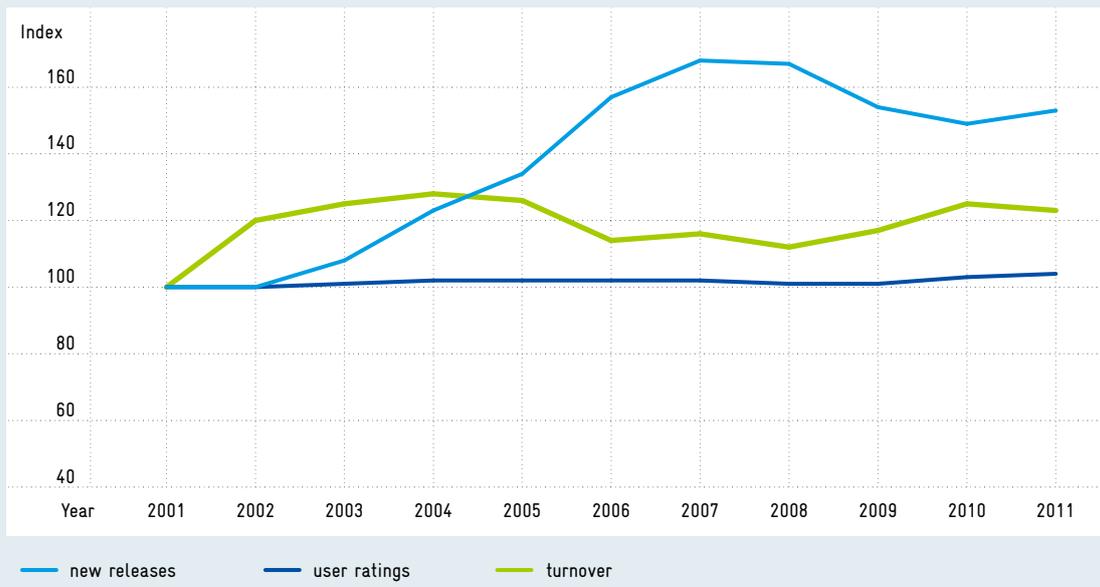
Fig 02
Data
Download



Index: 2001 = 100
Source: Own depiction based on Handke et al. (2015).

German film industry: new releases, user ratings, turnover, 2001 to 2011

Fig 03
Data
Download



Index: 2001 = 100
Source: Own depiction based on Handke et al. (2015).

B

Box 11

Empirical evidence on the impact of copyright law on the innovation activities and turnover of specific copyright industries

A recent econometric analysis examined the linkages between innovation activity and copyright law in Germany and several reference countries.²³⁴ The study's findings suggest that there is no significant causal relationship. The strength of copyright law and the extent of unauthorised copying of digital content have no influence on the number of new releases in the music and film industry. Furthermore, there is no evidence in either of the in-

dustries that copyright law has changed the quality of the supply (as measured by user ratings of music and films). However, caution is required when interpreting the study results. The possibility cannot be excluded that positive and negative digitisation effects are cancelling each other out or, more precisely, that incentives for innovation are being reduced by lost revenue, and simultaneously increased by productivity growth.

No conclusive assessment can be made on the basis of the study as to the causal effect of either copyright law or digitisation on the development of turnover in the individual sectors. However, there are initial indications that digitisation has had a positive impact on the film industry's turnover. This applies particularly to video sales, which are actually strongly affected by illegal copying activity, yet seem to benefit overall.

private end users in production processes. The on-line dissemination of copyright-protected works on file-sharing platforms is an impressive example of this: users make works available to each other free of charge, although the technical platforms they use are often commercial operating companies.

In recent years, it has become clear that more private end-users are creating content themselves that is widely disseminated and can even develop a considerable market value.²³⁵ A large proportion of the content accessible on the YouTube video portal, for example, comes from private end-users; above a certain number of user visits, YouTube now pays part of its advertising revenue to the people who uploaded the content. However, user-generated activities are not captured by official statistics on turnover and employment, because they often do not take place within the formal categories or on the traditional markets of the culture and creative industries.

On the basis of a random sample of 500 videos on YouTube, a recent study conducted on behalf of the Commission of Experts came to the conclusion that 33 percent of the videos posted on YouTube can be classified as user-generated content.²³⁶ An additional 21 percent of the videos in the sample at least indicate a certain creative contribution by the users (cf. Table 1). These are hybrid forms of creative works which also include professional content. Less than half of the videos have a purely professional background (46 percent).

Counting the number of hits, professional content is selected more than five times as frequently as purely user-generated content. However, if the average user ratings (likes) are used as the measure of content quality, there are hardly any differences between user-generated works and professional ones. On the basis of the sample, it is not possible to study developments over time or assess whether or not commercial offers are being replaced by user-generated content.

Up to now, existing copyright law has not been geared to dealing with this important change – especially in Germany, where the originator's consent is required for the publication and exploitation of a remixed or redesigned work. However, this consent is difficult to obtain, especially for private individuals, because the right to remix is not exercised by collecting societies. This is why many forms of user-generated creativity – e.g. FanFiction and Mashups – are currently in a legal limbo.²³⁷

In principle, however, the legal framework in Germany, as defined by sections 23 and 24 of the German Copyright Act (UrhG), is broad enough for reforms to create leeway for creative remixes that can still be distinguished from the original and comply with the moral rights of the first originator pursuant to section 14 of the UrhG. A distinction could also be made between the non-commercial public reproduction of remixed works in the internet and activities targeting a commercial purpose.²³⁹

Types²³⁸ of video content on the internet

Note: video searches were carried out on YouTube based on a random sample of words in different languages. In each case, a video was subsequently chosen randomly from the first ten search results listed. A random sample of 500 videos was generated in this way. The upload year, the number of views and the user rating (likes or dislikes) were recorded for each of these videos.

	Number of videos	Number of views	Average no. of views per video	No. of likes	Average no. of likes per video (per 1,000 views)
User-generated content	166 (33%)	6,748,299 (12%)	40,652	27,423 (38%)	165 (4 von 1,000)
Hybrid forms	103 (21%)	12,161,192 (21%)	118,070	730 (1%)	7 (6 von 10,000)
Professionally produced content	231 (46%)	38,502,567 (67%)	166,678	44,975 (61%)	194 (1 von 1,000)
Total (1 per 1,000)	500 (100%)	57,412,096 (100%)	325,400	73,128 (100%)	146 (1 von 1,000)

Source: Handke et al. (2015).

Tab 01

Data
Download

Foreign legal systems already contain regulations that allow parody or other adaptations by users without requiring the copyright holder's consent. For example, the Canadian Copyright Act allows creative remixes for non-commercial purposes, provided that they do not substitute the original work.²⁴⁰ The introduction of a similar exemption from law is currently under discussion in Ireland.

An overview of reform efforts in selected countries shows that up to now there is no international blueprint that might be regarded as a guideline.²⁴² Furthermore, it becomes clear that Germany is going it alone with some of its regulations. Especially problematic in this context is the reform of ancillary copyright law for publishing houses, which was passed by the German parliament after a fierce debate, even though scholars were unanimous in their sharp criticism of the proposal.²⁴³

B 3–4 Reform measures in Germany and other countries

In the past, although copyright law has been harmonised across national boundaries in many areas, considerable differences remain that hinder the trade in digital goods to a varying degree. For example, to date it has not been finally clarified in the legal context whether the digital distribution of unused licenses of ("used") software by users or third parties – without the consent of the actual software company – is allowed.²⁴¹ Most national legislators basically face the challenge of adapting copyright law to the developments of digitisation and ensuring greater public acceptance of the law. In Germany, a first set of copyright reforms (Zweiter Korb), which included new regulations on private copying, came into force in 2008. Most of the legal changes introduced by a second set of reforms (Dritter Korb) have already been implemented.

Recommendations

Copyright law lays down important framework conditions for creativity and innovation in a digital economy. The Commission of Experts therefore welcomes the fact that the Federal Government attaches great importance to the design of copyright law. The Commission believes there should be a shift in thinking on copyright law to make it more innovation-friendly. The design of this legal norm is part of Germany's economic and innovation policy – it must be more economically grounded than it has been in the past.

Digitisation and connectedness in copyright industries currently take place at high speed and also have an impact on innovation in these and related industries. In order to fully exploit Germany's innovation potential, the Commission of Experts recommends

B 3–5

the following measures which, where appropriate, should be implemented in a European context:

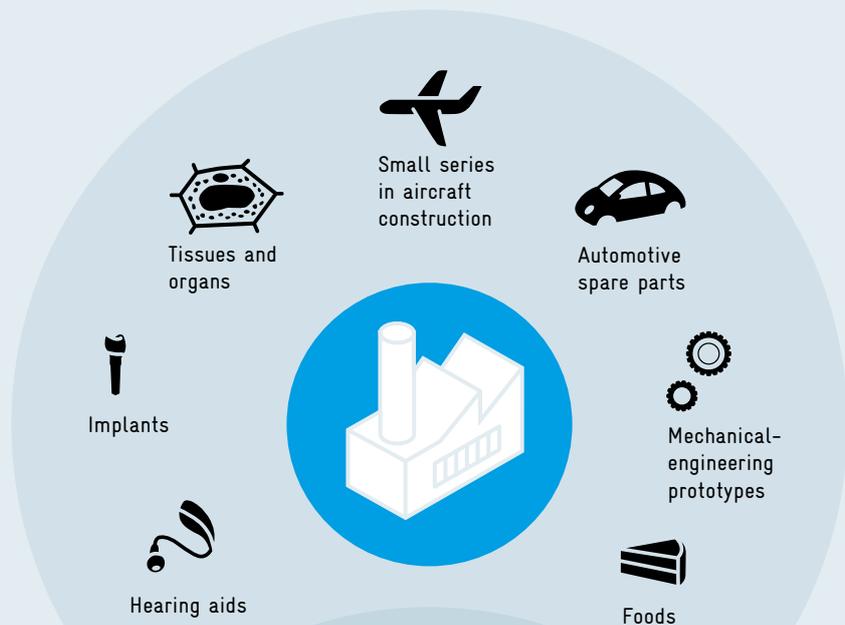
- The creative redesign of works should be permitted in order to set incentives for user innovations. Redesigns should be permissible based on an exemption from law, provided that – as demanded by the Wittem Group – an inherent difference from the original work is maintained, and provided that the redesign is non-commercial.
- Access to scientific findings should be simplified. To achieve this, a general exemption to copyright for scientific and education purposes should be introduced, thereby providing practicable regulations for the broadest possible access to the stock of knowledge. This exemption from law should be complemented by compulsory compensation. The current complex rules of German copyright for the domain of science have to be simplified.
- The current copyright regulations are very complex and therefore oppose a greater public acceptance of the law. The Commission of Experts therefore urges the Federal Government to simplify the copyright provisions as part of their ongoing reform efforts. These steps should also be flanked by policy measures that improve awareness among users and increase the transparency of copyright law.
- Sending violation alerts is a useful alternative to the common practice of issuing formal warnings. Violation alerts can help inform about rights violations and create transparency. A legal claim for reimbursement of the costs of a formal warning should be tied to the condition that a prior violation alert has been sent via the internet service provider to the infringer.
- Empirical research on the impact of copyright law on business models and innovation in the digital economy is still at an early stage in Germany. The necessary data infrastructure should be rapidly built up, and the responsible ministries should attach greater importance to further analyses on the effects of copyright.

Additive manufacturing ("3D printing")

Additive manufacturing (AM) or 3D-printing allows the direct manufacture of three-dimensional physical objects on the basis of digital information, e.g. in the form of a 3D-CAD data set. In this manufacturing process, products are usually manufactured by applying layer after layer of metals or plastics.

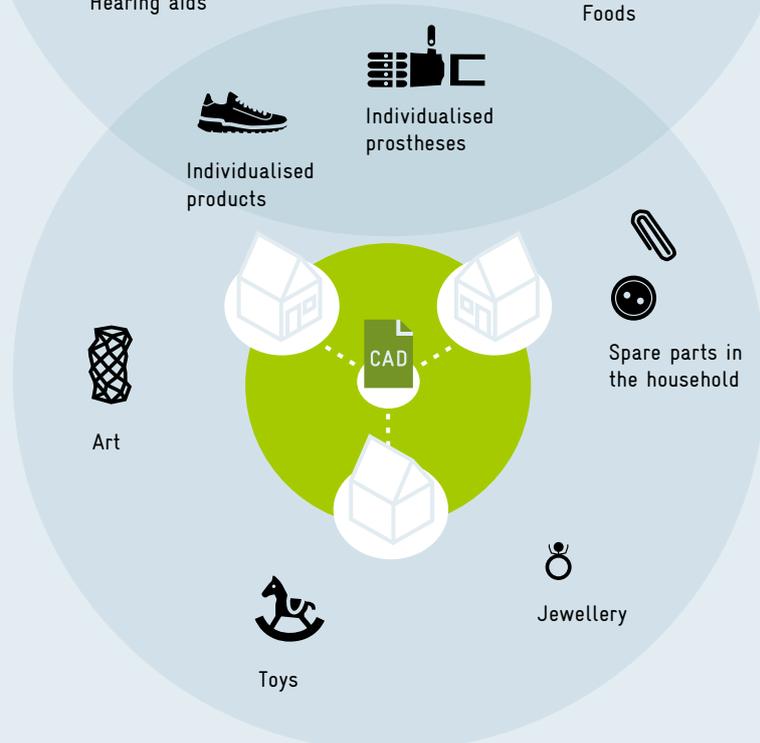
Applications in industry

A wide variety of materials are used in industry, e.g. metals, plastics, ceramics, even living cells.



Private applications

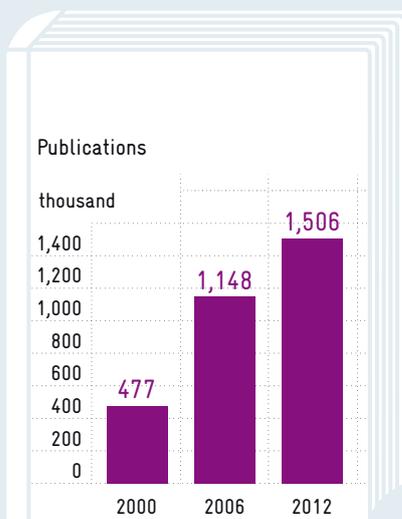
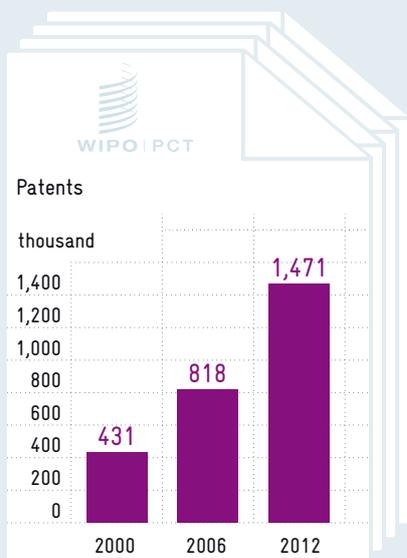
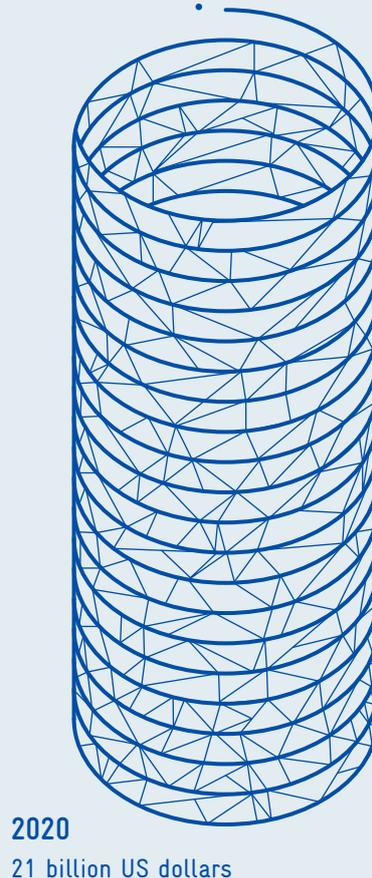
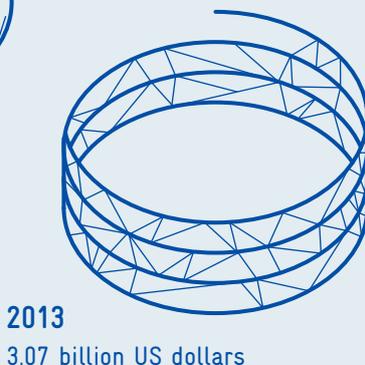
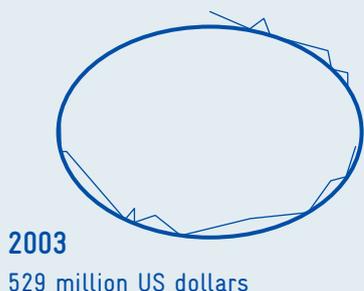
AM technologies are also used by private individuals. In the "maker movement", users network, exchange digital designs and individualise products.



Source: Own depiction.

Global turnover from the sale of AM goods and services in US dollars

AM goods include 3D printers, material, accessories and software, as well as AM-related services used to make additively manufactured products. Additively manufactured products are not included here.



Patents and publications

AM is a research- and innovation-intensive field. The number of scientific publications and patent applications worldwide in this field has risen strongly in recent years.

Source: Own depiction. Data on turnover: cf. Wohlers (2014: 110ff.), patent and scientific publication data based on written information from Fraunhofer IGD and Prognos AG.

B 4 Additive manufacturing ("3D printing")

B 4-1 Status quo and prospects

Additive manufacturing (AM) – also known under the terms “3D printing” or “generative manufacturing processes” – makes it possible to produce three-dimensional physical objects directly from digital information, e.g. in the form of a 3D CAD dataset.²⁴⁴ Unlike traditional subtractive manufacturing processes like milling and turning, or formative processes like casting and forging, in the case of additive manufacturing processes products are usually made by adding layer after layer of metals or plastics.²⁴⁵ This principle of layering allows the flexible production of almost any geometry or internal structure, however complex. In this way, it offers almost unlimited creative and design freedom when working with materials.²⁴⁶ One key advantage of AM is its versatility. AM can be used in a wide range of manufacturing industries – from aerospace to healthcare. It is even possible to build structures with living cells (“bioprinting”) with AM.

Furthermore, AM is also becoming more and more attractive for new user groups – both in the industrial sector and in private households – due to falling prices for the technical infrastructure. AM is therefore a suitable way to accelerate – and improve the quality of – product development thanks to the rapid availability of complex prototypes. The streamlining of the production steps enables companies to respond more quickly than traditional manufacturing processes to market requirements at much lower process costs. This can considerably shorten product development and the time to market,²⁴⁷ enabling companies to react flexibly to shorter product life cycles.²⁴⁸

AM is not a completely new technology. However, since the first fully functional system was unveiled in 1984, AM has been used almost exclusively for specific industrial applications such as the accelerated development of prototypes (rapid prototyping).²⁴⁹

Only since its application possibilities have become ever broader and costs have fallen has AM developed into a technology that is no longer used only in the industrial context, but also by private users, thus attracting a growing amount of public attention.

The technological maturity of AM technologies varies depending on the area of application – industrial automation, medical technology, bioprinting or home-based production by consumers (maker movement. cf. Box 12). Bioprinting and home-based production by consumers are at an early technological stage, whereas industrial AM is already regarded as an established technology.²⁵⁰

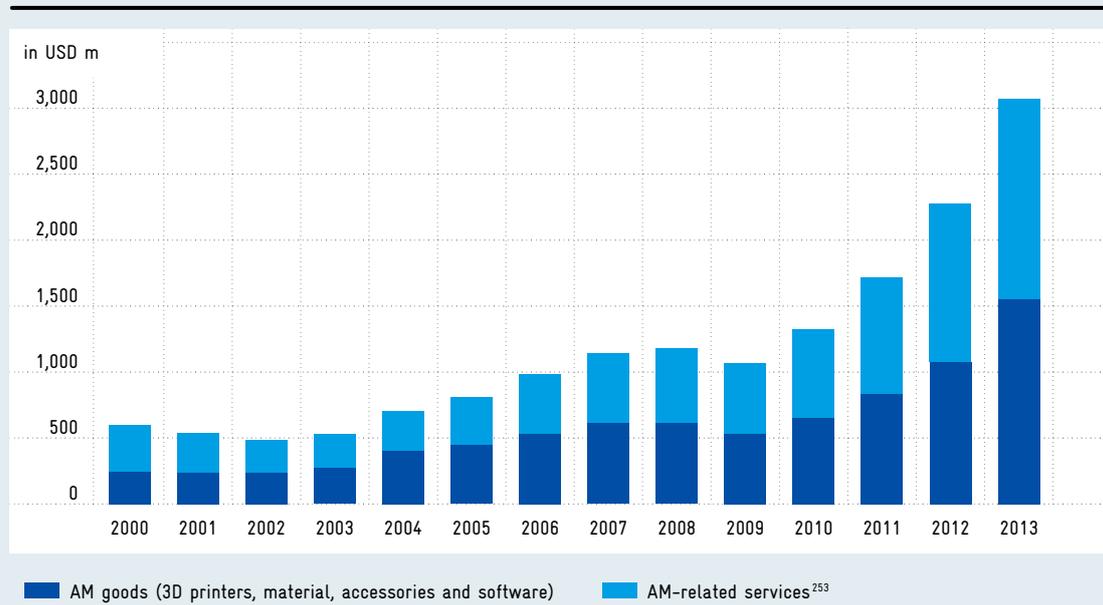
The Commission of Experts analyses the potential of AM for production and innovation and offers recommendations on whether and how framework conditions should be improved and existing support activities adapted.

Market situation in the field of additive manufacturing

Due to its versatile applications, AM is a much-debated technology that is thought to have a disruptive potential.²⁵¹ Products made by additive manufacturing are to be found primarily in the following sectors: motor vehicles and vehicle engines, chemical products, aircraft and spacecraft, machinery for generating and using mechanical energy, medical equipment and orthopaedic products, as well as measuring, monitoring, navigation and other instruments and devices.²⁵²

There are no reliable estimates on turnover generated by additively manufactured products. Market estimates and forecasts on market development only exist on the supplier side (suppliers of AM goods and AM-related services for producing additively manufactured products). The figures differ considerably depending on how the market is defined.

Global turnover with AM goods (hardware and software) and services in millions of US dollars



Source: Cf. Wohlers (2014: 110).

Fig 04

Data
Download

According to a study by a market-research company, global turnover from the sale of AM goods and AM-related services rose from 600 million to 3 billion US dollars per year between 2000 and 2013 (cf. Figure 4).²⁵⁴ By 2020, annual turnover is expected to rise to about 21 billion US dollars.²⁵⁵

Looking at Germany, a study conducted on behalf of the Federal Ministry for Economic Affairs and Energy (BMWi) has concluded that German companies generated between 15 and 20 percent of global turnover in AM goods and services in 2010 (1.3 billion US dollars).²⁵⁶ Using a narrow market definition, this corresponds to a volume of 200 to 250 million US dollars. If a broader definition²⁵⁷ of AM goods is used, approximately 1,000 companies making AM-relevant hard- and software or offering such services are operating in Germany. Their turnover for 2010 is estimated at EUR 8.7 billion. Assuming annual turnover growth of up to 15 percent (as the study does), the sales volume of German companies could grow to EUR 35.1 billion by 2020.²⁵⁸ These rough estimates underline AM's market potential. Prerequisites for such strong growth, however, include constant innovations and the development of new applications.²⁵⁹

Supply side: mainly medium-sized companies

The supply side in AM goods and services reflects the typical size structure of Germany's corporate landscape. Almost half of the approximately 1,000 companies mentioned in the above study have fewer than 25 employees. Almost two thirds of the firms generate an annual turnover of less than EUR 5 million. The EU defines small and medium-sized enterprises (SMEs) as firms with up to 250 employees. According to this definition, over 90 percent of the AM companies in the study are SMEs.²⁶⁰

The authors of the study classify many of the companies as world-market-oriented technology producers in a good competitive position and with a high propensity to innovate:²⁶¹ overall, Germany is a net exporter of AM goods and services.²⁶² About 160 of the identified companies operate as developers and producers of AM hardware; approximately 240 companies develop AM-relevant software; the remaining companies are either exclusively service providers or offer services in combination with hard- and software solutions.²⁶³

However, the AM device manufacturers (3D printer manufacturers) with the biggest global market share are located in the USA.²⁶⁴ The most important German producers, which also are very well positioned on the world market, include EOS Electro Optical Systems GmbH (Krailing, turnover in 2013: EUR 45.8 million), SLM Solutions GmbH (Lübeck, EUR 21 million), Voxeljet AG (Friedberg, EUR 11.7 million), Concept Laser GmbH (Lichtenfels, EUR 7 million), Envisiontec GmbH (Gladbeck, EUR 4.4 million) and Realizer GmbH (Borchen, EUR 2.6 million).²⁶⁵ In addition, established German mechanical engineering companies like Trumpf AG are also active in the development and manufacture of AM devices (3D printers).²⁶⁶

Support for additive manufacturing: an international comparison

In the past few years, many industrialised countries have recognised the growing importance of AM and set up support programmes for domestic AM businesses. Some of these programmes are briefly presented below to make it easier to classify Germany's support policies.

USA: The US government attaches great importance to AM and supports research, industrial applications, start-ups and the so-called maker movement.²⁶⁷ The aim in promoting AM is to rebuild lost industrial production capacity and create new jobs.²⁶⁸ In this context, AM funding is an integral part of a programme, launched in 2012, called the National Network of Manufacturing Innovation, which included the establishment of the National Additive Manufacturing Innovation Institute (called "America Makes" since 2013) as a pilot facility.²⁶⁹ America Makes is a public-private partnership of about 50 companies, 28 universities and research institutions, and 16 other organisations; the US government says it has provided 50 million US dollars in funding for the pilot.

The aim is to accelerate the development and transfer of AM technologies into the manufacturing sector and in this way improve the international competitiveness of the manufacturing industry in the USA.²⁷⁰ President Obama has announced that further Additive Manufacturing Innovation Institutes are to be set up.²⁷¹

China: There are concerns in China that the country might lose some of its attraction as a manufacturing location for the export market. In particular, people

fear that US and European companies could develop AM capacity directly within their respective sales markets and thus withdraw some of their production from China.²⁷²

This is probably why the Chinese government is supporting the development of a strong domestic AM industry. Since 2013, the Asian Manufacturing Association (AMA), a state-supported trading group, has been building up ten institutions engaged in AM research. Each institute initially received 3.3 million US dollars in funding.²⁷³ AM research capacity has also been expanded at some Chinese universities. Overall, China's government has earmarked around 245 million US dollars to fund AM projects over a period of three years.²⁷⁴ A strong and internationally successful business community has not developed so far; the Chinese AM industry is still dominated by public institutions.²⁷⁵

EU: The European Commission calls AM a driver of digital change and is optimistic about the prospects of strengthening Europe's manufacturing sector with the help of AM.²⁷⁶ At present, there are no support programmes specifically dedicated to AM at the EU level; rather, support is provided primarily in the context of general programmes and application fields.²⁷⁷ For example, the eighth Framework Programme for Research and Innovation – "Horizon 2020" – is funding research projects on new AM-relevant materials and processes.²⁷⁸ Furthermore, the EU is responding to the need to create uniform standards and coordinate standardisation activities in Europe with its initiative "Support Action for Standardisation in Additive Manufacturing" (SASAM).²⁷⁹

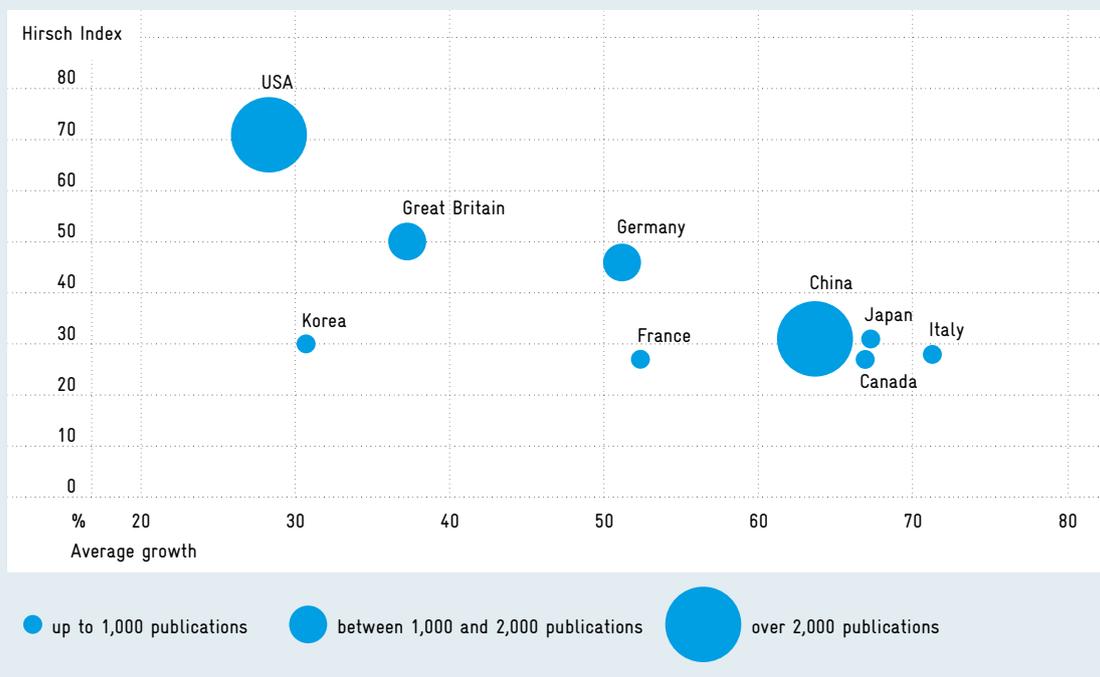
Germany: The Federal Government is promoting AM as part of its institutional funding for relevant non-university research institutions and in the context of federal project funding. The Federal Government has expanded its support activities in the field of AM.²⁸⁰ As at the EU level, AM is being promoted primarily in the context of specific applications. One example is the BMWi's Gemini Project for the development of viable business models in the context of Industry 4.0.²⁸¹ In addition, the BMWi is considering supporting AM in combination with ICT applications.

In addition to this support in the context of specific applications, the BMBF has also initiated measures in the meantime which primarily support AM research by, or cooperation between, research institutes and companies.²⁸²

Fig 05

Data
Download

Number, quality (Hirsch Index) and average growth of AM-relevant publications (2000 to 2014) in selected countries



Source: Scopus. Research and calculations by Fraunhofer IGD.

Note: Calculations of average growth are based on the changes between 3-year time slices over the entire period.

Furthermore, the BMBF promotes AM under the non-thematic Zwanzig20 regional development programme. In this context, the BMBF is providing up to EUR 45 million between 2013 and 2020 for a project called “Additive Generative Manufacturing – The 3D Revolution for Product Manufacturing in the Digital Age”.²⁸³ The aim of the Zwanzig20 programme is to promote collaborations between research institutions and companies in the new Länder.²⁸⁴

The Commission of Experts welcomes the fact that AM technology is now attracting greater interest in the Federal Government’s support programmes. However, an overarching strategic framework for this support seems to be lacking at present.

B 4–2 Publication and patenting activities in the field of additive manufacturing

Increasing publication activities

The annual number of scientific publications on AM-relevant subjects²⁸⁵ almost quadrupled world-

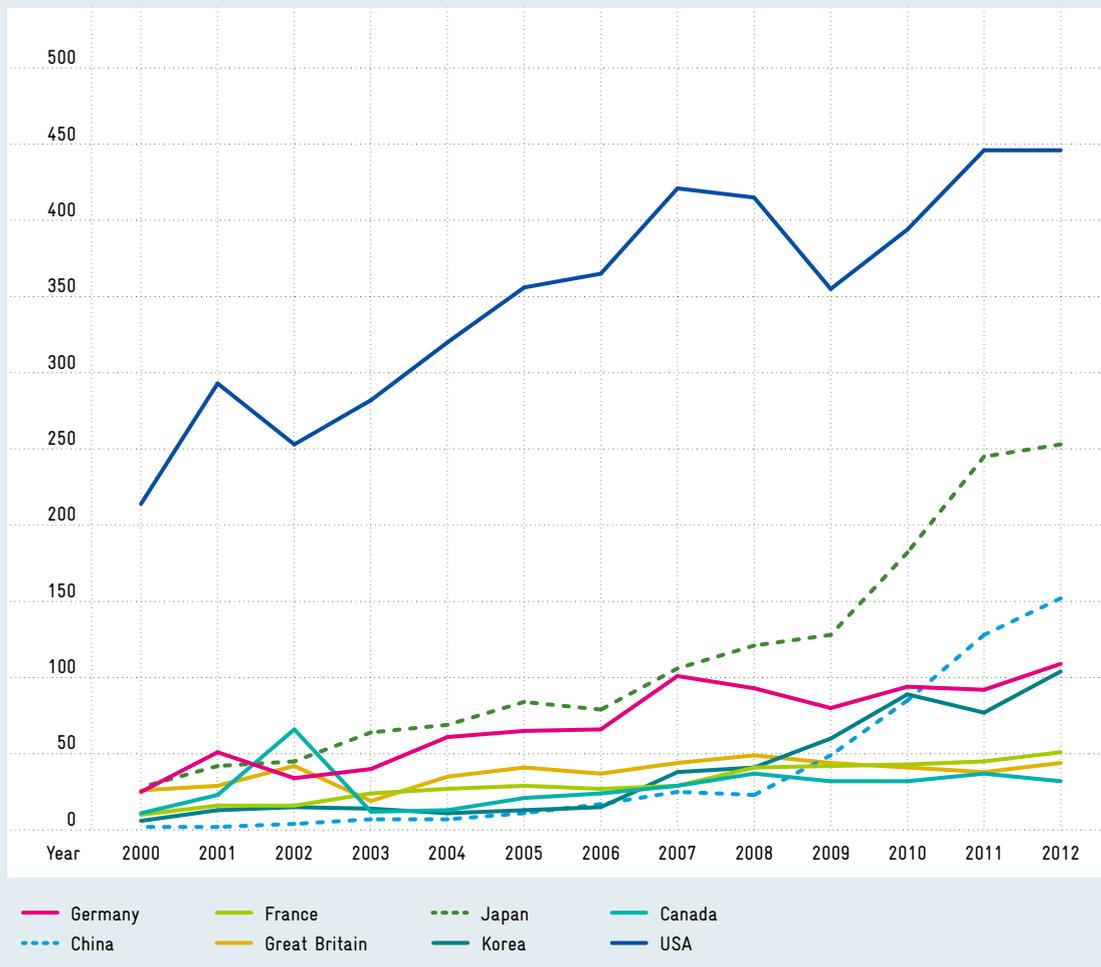
wide during the study period – from 477 in 2000 to 1,793 in 2013 (cf. infographic at the beginning of the chapter).²⁸⁶ Scientists resident in the USA were involved in a particularly large proportion of the publications in this period (cf. Figure 5), followed by China-based and Germany-based scientists. Scientists resident in the UK were in fourth place.²⁸⁷ The world’s most prolific institutions when it comes to publications on AM research are Loughborough University in the UK and Huazhong University of Science and Technology in China. There are three German universities in the Top 30 of the best research facilities worldwide in this field: the Technical University of Munich, the Friedrich Alexander University of Erlangen-Nuremberg, and the RWTH Aachen University of Technology. In addition, publications by scientists resident in Germany are of high quality by international comparison, as measured by the Hirsch Index.²⁸⁸ Only publications in the USA and the UK are of even higher quality.

The number of scientific publications has grown especially strongly since 2000 in Italy, Canada, Japan and China. In Germany, too, much more is being

Fig 06

Data
Download

Development of the number of AM-relevant PCT patent families in selected countries, 2000 to 2012



Source: Database of the European Patent Office (EPO) DocDB/INPADOC. Research and calculations by Prognos AG. Note: Fractional counting²⁸⁹

published than in 2000, although the average annual increase is slightly lower than in the countries with particularly high growth rates.

Increase in internationally registered patent families

Worldwide, the number of AM-relevant²⁹⁰ PCT patent families²⁹¹ more than tripled between 2000 and 2012 (cf. infographic at the beginning of the chapter). By far the biggest share of all patent families worldwide in 2012 were applied for in the USA and Japan (cf. Figure 6). Applicants in Germany followed in fourth place. The rapidly growing patenting activities in Asia since 2008 have been particularly striking.

Additive manufacturing's potential for innovation and production

B 4-3

Today, AM already provides an important technological basis for innovative and production processes in industry. This applies in particular to prototyping in product development and to the manufacture of tools for industrial production. Manufacturing based on AM makes it possible to produce in particular small quantities at a lower cost than when traditional methods are used.²⁹² The time and costs involved in implementing a new design are reduced in this virtually tool-free form of manufacturing (“rapid manufacturing”). For example, it is no longer necessary to adjust casting moulds or other component-dependent manufacturing tools.²⁹³ Instead, only the new, digital

design, i.e. a corresponding CAD file, needs to be replaced. And it can be used as often as necessary, also at multiple locations at the same time – without generating high production costs.

The use of AM represents a process innovation that also opens up greater freedoms in the development of new products and allows more product variety. It makes the industrial production of more complex product and part shapes possible.²⁹⁴ Design activities are less often limited by technical restrictions than in the case of traditional manufacturing processes like casting.²⁹⁵ The absence of such restrictions means that product design can be geared more towards functionality and customer benefit.

AM allows suppliers to pay more attention to customers' individual needs. For example, perfectly fitting implants or prostheses in medicine require personalised products,²⁹⁶ and these can be made at lower cost with AM. Today, for example, additive manufacturing methods are already being used almost exclusively to make hearing aids.²⁹⁷ By contrast, standardised mass products are usually less flexible in their range of applications and offer less individual comfort.²⁹⁸

Additive manufacturing: driver of individualised mass production and user innovation

AM enables companies to offer customers simple design tools; in this way consumers can increasingly incorporate their preferences and know-how into the design, innovation and production process. The companies can achieve higher prices in the market, since consumers are usually willing to pay more for self-designed products than for mass-produced products.²⁹⁹ At the same time, it is less costly for manufacturers to differentiate their products from competitors. In combination with new services and digital production, AM can thus offer technical and organisational ways of establishing an individualised form of mass production.

Up to now, concepts of individualised mass production have been largely based on modularisation approaches. For example, production in the automotive industry is often based on standardised model platforms in which modularisation begins as late as possible in the production process – for cost reasons. AM offers a more flexible process by comparison: in principle, customer preferences can be incorporated quickly at every phase of the value-added chain – also and especially in upstream innovation processes.

In addition to a greater variety of supply thanks to niche products, AM can support the emergence of new business models (cf. chapter A 4), in combination with advancing digitisation and connectedness in the economy and society. Interacting with digitisation and connectedness, AM can lead to a greater decentralisation of production structures in the future and to a further blurring of the borderlines between digital and physical production.³⁰⁰

As the prices of AM devices continue to fall, more and more private users are able not only to modify products, but also, for example, to design, produce and distribute the latter over the internet. These users are thus acting in a similar way to decentralised microentrepreneurs. Another term used in this context is the "maker movement" (cf. Box 12) made up of so-called prosumers and user innovators.³⁰¹ Accordingly, the maker movement can lead to the participation of new innovators and increase market entry.

Potential of additive manufacturing for reshoring production

Although AM is currently used primarily to produce complex parts, prototypes and small series, the pace of technical change suggests that AM might also be increasingly applied in series production in the future.³⁰² Labour-intensive manufacturing processes can be increasingly automated by AM. In combination with the possibility of customising products and adapting them quickly to changing customer preferences, the relative importance of labour costs will therefore decline. At the same time, proximity to the customer is becoming increasingly important,³⁰³ making it more attractive for companies to locate their production facilities close to their buyer markets and consumers. In the medium term, AM could thus result in companies reshoring back to Germany production processes they had outsourced abroad. Some countries expect reshoring to develop such a massive impact on their economies, that these prospects are now legitimising comprehensive AM-support measures (cf. B 4-1).

Potential of additive manufacturing for the High-Tech Strategy

The Commission of Experts believes AM could be a key enabling technology. AM can contribute to meeting the priority future challenges defined in the new High-Tech Strategy (HTS; cf. chapter A 3). Industry

Box 12

The maker movement

The maker movement is a group of early adopters and user innovators (cf. chapter B 3) in the AM field. The group is marked by two characteristics. On the one hand, users apply digital tools and software especially frequently to design new products and build prototypes. On the other hand, users in this group are often willing to collaborate and exchange their designs in online communities – in the spirit of an open source culture.

EAt present, it is not possible to say exactly how large the German and international maker movements have become in the meantime, or what long-term growth potential and decentralisation trends they might generate. To date, it is at most a small,

but growing number of individual users. However, AM devices for private households and small businesses, so-called desktop 3D printers, are now coming onto the market at a price of around EUR 500, making them affordable for a relatively large number of individual users for the first time.³⁰⁴ One of the most important producers in this area of AM was MakerBot, which has since been bought by Stratasys for more than 400 million US dollars. Up to 2013, MakerBot had already sold more than 22,000 printers for household use.³⁰⁵

On Thingiverse, the world's biggest community platform, more than 130,000 members are now sharing their digital designs. The online trading platform Shape-

ways has been bringing a large number of designers and end users together since 2007; and with more than 50 AM systems of their own, they even take on the production and shipping of the selected designs.³⁰⁶ More than 120,000 print products are sold there every month.³⁰⁷ Their business model, for example, includes offering users tutorials for creating their own designs. At the same time, the first independent start-ups have already emerged that use nothing but Shapeways' production infrastructure.³⁰⁸ This can be seen as evidence that AM is already successfully promoting the emergence of new business models and innovative services in the internet.

4.0 is one of the central fields of action for the priority future challenge "Digital economy and society". Industry 4.0 means that companies increasingly use cyber-physical systems to network their machines, storage systems and operating resources, creating intelligent factories.³⁰⁹ The aim of this digital networking is to achieve greater flexibility and decentralise production processes. AM builds on a digital basis and – more than most other technologies – contributes towards making production processes more flexible and decentralised.

AM can therefore be regarded as an important enabling technology for the realisation of Industry 4.0.

AM's broad range of potential applications in the medical field – e.g. the production of personalised medical devices and bioprinting – can make an important contribution to tackling the HTS priority challenge "Healthy Living". On the one hand, AM can help secure the cost-effective provision of healthcare and quality of life for a rapidly ageing population; on the other hand, it opens up new economic prospects for German companies, since Germany is well posi-

tioned both in the AM field and in medical technology and medical research.³¹⁰

The use of AM also generates new, important stimuli in education and training. With AM, learners can be familiarised at an early stage with a new, design-oriented way of thinking. The application of AM can teach important innovation-relevant skills and inspire enthusiasm for innovation at an early stage.

In addition, the use of experimental processes can help students to develop a better understanding of mathematics, natural sciences, design and art.³¹¹ However, this means that the education and training of teachers and curricula will have to be adjusted accordingly. At the same time, the necessary infrastructures should be made available in schools and other educational institutions.³¹²

Legal framework

AM makes it possible to reproduce and copy products quickly and cost-effectively. In the future, therefore,

manufacturers, designers and engineers of products will be confronted with similar problems to those that the music and film industry have already known for years: the illegal reproduction and the commercial and non-commercial distribution of products.³¹³ AM can also lead to the illegal copying of patent- or design-protected products. There might therefore be collisions with all types of intellectual property rights: e.g. patent and utility model law, copyright law, and trademarks and design law.³¹⁴

In order to make it possible to exploit the innovative potential of AM to increase overall economic welfare, a balance must be found between the legitimate interests of rights owners on the one hand, and the growing possibilities of applicants and innovators on the other.

Clarification is also needed regarding the extent to which manufacturers of additively manufactured products can be held liable for defects. Product liability requires CAD files to be defined and treated as products in the legal sense. However, the legal status of software – and therefore CAD files – has not yet been defined.³¹⁵ Yet, even if CAD files were defined as products, product-liability regulations could only be applied in the commercial sphere – which cannot always be clearly distinguished from the non-commercial sector.

It is also unclear to what extent a service provider who creates a product on behalf of a customer based on the latter's CAD file is liable for damage caused by product defects. Furthermore, there is currently no law regulating the production and dissemination of CAD files that can be used to make prohibited goods such as weapons.³¹⁶

B 4–4 Recommendations

AM has the potential to become a key enabling technology. As such, AM can strengthen Germany as an industrial location, limit the shift of value added and employment to other countries, and even reshore value-added chains to Germany. The Commission of Experts therefore recommends reviewing the framework conditions for AM and, where appropriate, to increase funding for research in this field. Research funding should go not only to the technology suppliers, but also to the industrial applicants of AM, in order to jointly expand and develop applications.

Bring actors and disciplines together

- The Federal Government should step up its coordination efforts to bring together experts from different disciplines and applications on cooperation platforms – e.g. in networks and clusters.
- Interdisciplinary research collaboration (e.g. with material sciences and nanotechnology) at higher education institutions and non-university research institutions should be strengthened via appropriate measures, and technology transfer to businesses should be supported further.

Exploit the potential of additive manufacturing for Industry 4.0

- In the context of promoting Industry 4.0, the potential of AM should also be pursued further.
- To reduce information costs and to overcome lock-in effects, the diffusion of AM technologies may require support on the demand side. This may include a stronger focus on AM in best-practice examples for Industry 4.0 and Smart Services to be showcased in the competence centres, which have been announced by the Federal Government as part of the Digital Agenda.³¹⁷
- Current support measures for AM are being provided detached from each other and not in a systematic way. The Commission of Experts suggests that support measures for AM should be embedded in a consistent overall framework.

Clarify standardisation and legal issues – strengthen international cooperation

- The Commission of Experts recommends clarifying unresolved legal issues relating to AM, such as liability, without delay in order to increase legal certainty for innovators. Furthermore, fast technological change in the AM field requires continuous monitoring of the needs for adjustment within the German and European legal framework.
- The Federal Government should set stronger incentives for developing quality standards and for testing and certification activities in the area of AM designs, materials and products.
- European and non-European cooperation in the fields of AM research and standardisation should be promoted to a greater extent.

Integrate additive manufacturing into the education system

- Skills in the use of AM should be taught across the vocational education and training system. AM technologies should be broadly employed not only in the higher-education sector, but also in vocational training and in schools. Parallel to this, teaching staff and vocational trainers should receive relevant training.

STRUCTURE AND TRENDS



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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.³¹⁸ Furthermore, individual indicators are shown at the federal-state level to reveal differences in performance within Germany. Most of the indicators have been drawn from studies on the German innovation system commissioned by the Commission of Experts. In addition to the indicators listed here, these studies also offer comprehensive further material for indicators and analysis. All the studies can be accessed and downloaded on the Commission of Experts' website. The same applies to all the charts and tables in the Report and to the related data sets.

C 1 Education and qualification

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

C 2 Research and development

Research and development processes are essential 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 share of revenue 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 revenue, 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 – are challenging 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 are emerging, 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 employment and value added 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 in an 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

Gainfully employed persons with tertiary education qualifications (ISCED 6, ISCED 5A and 5B) made up 29.2 percent of the total labour force in Germany in 2013 (C 1-1); the figures were virtually unchanged compared to the previous year. However, the number of new tertiary students as a percentage of the relevant age group (C 1-2) rose sharply again in Germany. From 2011 to 2012, the share of new tertiary students grew by 7 percentage points from 46 to 53 percent, primarily because there were twice as many upper secondary school graduates, and the international figures for new tertiary students also rose. The share of school-leavers qualified for higher education in Germany (C 1-3) rose slightly from 2013 to 2014 and, according to forecasts, will continue to rise gradually.

First-time graduates numbered 309,870 in 2013, slightly up on the previous year's figure of 309,621 (C 1-4). The subjects structure rates also hardly changed compared to 2012. The biggest changes were seen in the mathematics/natural sciences subject group, whose share of all subject groups fell from 15.6 to 15.1 percent, and in engineering sciences, whose share rose from 19.5 to 20 percent. The STEM subject group as a whole was unchanged with a share of approximately 35 percent. The number of foreign students at German tertiary education institutions also rose (C 1-5). Their numbers increased from 282,201 in the 2012/13 winter semester to 301,350 in the 2013/14 winter semester. This jump of almost 20,000 students represented the highest level of growth in the last ten years.

The indicator "Further training according to employment status and qualification level" (C 1-6) was extended this year to include participation by firms in further education. The table initially shows a very positive development over the last decade. In 2005, only just under 43 percent of company plants participated in the further education of their employees by releasing them from work or paying the costs of their further training; this figure had risen to more than 53 percent by 2012. In this context, the participation of knowledge-intensive manufacturing plants in further training was generally above average; in 2012 they were ahead of all other industries with 67.2 percent. However, the biggest percentage increase in company participation in further training was recorded by the non-knowledge-intensive manufacturing sector, rising between 2005 and 2012 from 32.4 percent to 43.2 percent (up 33 percent). There were also considerable differences in participation in further training depending on firm size. Whereas virtually all companies with more than 500 employees participated in training (97.8 percent), in the case of companies with fewer than 50 employees the figure was just over half (50.9 percent). Even so, these small firms have shown the strongest growth over the last decade: the percentage of firms providing further training in this category rose from 40.5 to 50.9 percent.³¹⁹

C 1-1

Data
Download

Qualification levels of gainfully employed persons in selected EU countries, 2013 (figures in percent)



The classification of the qualification levels is based on the International Standard Classification of Education – ISCED³²⁰

- ISCED 0–2: (Pre)primary and lower secondary
- ISCED 3: Upper secondary education (Abitur: school-leaving examination or apprenticeship)
- ISCED 4: Post-secondary non-tertiary education (Abitur: school-leaving examination and apprenticeship)
- ISCED 5b: Practically, technically or occupationally oriented tertiary degree
- ISCED 5a: Theory-based tertiary degree
- ISCED 6: PhD

Source: Eurostat, European Labour Force Survey. Calculation by NIW. In: Baethge et al. (2015).

C 1-2

Data
Download

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. It is a measure of the degree to which the demographic potential for the formation of academic human capital is realised.

OECD countries	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2012 ¹⁾
Germany	35	36	37	36	35	34	36	40	42	46	53	46
France	37	39	-	-	-	-	-	-	-	39	41	-
Great Britain	48	48	52	51	57	55	57	61	63	64	67	44
Japan	39	40	40	41	45	46	48	49	51	52	52	-
Korea	-	47	49	54	59	61	71	71	71	69	69	-
Sweden	75	80	79	76	76	73	65	68	76	72	60	55
Switzerland	-	38	38	37	38	39	38	41	44	44	44	33
USA	64	63	63	64	64	65	64	70	74	72	71	-
OECD average	52	53	53	54	56	56	56	59	61	60	58	-
China	-	-	-	-	-	-	-	17	17	19	18	-

¹⁾ Adjusted rate excluding international new tertiary students.

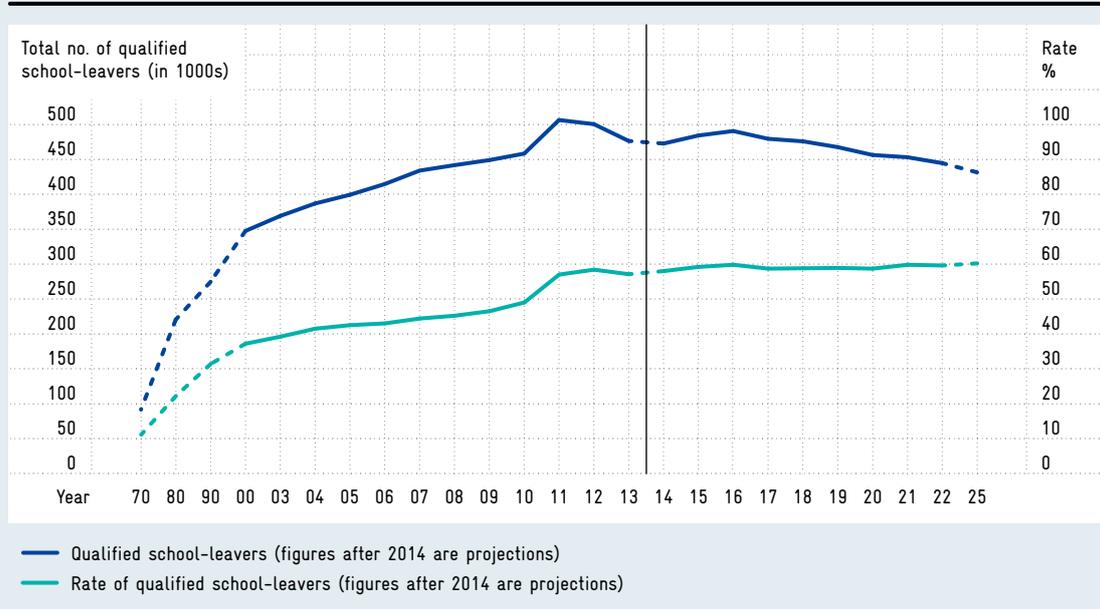
Sources: OECD (ed.): Education at a glance. OECD indicators, various years. In: Baethge et al. (2015).

C 1-3

Data
Download

School-leavers qualified for higher education in Germany, 1970 to 2025 (figures after 2014 are projections)

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



Source of actual figures: Germany's Federal Statistical Office (2014).

Source of forecast figures: Statistical Publications of the Standing Conference of Education Ministers.

In: Baethge et al. (2015).

* Since 2013, the figures do not include school leavers who have passed the schooling part only of the vocational baccalaureate (Fachhochschulreife) but who must still do a period of professional practical training according to Länder rules to gain a recognized vocational baccalaureate.

C 1-4

Data
Download

Number of first-time graduates and subject structure rates

First-time graduates and subject structure rate: the subject structure rate indicates the percentage of first-time graduates in a specific subject or subject group. First-time graduates are students who have successfully completed an undergraduate degree.

	2000	2005	2007	2009	2010	2011	2012	2013
Total no. of graduates	176,654	207,936	239,877	287,997	294,330	307,271	309,621	309,870
Percentage of women	45.6	50.8	51.8	51.7	52.1	51.4	51.3	51.5
Percentage of university graduates	64.3	60.8	62.4	62.0	62.0	62.1	61.3	59.9
Linguistic and cultural sciences	29,911	35,732	43,827	53,003	54,808	56,140	55,659	56,313
Subject group percentage	16.9	17.2	18.3	18.4	18.6	18.3	18.0	18.2
Law, economics, social sciences	62,732	76,566	85,838	101,391	102,315	105,589	105,024	105,105
Subject group percentage	35.5	36.8	35.8	35.2	34.9	34.4	33.9	33.9
Medicine/health sciences	10,620	11,817	13,358	15,142	15,222	15,686	15,856	16,534
Subject group percentage	6.0	5.7	5.6	5.3	5.2	5.1	5.1	5.3
Agriculture, forestry, food sciences	4,761	5,312	5,661	6,787	6,215	6,563	6,405	6,193
Subject group percentage	2.7	2.6	2.4	2.3	2.1	2.1	2.1	2.0
Art, art history	7,630	9,678	10,399	11,541	11,820	12,525	12,866	12,542
Subject group percentage	4.3	4.7	4.3	4.0	4.0	4.1	4.2	4.0
Mathematics, natural sciences	21,844	30,737	38,417	47,782	48,561	49,593	48,231	46,707
Subject group percentage	12.4	14.8	16.0	16.6	16.5	16.1	15.6	15.1
Engineering sciences	35,725	34,339	38,065	47,004	49,860	55,631	60,259	62,007
Subject group percentage	20.2	16.5	15.9	16.3	16.9	18.1	19.5	20.0

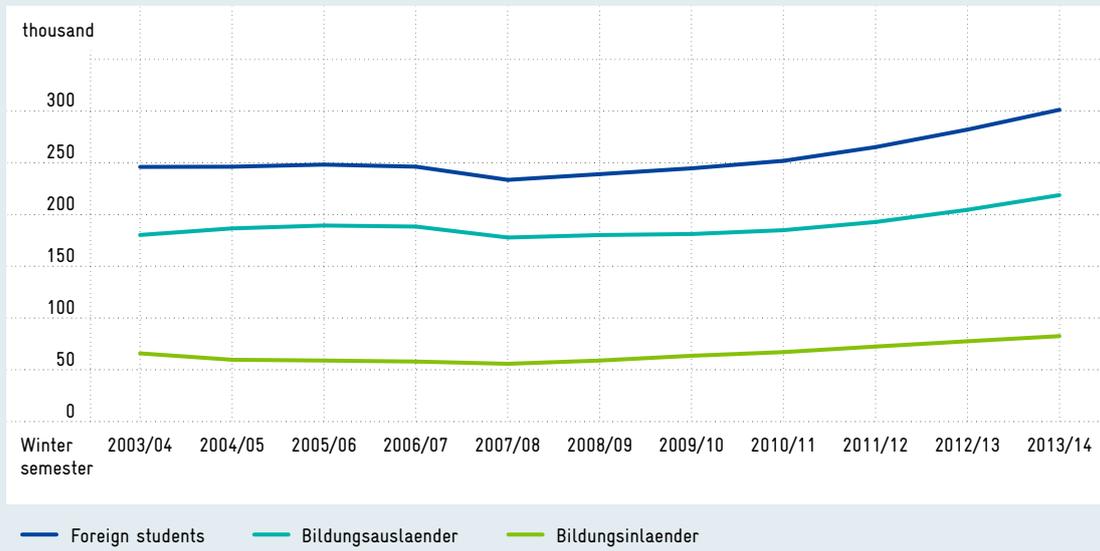
Federal Statistical Office and research in DZHW-ICE. In: Baethge et al. (2015).

Foreign students at German tertiary education institutions

Foreign students are defined as persons without German citizenship. They are divided into Bildungsinländer, who acquired their university entrance qualification in Germany, and Bildungsausländer who acquired it abroad.

C 1-5

Data
Download



Source: Federal Statistical Office and research in DZHW-ICE. In: Baethge et al. (2015).

C 1-6

Data
Download

Percentage participation of individuals and establishments in further training

Individual further-education rate: percentage of people who participated in some form of further education during the last four weeks prior to the interview date.

Corporate further-education rate: percentage of establishments where employees were released for training or whose training costs were paid.*

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
a) Individual further-education rate										
Working population	6.8	6.3	5.9	6.0	6.1	5.9	5.8	5.8	5.8	5.5
low (ISCED 0-2)	3.9	2.4	2.1	1.9	2.1	1.9	1.8	1.7	1.6	1.6
medium (ISCED 3-4)	5.0	4.7	4.5	4.6	4.7	4.5	4.5	4.4	4.3	4.0
high (ISCED 5-6)	12.1	12.1	11.5	11.8	11.8	11.0	10.5	10.6	10.6	10.0
Unemployed	3.9	3.2	3.4	3.6	4.3	4.5	4.1	3.6	3.6	3.4
low (ISCED 0-2)	2.4	2.3	2.4	2.7	2.9	3.1	3.0	2.7	2.7	2.8
medium (ISCED 3-4)	3.7	3.0	3.2	3.5	4.5	4.2	4.0	3.5	3.4	3.4
high (ISCED 5-6)	7.8	6.1	7.0	7.1	7.6	9.1	7.1	6.2	6.4	5.4
Non-working population	2.8	2.2	2.1	2.0	2.2	2.1	2.1	1.9	1.7	1.7
low (ISCED 0-2)	1.7	1.4	1.4	1.4	1.5	1.6	1.5	1.5	1.5	1.5
medium (ISCED 3-4)	3.5	2.5	2.2	2.2	2.3	2.2	2.1	1.8	1.6	1.6
high (ISCED 5-6)	4.6	4.3	4.4	4.0	4.6	3.9	3.8	3.5	3.0	3.7
b) Corporate further-education rate										
By sector	-	42.7	-	45.5	49.0	44.6	44.1	52.6	53.1	-
Knowledge-intensive manufacturing	-	55.7	-	65.3	65.1	52.6	55.9	62.9	65.5	-
Non-knowledge-intensive manufacturing	-	32.4	-	33.2	37.8	32.5	33.3	41.2	43.2	-
Knowledge-intensive services	-	58.8	-	63.2	68.3	58.7	57.1	68.7	67.2	-
Non-knowledge-intensive services	-	34.9	-	37.3	39.4	38.0	37.5	44.9	45.3	-
Non-industrial economy	-	46.9	-	49.9	53.8	51.9	51.2	59.0	60.3	-
By establishment size										
< 50 employees	-	40.5	-	43.2	46.9	42.5	41.8	50.5	50.9	-
50 - 249 employees	-	82.9	-	85.1	86.7	81.3	83.3	90.8	89.7	-
250 - 499 employees	-	95.6	-	95.2	95.9	92.0	93.3	95.9	96.5	-
≥ 500 employees	-	97.0	-	95.3	97.8	96.0	97.9	98.4	97.8	-

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: Baethge et al. (2015).

Source b): IAB Establishment Panel (special evaluation). Calculations by NIW. In: Cordes; von Haaren (2015).

* 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?"

Research and development

C 2

R&D intensity in Germany fell in 2013, accounting for 2.85 percent of the gross domestic product (C 2-1). The decline was due partly to a loss of momentum in the private sector, but mainly to statistical effects, which are described in detail in section A 2.

This decline did not lead to any changes in the general ranking of countries. In Asia, R&D intensity was highest in Korea and Japan; in Europe, Sweden and Switzerland were still in the lead. The level was lower in Germany and the United States. Overall, European countries reported stagnating or declining R&D intensities in 2013. China made up ground with high growth rates and almost reached the level of R&D intensity in France.

Government budget appropriations or outlays on civil R&D (C 2-2) rose again in Sweden and Germany in 2013, albeit much more slowly in Germany. In France and the UK, the government budget outlays were virtually unchanged from the previous year. The 2013 budget outlays declined in the United States and Japan.

Between 2003 and 2013, the distribution of gross domestic expenditure on R&D by performing sector (C 2-3) developed in different ways. Whereas the importance of the private sector in performing R&D grew (in some cases significantly) in the Asian countries, the USA, France and the UK, private-sector performance declined in Germany, Sweden and Switzerland. In Germany, it fell from 69.7 percent in 2003 to 66.9 percent in 2013. In Germany, but particularly in Sweden and Switzerland, the universities greatly increased their share of total R&D expenditure: Sweden from 21.8 percent in 2003 to 27.8 percent in 2013, Switzerland from 22.9 percent to 28.1 percent.

No new data were available for the indicators for the R&D intensity of Germany's Länder (C 2-4) or for the R&D expenditure of companies (C 2-5). The tables were taken over from last year. No commentary is made here for this reason.

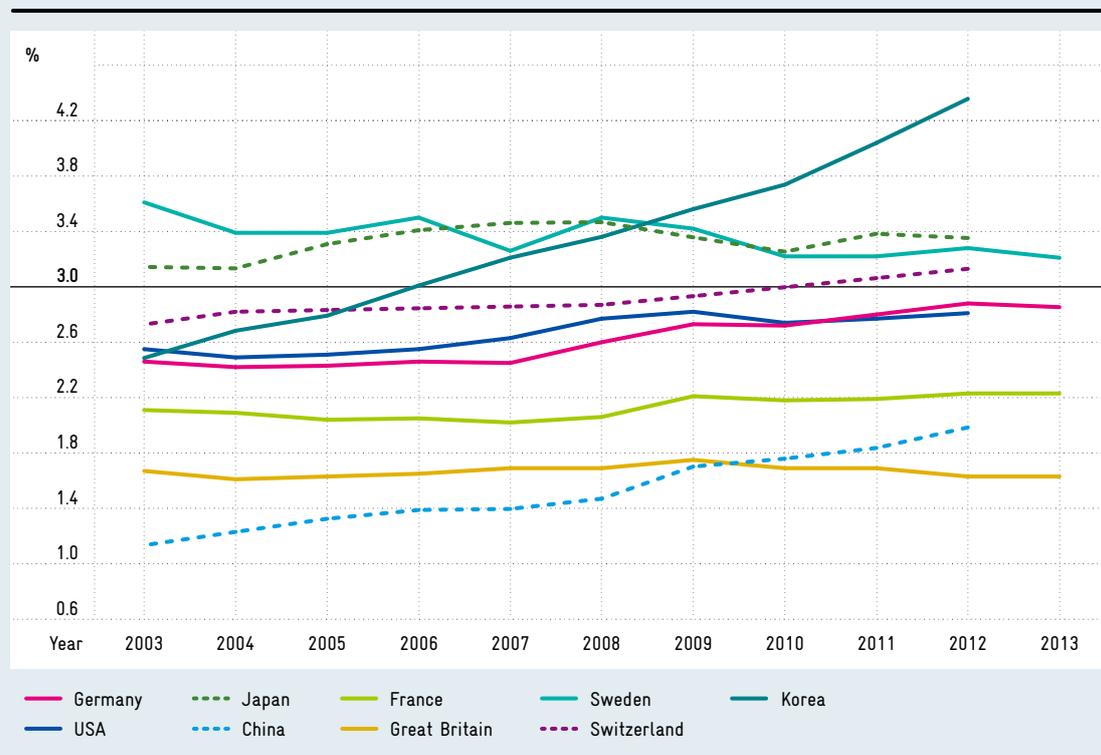
The last table presents sectoral data on R&D intensities, i.e. internal R&D expenditure as a percentage of revenue from the company's own products (C 2-6). The R&D intensity of German air- and spacecraft manufacturing fell markedly from 12 percent in the previous year to 9 percent in 2013. The slight downturn already observed in 2012 continued in the pharmaceutical industry. Nevertheless, its R&D intensity remained at a comparatively high level – at 12.7 percent. Only the producers of IT equipment, electrical engineering and optics continued to show a consistently higher R&D intensity, spending 13 percent of their revenue on internal R&D. However, only the manufacturers of electrical equipment reported a clear increase in R&D intensity – from 1.8 percent in 2012 to 2.1 percent in 2013.³²¹

C 2-1

Data
Download

R&D intensity in selected OECD countries and China, 2003 to 2013 (figures in percent)

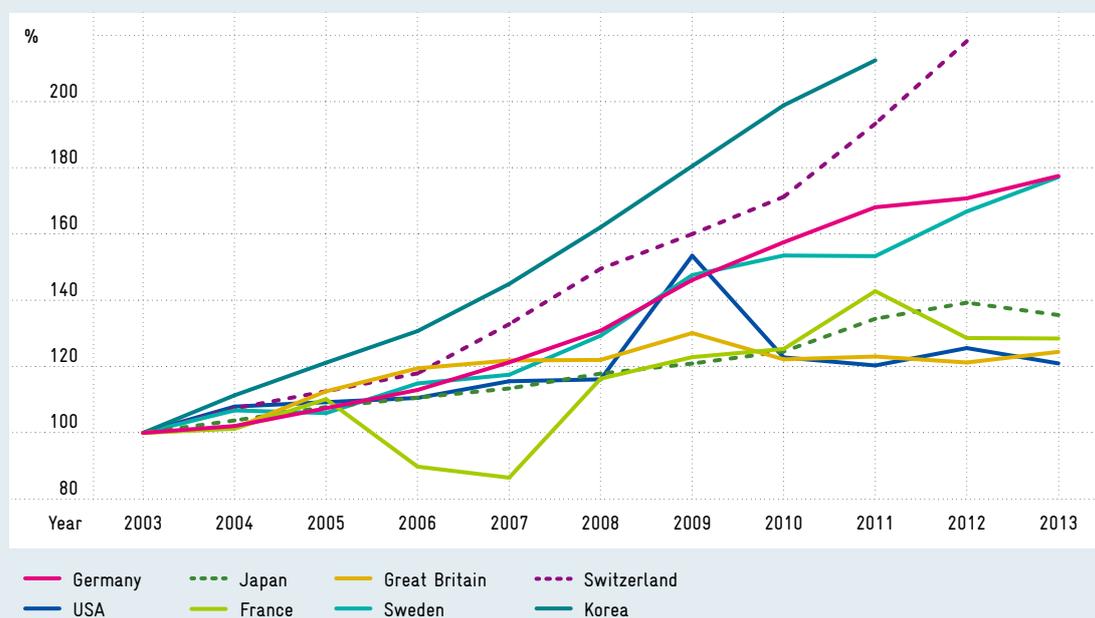
R&D intensity: Percentage of an economy's gross domestic product (GDP) spent on research and development. R&D intensity reported for the first time on the basis of the new national accounts (NA), where R&D expenditure is posted as investment in GDP.



Source: OECD, EUROSTAT. Calculations and estimates by NIW in Schasse et al. (2015).

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: 2003 = 100, some data are estimated.

Source: OECD, EUROSTAT. Calculations and estimates by NIW in Schasse et al. (2015).

C 2-2

Data
Download

Distribution of gross domestic expenditure on R&D (GERD) by performing sector, 2003 and 2013

Gross domestic expenditure on research and development (GERD) in industry, tertiary education institutions and government.

	2003					2013 ¹⁾				
	GERD in USD m ²⁾	of which by ... (in percent)				GERD in USD m ²⁾	of which by ... (in percent)			
		private sector	higher education sector	public sector	non-profit sector		private sector	higher education sector	public sector	non-profit sector
France	36,870	62.6	19.4	16.7	1.3	56,092	64.8	20.7	13.1	1.3
Germany	59,457	69.7	16.9	13.4	-	102,612	66.9	18.0	15.1	-
Great Britain	31,057	63.7	24.0	10.4	1.9	40,146	64.5	26.3	7.3	1.9
Japan ³⁾	112,205	75.0	13.7	9.3	2.1	148,389	77.0	13.2	8.4	1.5
Korea ³⁾	24,016	76.1	10.1	12.6	1.2	58,380	76.5	10.1	11.7	1.6
Sweden	10,369	74.4	21.8	3.5	0.4	14,019	68.2	27.8	3.8	0.2
Switzerland ⁴⁾	5,773	73.9	22.9	1.3	1.9	13,303	69.3	28.1	0.8	1.8
United States	293,852	68.3	14.3	12.9	4.5	453,544	69.8	13.8	12.3	4.0
China ⁵⁾	56,463	62.4	10.5	27.1	-	293,550	76.2	7.6	16.3	-

¹⁾ Provisional. Germany acc. to WiStat 12/2014. ²⁾ GERD in US dollars by purchasing power parity

³⁾ 2011 instead of 2013. ⁴⁾ 2000 instead of 2003, and 2012 instead of 2013. ⁵⁾ 2012 instead of 2013.

Private non-profit organisations: in some countries included under "public sector" (e.g. Germany).

Source: OECD, EUROSTAT (data from 27 Nov. 2014). Calculations by NIW in Schasse et al. (2015).

C 2-3

Data
Download

C 2-4

Data
Download

R&D intensity of Germany's Länder, 2001 and 2011 (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	2001				2011			
	Total	private sector	public sector	higher education sector	Total	private sector	public sector	higher education sector
Baden-Württemberg	3.86	3.05	0.40	0.41	5.08	4.10	0.43	0.55
Bavaria	3.07	2.46	0.24	0.37	3.15	2.41	0.30	0.44
Berlin	3.94	2.15	1.01	0.78	3.55	1.39	1.24	0.92
Brandenburg	1.47	0.54	0.65	0.28	1.68	0.54	0.78	0.36
Bremen	2.14	1.05	0.56	0.53	2.78	1.00	1.00	0.78
Hamburg	1.40	0.72	0.33	0.34	2.24	1.26	0.47	0.51
Hesse	2.37	1.92	0.15	0.30	3.01	2.35	0.23	0.44
Mecklenburg-Vorpommern	1.17	0.18	0.48	0.51	2.09	0.68	0.73	0.67
Lower Saxony	2.49	1.79	0.31	0.39	2.88	1.97	0.40	0.51
North Rhine-Westphalia	1.74	1.09	0.28	0.38	2.01	1.21	0.31	0.49
Rhineland-Palatinate	1.96	1.48	0.14	0.34	2.07	1.46	0.18	0.44
Saarland	1.02	0.38	0.22	0.42	1.49	0.54	0.43	0.52
Saxony	2.44	1.22	0.60	0.61	2.91	1.26	0.88	0.77
Saxony-Anhalt	1.28	0.34	0.40	0.54	1.49	0.43	0.57	0.49
Schleswig-Holstein	1.15	0.53	0.31	0.32	1.43	0.69	0.36	0.37
Thuringia	2.11	1.13	0.44	0.53	2.22	1.03	0.54	0.65
Germany	2.47	1.73	0.34	0.41	2.89	1.96	0.42	0.51

Source: SV Wissenschaftsstatistik, Federal Statistical Office. Calculations by NIW in Schasse et al. (2014).

C 2-5

Data
Download

Internal R&D spending by companies: origin of funds, economic sector, company size and technology category, 2011

Internal R&D: R&D carried out within a company either for its own purposes or on behalf of others

	Internal R&D expenditure				
	Total	of which financed by			
		Industry	Government	other Länder	other countries
in Euros	in percent				
All researching companies	50,804,210	91.7	4.0	0.3	4.0
Manufacturing	43,733,376	93.1	3.2	0.2	3.6
Chemical industry	3,296,674	95.3	2.0	0	2.7
Pharmaceutical industry	4,069,729	97.9	0.4	0	1.6
Plastics, glass and ceramics	1,224,873	93.3	2.5	0.5	3.8
Metal production/metalworking	1,242,073	80.5	7.4	0	12.1
Electrical/electronic engineering	8,165,077	94.8	3.2	0.1	1.9
Mechanical engineering	4,902,500	94.8	1.9	0	3.2
Vehicle manufacturing	18,914,281	91.5	4.0	0.3	4.3
Other manufacturing	1,918,170	91.2	3.3	0	5.5
Other industries	7,070,835	83.3	9.3	0.8	6.6
fewer than 100 employees	2,864,072	81.0	14.9	0.5	3.6
100–499 employees	5,147,816	89.3	5.3	0.4	5.0
500–999 employees	3,027,362	87.5	7.1	0.1	5.3
1,000 or more employees	39,764,960	93.1	2.8	0.2	3.8
Technology classes in industry					
Cutting-edge technology (R&D expenditure > 7 percent of turnover)	13,092,505	90.6	6.9	0	2.5
High-value technology (R&D expenditure 2.5–7 percent of turnover)	25,497,475	95.0	1.3	0.2	3.6

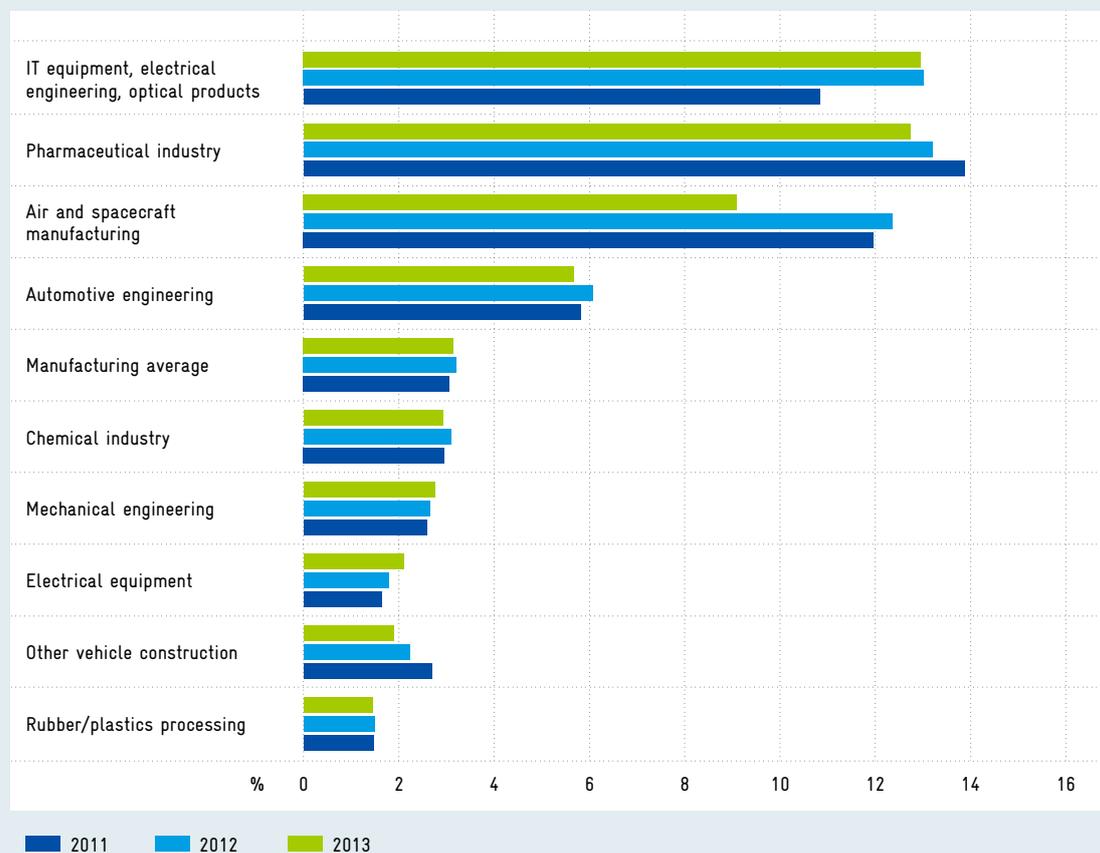
Source: SV Wissenschaftsstatistik. In: Schasse et al. (2014).

C 2-6

Data
Download

Internal corporate R&D expenditure as a percentage of turnover from the company's own products, 2011, 2012 and 2013

Internal R&D: R&D carried out within a company either for its own purposes or on behalf of others



Figures without tax. 2013: break in series.

Source: SV Wissenschaftsstatistik, Federal Statistical Office, corporate results for Germany.

Calculations by NIW in Schasse et al. (2015).

Innovation behaviour in the private sector

C 3

The Europe-wide Community Innovation Surveys (CIS) are conducted every two years and provide the database for the international comparison of the private sector's innovation behaviour (C 3-1).³²² Coordinated by Eurostat and based on a harmonised methodology, the CIS are conducted in all EU member states and a number of other European countries. The CIS are based on a largely uniform questionnaire and directed at businesses with ten or more employees in the manufacturing industry and selected services sectors. The current analysis relates to 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 and C 3-3, 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.³²³

The innovation intensity (C 3-2) of R&D-intensive industry rose from 8.4 percent in 2012 to 8.8 percent in 2013. In knowledge-intensive services (excluding financial services), the rate rose from 4.6 to 5.1 percent. In other industry, other services and financial services, however, innovation intensity hardly changed.

In R&D-intensive industry, 35 percent of revenue was generated with new products (C 3-3), substantially more than in knowledge-intensive services (10 percent), other industry (8 percent) and other services (4 percent).

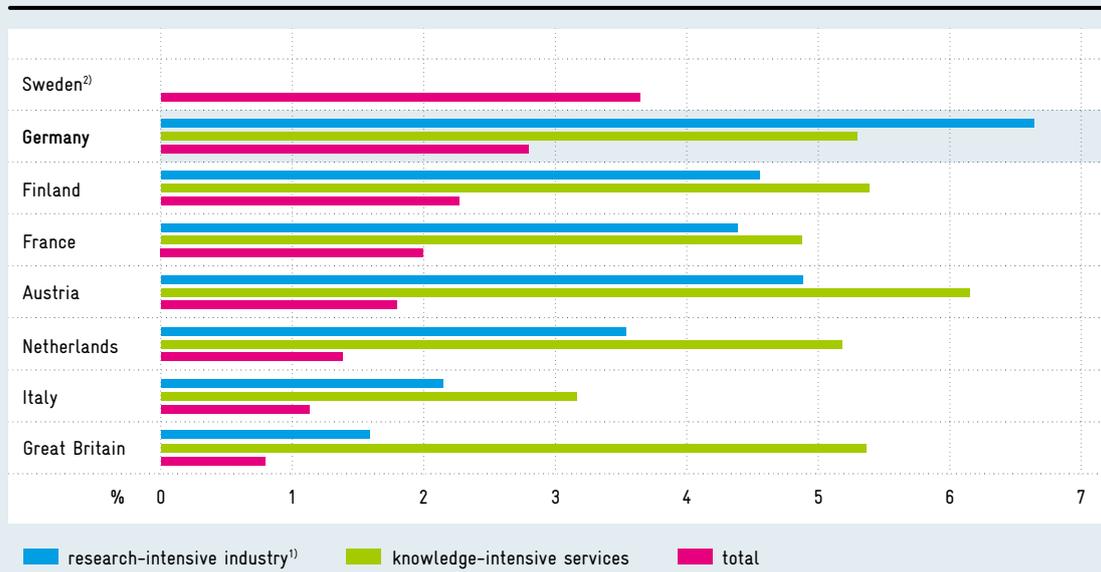
Standardisation is an important factor in the commercialisation of innovative technologies. At the international level, standards are developed in the committees of the International Organization for Standardization (ISO). Through participation in these committees, a country can make a significant impact on global technical infrastructures (C 3-4).³²⁴ German companies are more frequently involved in the work of the ISO than the representatives of any other country.

C 3-1

Data
Download

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

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



¹⁾ Research-intensive industry: sectors 19–22, 25–30. 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.

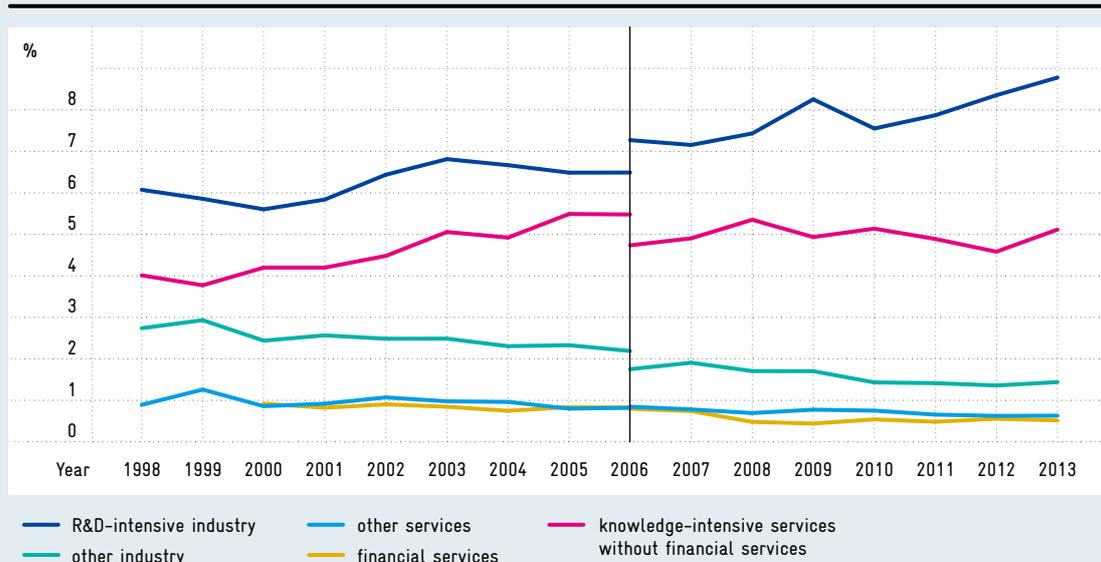
²⁾ No figures are available for research-intensive industry or knowledge-intensive services in Sweden.
Source: Eurostat, Community Innovation Surveys 2012. Calculations by ZEW

C 3-2

Data
Download

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

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

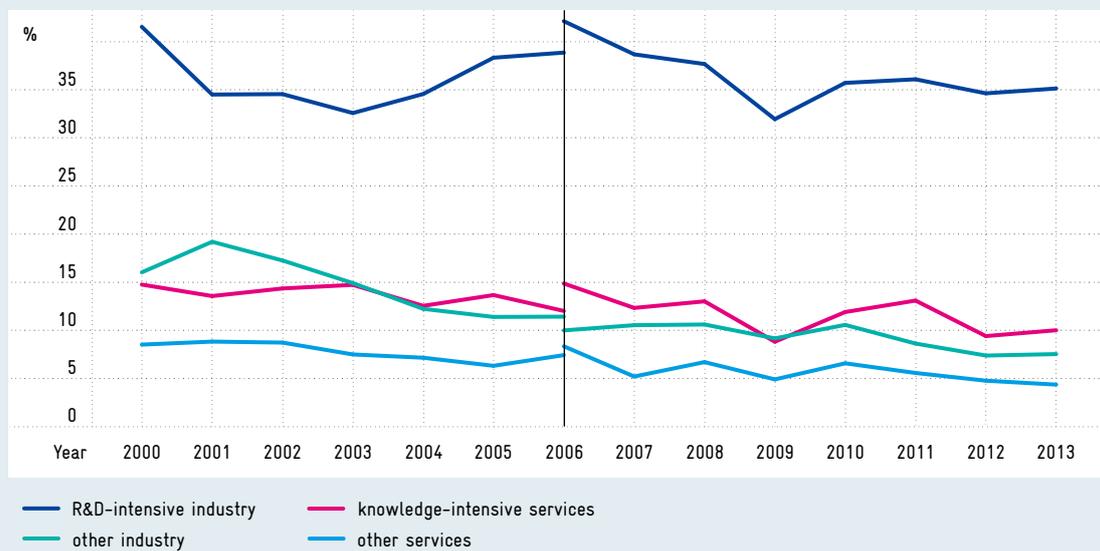


2006: break in series. Figures for 2013 preliminary.
Source: Mannheim Innovation Panel. Calculations by ZEW

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

C 3-3

Data
Download

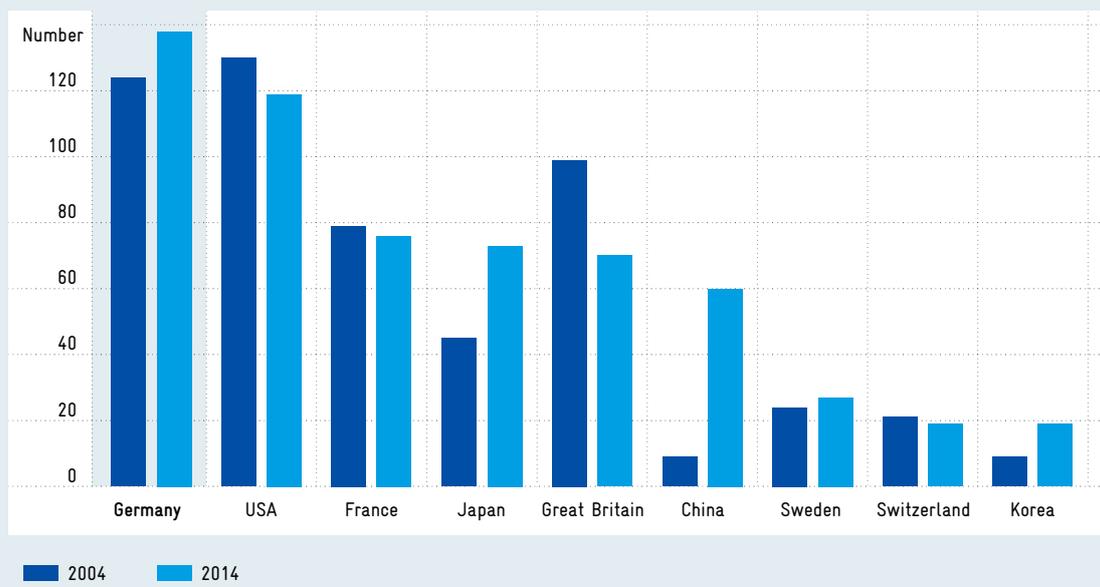


2006: break in series. Figures for 2013 preliminary.
Source: Mannheim Innovation Panel. Calculations by ZEW (Centre for European Economic Research).

Number of assigned secretariats for technical committees and sub-committees of the International Organization for Standardization (ISO)

C 3-4

Data
Download



Source: Own diagram based on ISO (2005: 19) and http://www.iso.org/iso/home/about/iso_members.htm?membertype=membertype_MB (last accessed on 12 January 2015).

C 4 Funding of research and innovation

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.³²⁵ 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. This means that companies receive tax credits in proportion to the amount of their R&D expenditure. From an economic point of view, this lowers the marginal costs of carrying out R&D. While this instrument is available to businesses 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 in the growth phase. Internal financing of investments and current expenditure is rarely an option, as these companies initially generate little or no revenue. 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.

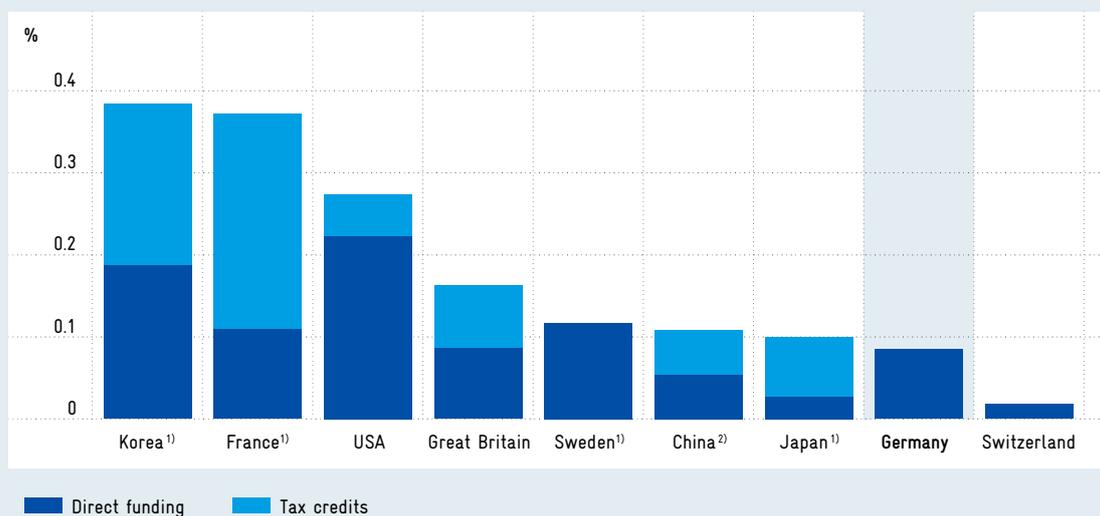
Figure C 4-2 provides an overview of venture-capital investment as a percentage of the national gross domestic product of selected European countries. It shows that in Germany this share remains relatively low by European comparison. Although venture-capital investment in Germany rose between 2012 and 2013 (C 4-3), there were also increases in most other countries, so that Germany was not able to improve its relative position. The biggest increase took place in Finland, which raised venture-capital investment from 0.04 to 0.07 percent of gross domestic product, overtaking Sweden at the top of the table. By contrast, venture-capital investment in Sweden, hitherto European leader, stagnated between 2012 and 2013.

C 4-1

Data
Download

R&D spending in the business sector directly and indirectly funded by the public sector in 2012 as a percentage of national GDP

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



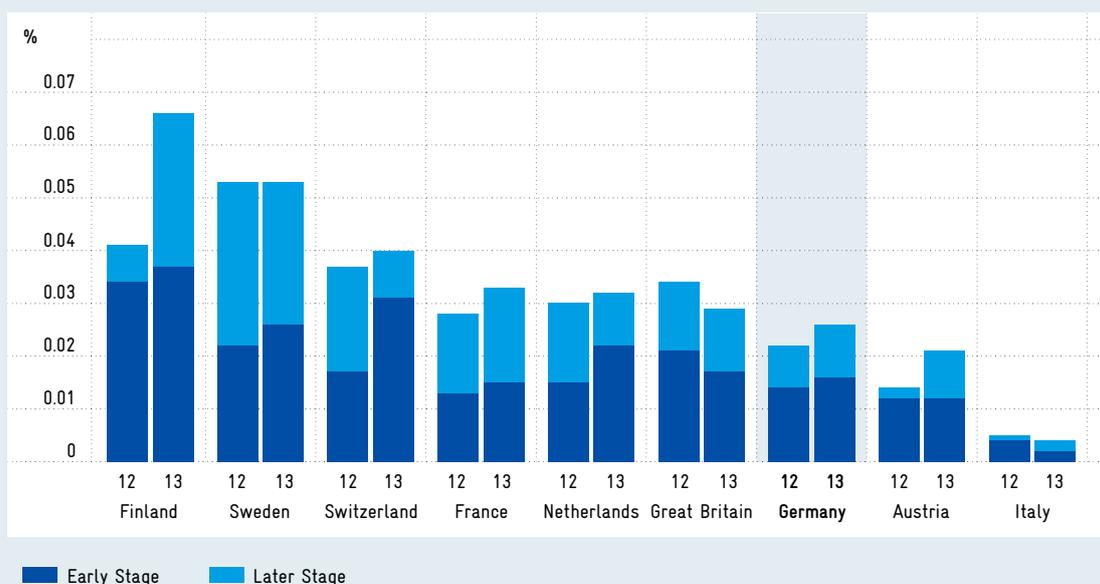
¹⁾ 2011, ²⁾ 2009
Source: OECD 2014b.

C 4-2

Data
Download

Venture-capital investment as a percentage of national GDP in 2012 and 2013

Venture capital refers to temporary equity investments in young, innovative, non-listed companies.



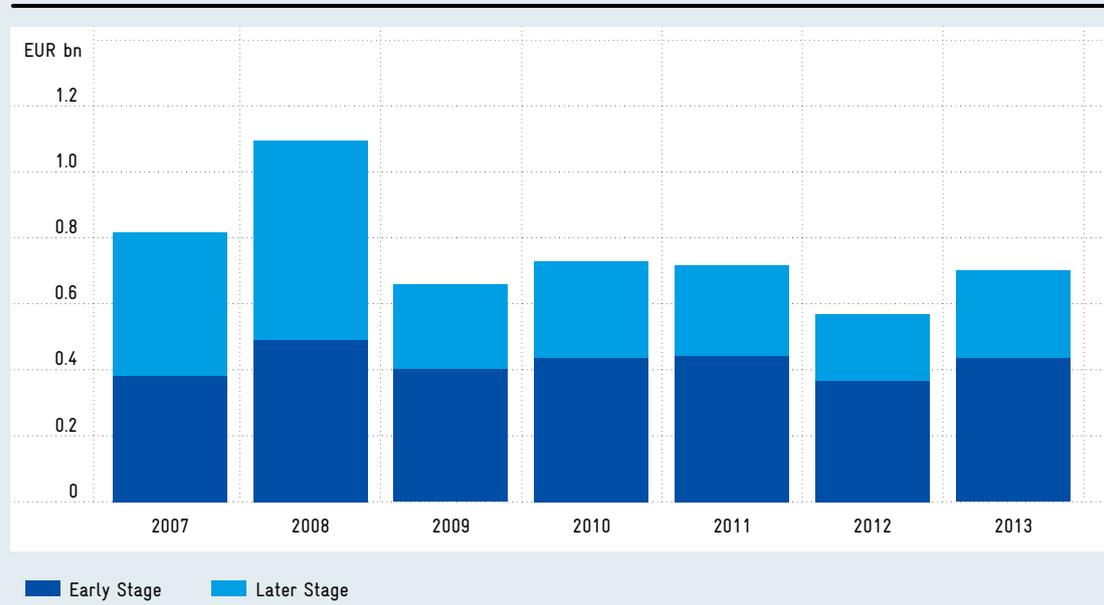
Investments according to registered office of the portfolio companies. Early stage includes the seed phase and the start-up phase.
Source: EVCA (2014), Eurostat. Own calculations.

C 4-3

Data
Download

Development of venture-capital investment in Germany in billions of euros 2007 to 2013

Venture capital refers to temporary equity investments in young, innovative, non-listed companies.



Investments according to registered office of the portfolio companies. Early stage includes the seed phase and the start-up phase.
Source: EVCA (2014).

New enterprises³²⁶

C 5

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 performed at a European level.³²⁷ The Business Demography Statistics provided by Eurostat are used for this purpose (C 5-1). They constitute part of the European Union’s Structural Business Statistics (SBS). This official database is based on evaluations of the individual member countries’ business registers. The figures for Germany are provided by the Federal Statistical Office’s business demography statistics, which are derived from the German business register.³²⁸ In 2012, the start-up rate in Germany was around 8 percent, well below the rate in the Great Britain (11.8 percent), which had the highest figure of the countries considered here. Even in R&D-intensive industry (4.4 percent) and knowledge-intensive services (9.5 percent), Germany’s start-up rates were considerably below those of the leader Great Britain (6.4 percent and 14.3 percent respectively).

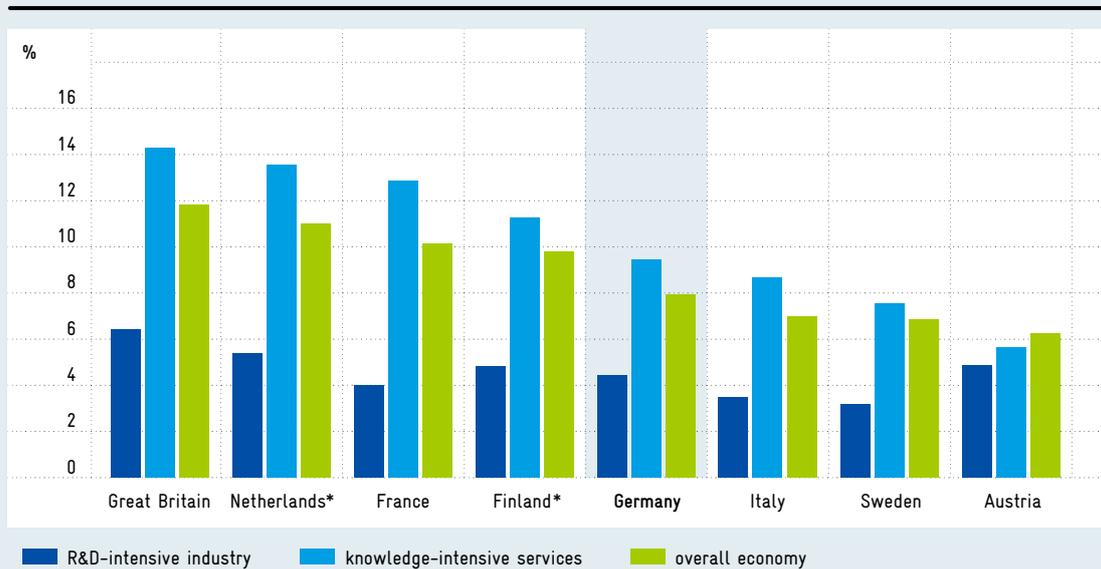
The figures on company dynamics in the knowledge economy shown in charts C 5-2 to C 5-4 draw on an evaluation of the Mannheim Enterprise Panel (MUP) conducted by the Centre for European Economic Research (ZEW). The MUP is a ZEW panel dataset of businesses located in Germany. It is compiled in cooperation with Creditreform, the largest credit information bureau in Germany. The definition of “company” used by the MUP is restricted exclusively to economically active companies; “start-ups” are only original, newly formed companies.³²⁹ The start-up rate shown in Figure C 5-2 is calculated on the basis of different data from those used in the Business Demography Statistics, which means that a direct comparison cannot be drawn here.³³⁰ According to the data provided by the MUP, the start-up rate in the knowledge economy was approximately 4.6 percent in 2013, and had thus declined by almost 2 percent points since 2009 (C 5-2). Within the knowledge economy, the sector IT/telecommunications had the highest start-up rate during the entire period under consideration. In 2013 it was 6.1 percent. The closure rate in the knowledge economy rose slightly in 2013 compared to the previous year – from 5 percent to 5.2 percent (C 5-3). Particularly low closure rates were observed in high-value technology and cutting-edge technology (3.7 and 3.5 percent respectively). The comparison at federal-state level reveals significant differences in start-up rates within Germany (C 5-4). Across all industries, the city states Berlin and Hamburg (7.2 and 5.8 percent) and the more rural state of Rhineland-Palatinate (5.7 percent) recorded the highest rates for the period from 2011 to 2013; the east German Länder lagged behind. However, the picture is more nuanced in R&D-intensive industries and knowledge-intensive services.

C 5-1

Data
Download

Start-up rates in 2012 by international comparison (figures in percent)

Start-up rate: number of start-ups as a percentage of all companies.



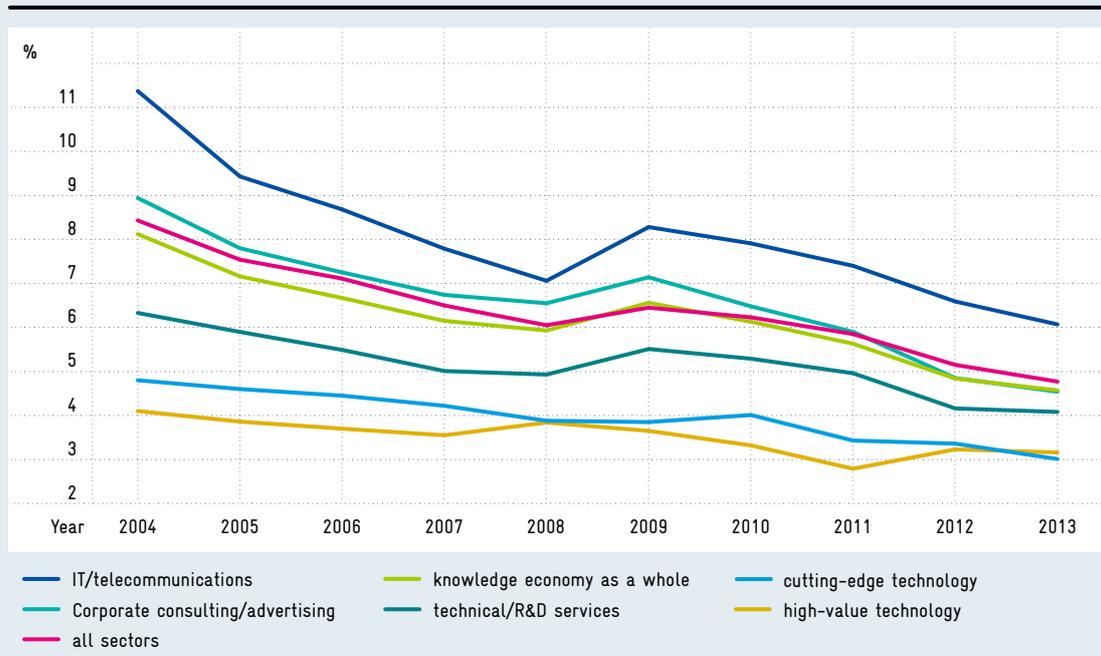
* Data for Finland and the Netherlands refer to 2011, no data available for 2012.
Source: Business Demography Statistics (Eurostat). Calculations by ZEW in Müller et al. (2015)

C 5-2

Data
Download

Start-up rates in Germany's knowledge economy, 2004 to 2013 (figures in percent)

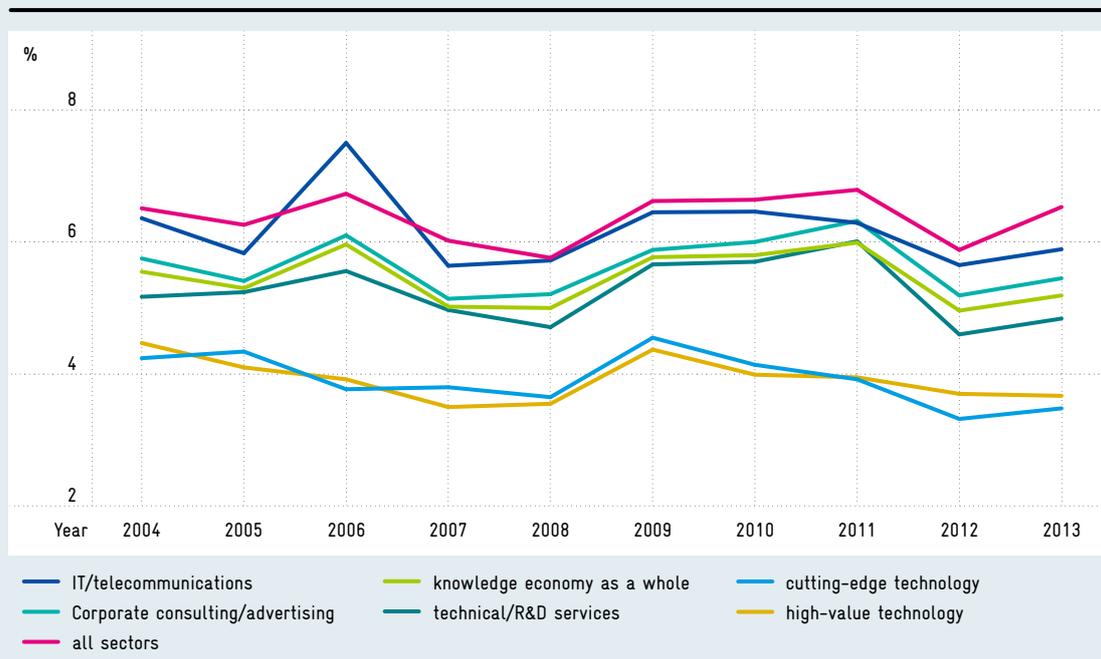
Start-up rate: number of start-ups as a percentage of all companies.



All figures are provisional.
Source: Mannheim Enterprise Panel (ZEW). Calculations by ZEW in Müller et al. (2015)

Closure rates in Germany's knowledge economy, 2004 to 2013 (figures in percent)

Closure rate: Number of companies that close down during a year as a percentage of all companies.



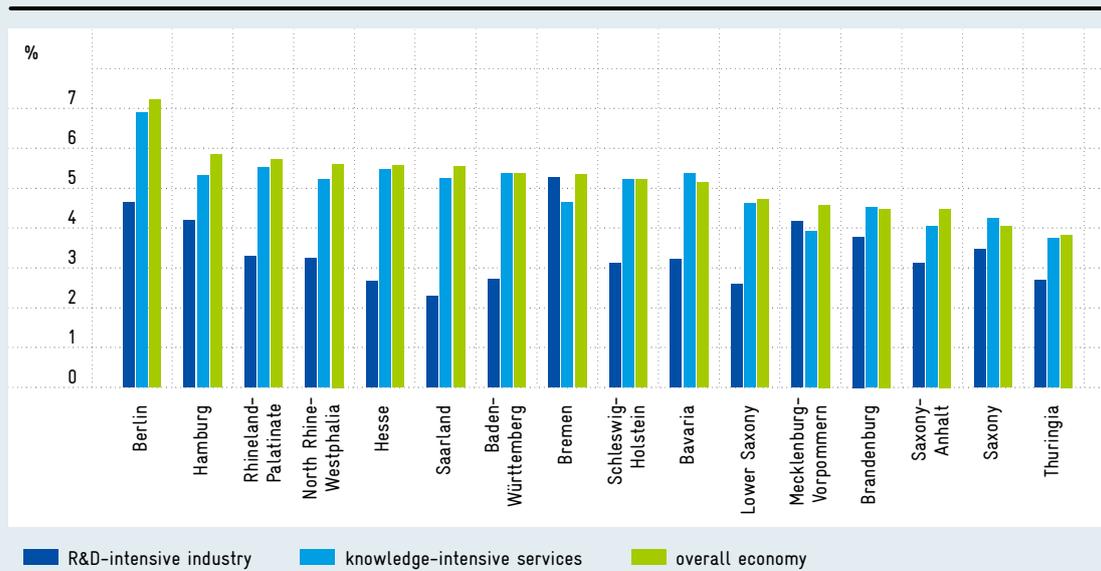
All figures are provisional.
Source: Mannheim Enterprise Panel (ZEW). Calculations by ZEW in Müller et al. (2015)

C 5-3

Data
Download

Start-up rates by Länder, 2011 to 2012 (figures in percent)

Start-up rate: number of start-ups as a percentage of all companies.



All figures are provisional.
Source: Mannheim Enterprise Panel (ZEW). Calculations by ZEW in Müller et al. (2015)

C 5-4

Data
Download

C 6 Patents

In 2012, most countries recovered further from the international financial and economic crisis. In terms of transnational patent applications, the United States returned to the level before the crisis (C 6-1). Japan in particular was quick to return to pre-crisis figures, since its growth rates were higher than those in the USA.³³¹ Transnational patent applications in Germany were less severely affected by the financial crisis than those in the USA, so the number of applications in Germany has remained comparatively constant over the last few years. Although Germany files fewer applications than the United States or Japan, it is still one of the world's leading nations in transnational patent applications.

The strongest positive dynamics in the last decade, as measured by the growth rates, came from China and Korea, followed by Japan. They have left the major European economies – Germany, the UK and France – a long way behind.

Although the United States is in the lead in terms of the absolute number of applications, it is not among the frontrunners with regard to patent intensity (patent applications per million of the working population; C 6-2). Here, the leaders are smaller countries like Finland, Switzerland and Sweden. The larger countries ranked in the upper third are Japan, Germany and Korea. Patents are an important tool for securing market shares in the context of the international technology trade. A high patent intensity therefore reflects both a strong international orientation and a pronounced export focus on the part of the relevant economy.

Further conclusions on a country's technological performance can be derived 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 revenue 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 and Switzerland are more specialised in these fields.

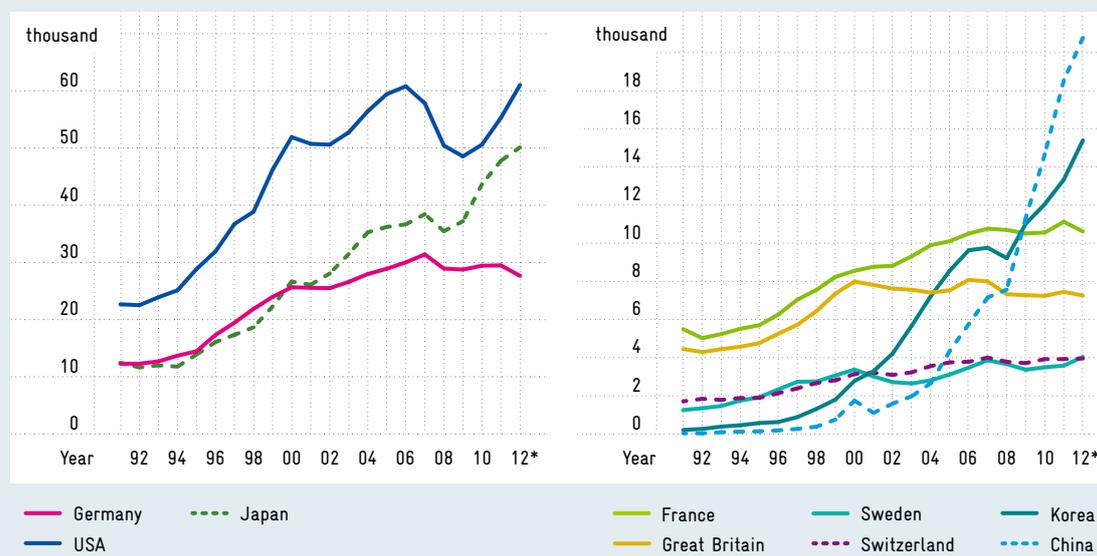
By contrast, China, Korea and the United States show a strong focus on cutting-edge technology (C 6-4). Germany is still poorly positioned in this field, behind Japan and the European countries of France and the UK (C 6-4). Switzerland was able to improve its position in the field of cutting-edge technology in 2012 and is now pulling ahead of Germany.

Development of the number of transnational patent applications in selected countries

C 6-1

Data
Download

Transnational patent applications comprise applications in patent families with at least one application to the World Intellectual Property Organisation (WIPO) via the PCT route or one application to the European Patent Office.



* Projection for the 2nd half of 2012. See Neuhäusler et al. (2015) for the actual numbers for 2012
Source: EPA (PATSTAT). Calculations by Fraunhofer ISI. December 2014.

Absolute number, intensity and growth rates of transnational patent applications in the field of R&D-intensive technology in 2012¹⁾

C 6-2

Data
Download

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 employees.

	absolute ²⁾	Intensities ²⁾	Intensities: R&D-intensive technology	Growth (2002 = 100) ²⁾	Growth of R&D-intensive technology (2002 = 100)
Total	244,323	-	-	152	159
Canada	4,092	234	153	145	146
China	20,770	28	21	1,306	1,532
EU-28	72,842	335	193	117	119
Finland	2,385	961	594	145	136
France	10,616	411	253	120	132
Germany	27,638	690	391	108	106
Great Britain	7,260	247	149	95	100
Italy	5,232	228	117	107	114
Japan	50,091	799	509	179	178
Korea	15,393	624	439	365	396
Netherlands	4,281	508	286	112	103
Sweden	4,042	868	615	149	170
Switzerland	3,956	897	533	128	141
USA	60,990	428	296	121	129

¹⁾ Projection for the 2nd half of 2012. See Neuhäusler et al. (2015) for the actual numbers 2012.

²⁾ Figures refer to all industries.

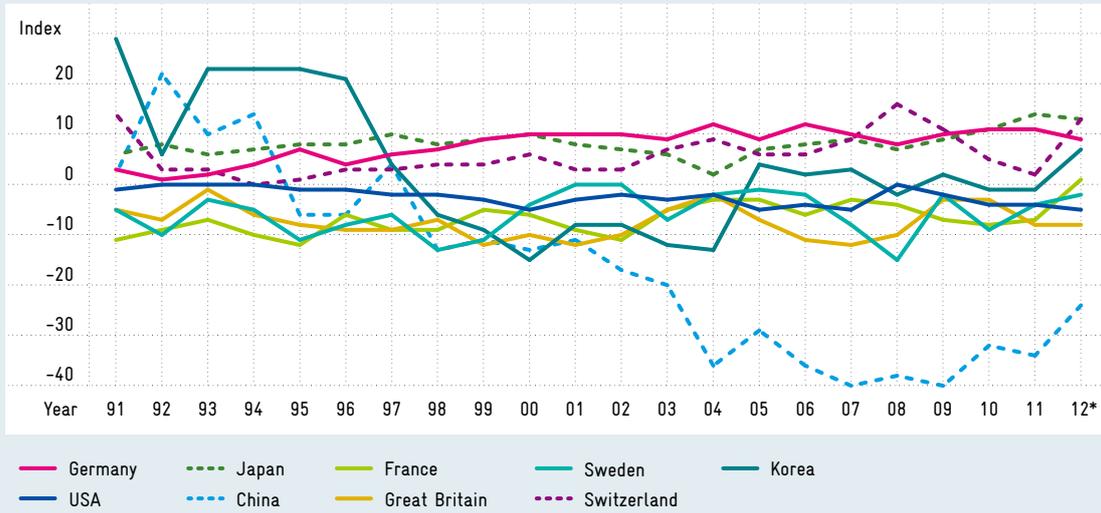
Source: EPA (PATSTAT). OECD (MISTI). Calculations by Fraunhofer ISI. December 2014.

C 6-3

Data
Download

Development of the specialisation index in selected countries: high-value technology

The specialisation index is calculated with reference to all global transnational patent applications. 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.



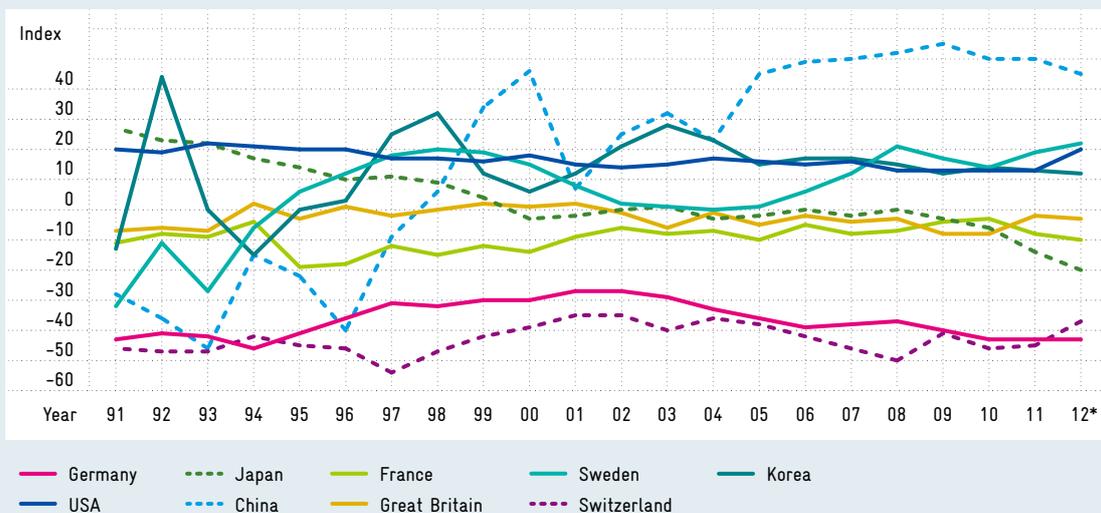
* Projection for the 2nd half of 2012. See Neuhäusler et al. (2015) for the actual numbers 2012.
Source: Questel (EPPATENT, WOPATENT). EPA (PATSTAT). Calculations by Fraunhofer ISI. December 2014.

C 6-4

Data
Download

Development of the specialisation index in selected countries: cutting-edge technology

The specialisation index is calculated with reference to all global transnational patent applications. 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.



* Projection for the 2nd half of 2012. See Neuhäusler et al. (2015) for the actual numbers 2012.
Source: Questel (EPPATENT, WOPATENT). EPA (PATSTAT). Calculations by Fraunhofer ISI. December 2014.

Scientific publications

C7

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. In cases where several co-authors of a single publication reside in different countries, fractional counting is employed.

The extent to which countries were represented in all WoS publications changed significantly between 2003 and 2013 (C 7-1)³³² China in particular almost tripled its share of publications from 4.8 to 13.4 percent. The shares of Korea, Brazil, India and South Africa also increased during this period. By contrast, the shares of established science systems in the USA, western Europe and Japan decreased: the USA lost nearly 7 percentage points, Germany only just under 2 percentage points. Despite the massive growth in publications in China, some countries in Europe still succeeded in keeping their shares constant over time, or even to increase them slightly. These countries included e.g. the Netherlands, Denmark, Poland, Spain and Italy.

In 2011, scientists above all in Switzerland, the Netherlands, Denmark and the USA succeeded in placing their publications particularly in scientific journals with an international audience (C 7-2). According to this quality indicator, Germany was on a comparable level to the UK, Sweden and Israel in 2011. Scientific publications from the Netherlands, Denmark and Israel have developed especially positively since 2003. Publications from Germany also developed very positively during this period. By contrast, scientists from the United States seem to have lost ground with regard not only to the quantity (see above), but also to the quality of their published works. Most of the BRICS countries (Brazil excluded) succeeded in improving their global position in the index, at least slightly, over time.

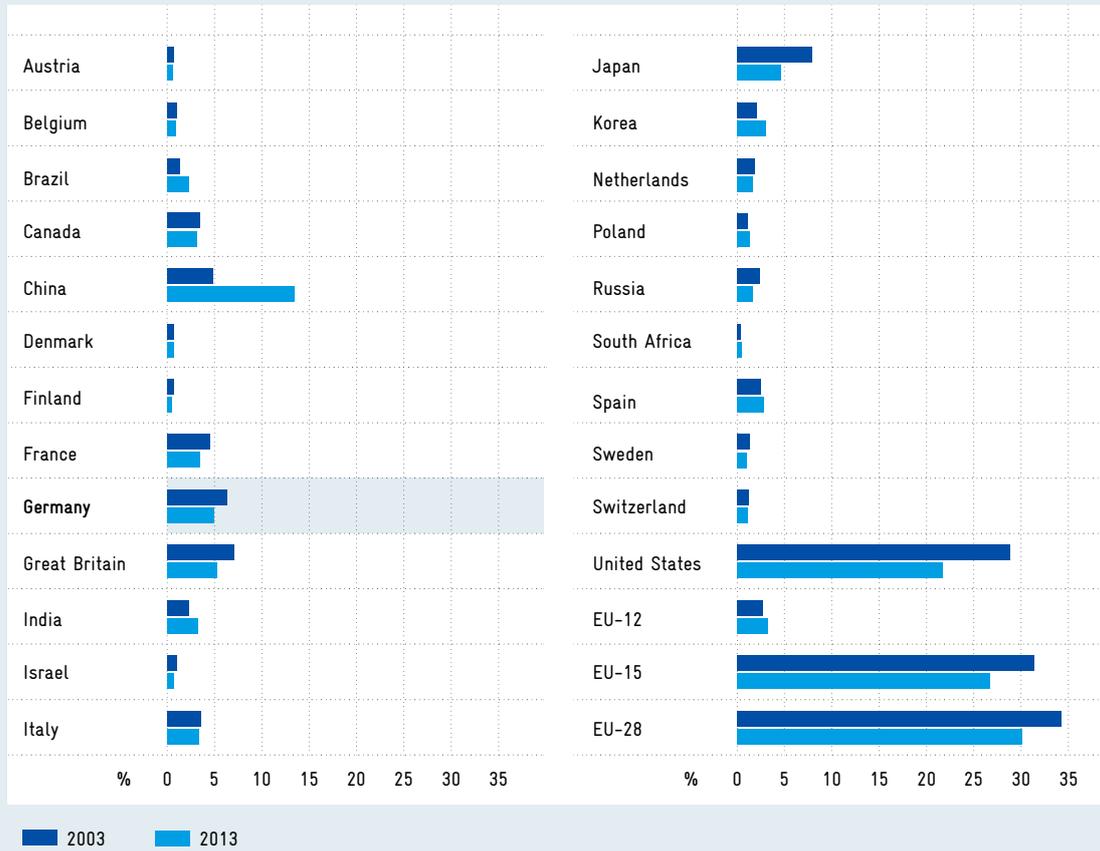
When compared internationally, publications from the Netherlands, Denmark and Switzerland were cited in scientific journals most frequently (C 7-3), indeed more often than publications from the United States and the UK. Brazil, China and India have experienced a particularly promising development since 2003. In terms of dynamics, a decline could be observed primarily in the Netherlands and Denmark, despite the good starting position in these countries. Germany's position deteriorated slightly. With regard to the two quality measures of the publication activities of scientists in Germany, the overall picture emerging is somewhat mixed (C 7-2 and C 7-3).

C 7-1

Data
Download

Percentages of all publications in the Web of Science that stem from selected countries and regions, 2003 and 2013

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



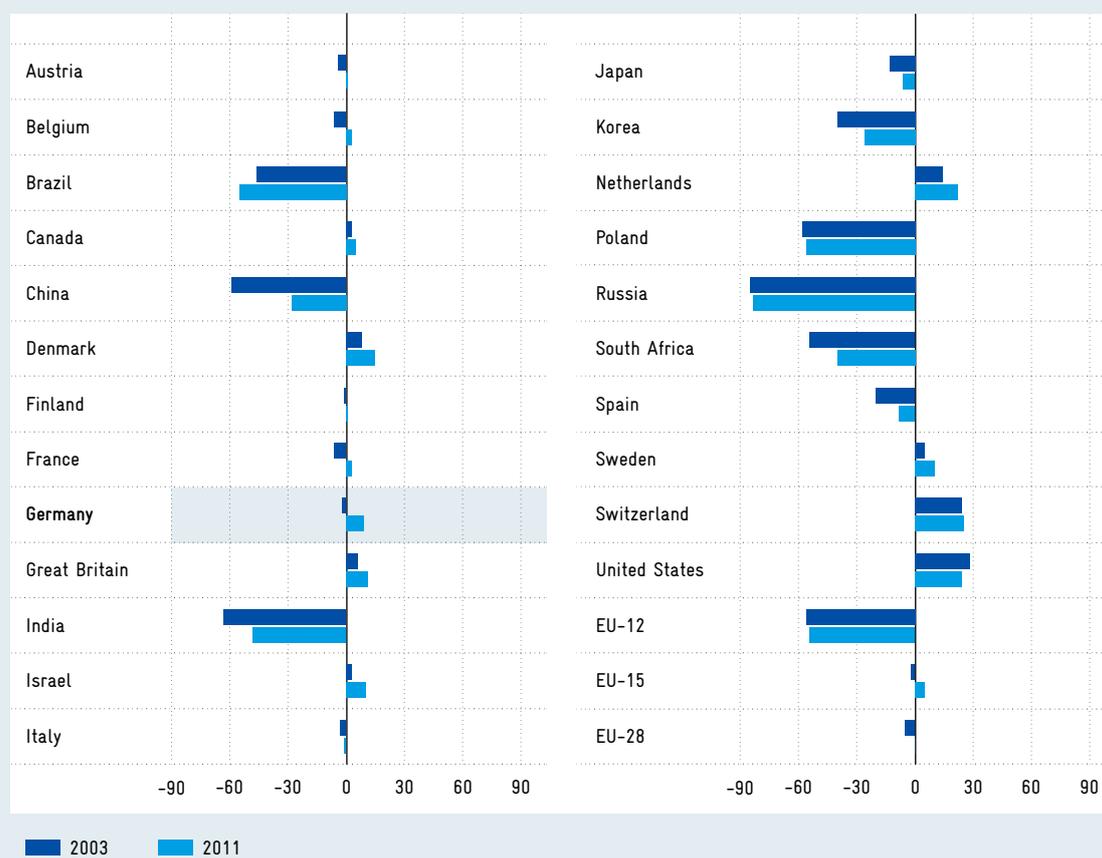
Source: Web of Science. Research and calculations by Fraunhofer ISI. Fractional counting.

C 7-2

Data
Download

International alignment (IA) of publications in the Web of Science from selected countries and regions, 2003 and 2011 (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.



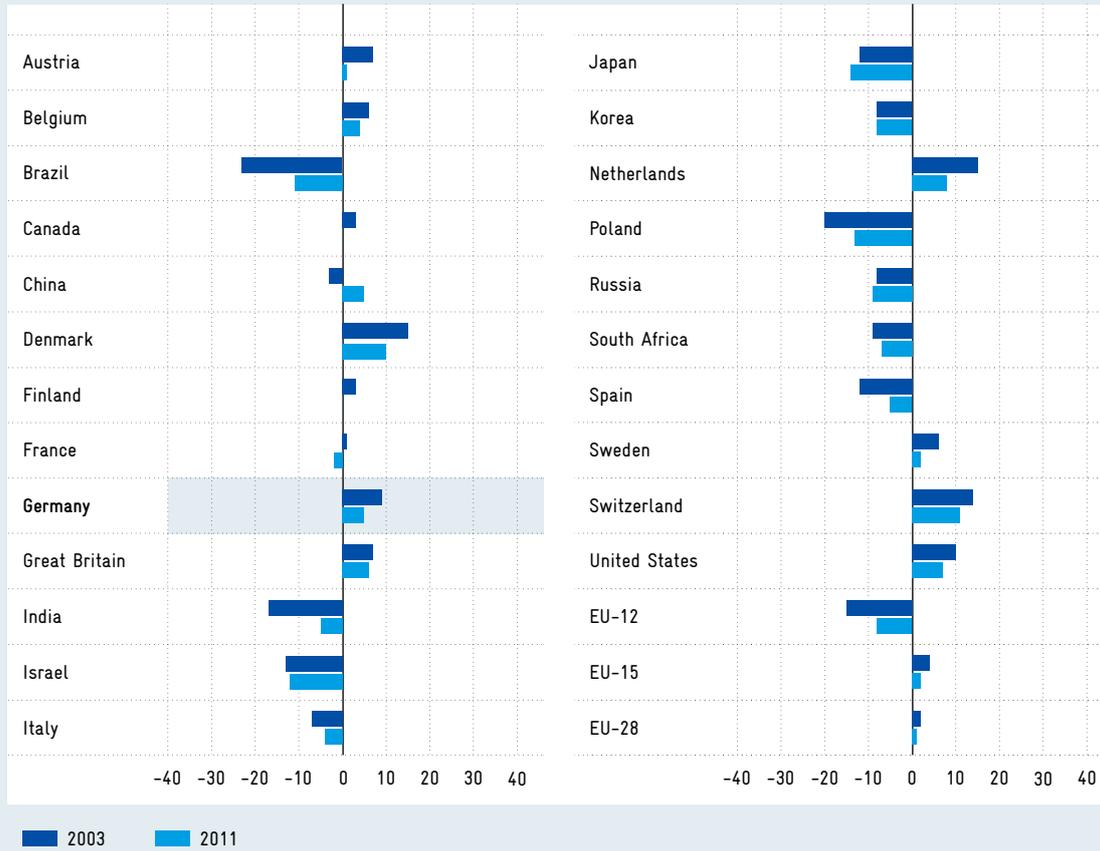
Source: Web of Science. Research and calculations by Fraunhofer ISI. Fractional counting.

C 7-3

Data
Download

Scientific regard (SR) of publications in the Web of Science from selected countries and regions, 2003 and 2011 (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. Fractional counting.

Production, value added and employment³³³

C 8

A country's specialisation pattern in foreign trade can be measured using the RCA indicator,³³⁴ 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, in 2013 Germany again showed a comparative advantage in the trade in R&D-intensive goods (C 8-1). R&D-intensive goods are made up of high-value technology goods and cutting-edge technology goods. Germany has a positive comparative advantage only in 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. By contrast, France, Switzerland, the USA and Korea have positive RCA indicator figures for cutting-edge technology. France and Switzerland, furthermore, show a continuous increase. The figures for the United States and Korea, however, have declined in recent years. Japan and China have negative RCA indicator values in cutting-edge technology. After rising for a few years, the figure for China has been falling again recently; in Japan it has been declining continuously for years.

The contribution of research- and knowledge-intensive industries to a country's value added reflects the importance of these industries and allows conclusions to be drawn on the country's technological performance (C 8-2). Relative to the other countries studied, Germany has the highest share of value added in the field of high-value technology. In 2012, it amounted to 8.2 percent of total German value added. In the field of cutting-edge technology, Germany's figure of 2.4 percent is much lower than the frontrunners Switzerland (8.1 percent) and Korea (7.3 percent).³³⁵

Following the decline in gross value added in several industrial sectors during the crisis year of 2009, value added in Germany has risen again since 2010 (C 8-3). However, the increase between 2011 and 2012 was smaller than in the previous years. Between 2011 and 2012, the biggest rise in value added was observed in knowledge-intensive services (3.2 percent). Similar growth rates were recorded by knowledge-intensive manufacturing (2.8 percent) and non-knowledge-intensive manufacturing (2.6 percent). The increase in the field of non-knowledge-intensive services was only 0.4 percent.

A similar trend can be observed in the development of employment covered by social security (C 8-4). Here, too, between 2011 and 2012 the highest increase was in employment in knowledge-intensive services (3.0 percent). There were also increases in knowledge-intensive manufacturing and non-knowledge-intensive services (1.1 percent and 0.7 percent respectively). Only in non-knowledge-intensive manufacturing did employment covered by social security stagnate.

C 8-1

Data
Download

Revealed comparative advantages (RCA) of selected countries in foreign trade in research-intensive goods 2000 to 2013

A positive RCA value means that the export/import ratio for this product group is higher than that of the total of all manufactured industrial goods.

Year	China ¹⁾	France	Germany	Great Britain	Japan	Korea	Sweden	Switzerland	USA ²⁾
R&D-intensive goods									
2000	-41	7	11	14	47	0	0	10	13
2005	-29	7	10	14	42	17	-1	18	17
2010	-27	6	12	11	33	19	-6	22	1
2013	-29	7	16	-7	34	20	-6	21	-2
High-value technology goods									
2000	-17	5	27	10	86	5	-7	26	-13
2005	0	6	27	4	75	11	-2	24	-5
2010	-16	-2	30	15	61	7	-3	21	-10
2013	-10	-5	30	-3	70	17	-2	16	-13
Cutting-edge technology goods									
2000	-66	11	-27	19	-10	-5	13	-30	47
2005	-53	8	-34	33	-14	24	1	4	55
2010	-35	20	-35	1	-22	33	-11	25	22
2013	-45	23	-23	-16	-37	23	-19	32	17

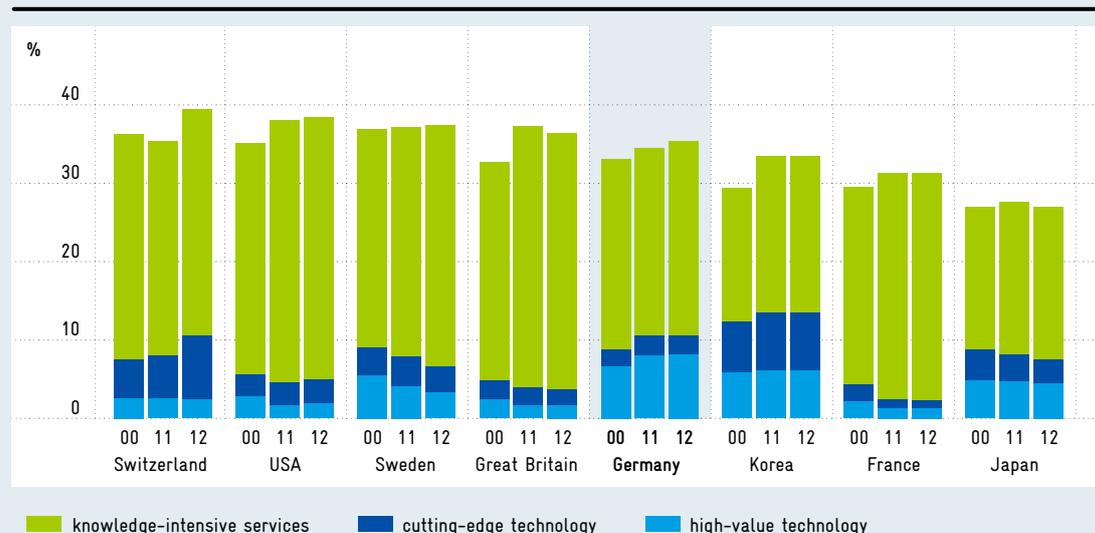
¹⁾ Incl. Hong Kong, 2013 estimated. ²⁾ From 2009, data for the USA have been revised on the basis of national sources. Source: UN COMTRADE Database. Calculations and estimates by NIW in Gehrke and Schiersch (2015).

C 8-2

Data
Download

R&D-intensive industries and knowledge-intensive services as a percentage of value added 2000 to 2012

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.



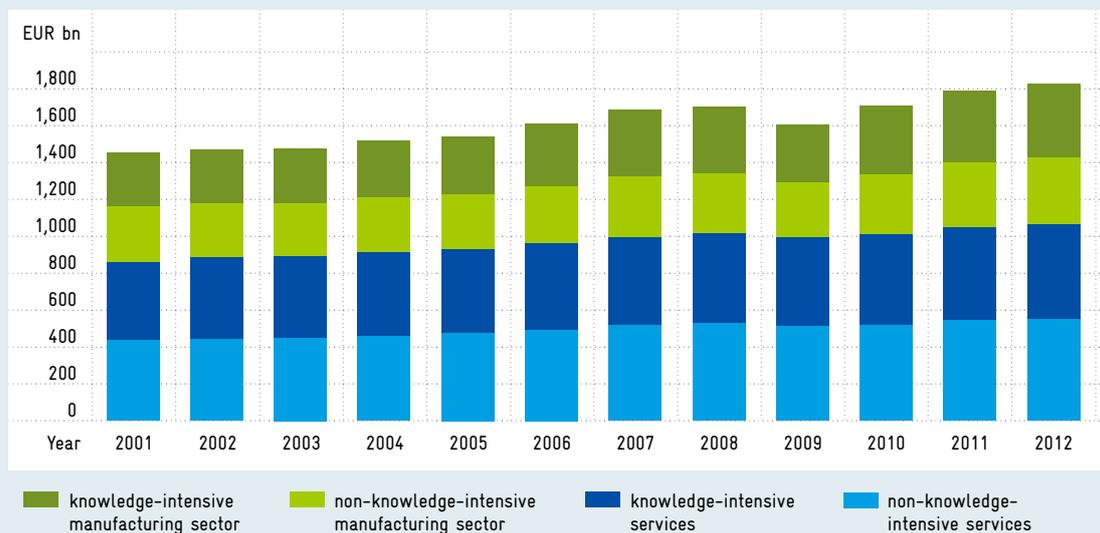
Source: OECD-STAN (2014), Eurostat (2014), EUKLEMS (2013, 2007), BEA (2014), BOK (2014), Statistics Bureau, Ministry of Internal Affairs and Communications Japan (2013). Calculations and estimates by DIW Berlin in Gehrke and Schiersch (2015).

Development of gross value added in various industry sectors in Germany in billions of euros

C 8-3

Data
Download

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, fishing, public administration and services, real estate and housing, education, private households, social insurance, religious and other organisations, associations and trade unions.

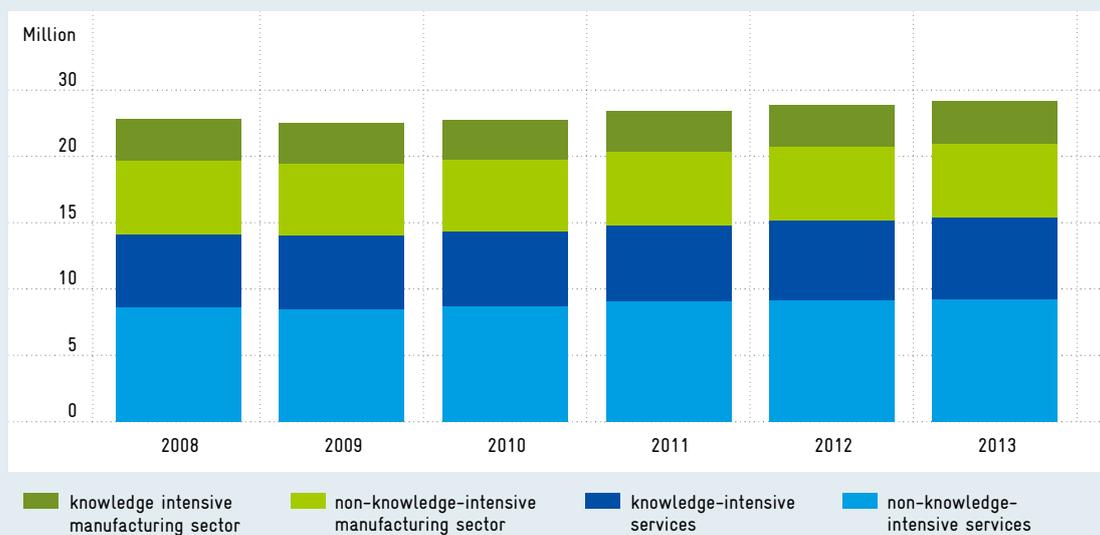
Source: Federal Statistical Office, Fachserie 18, Reihe 1.4. Calculations by NIW in Gehrke and Schiersch (2015).

Development of employment covered by social security in various industry sectors in Germany

C 8-4

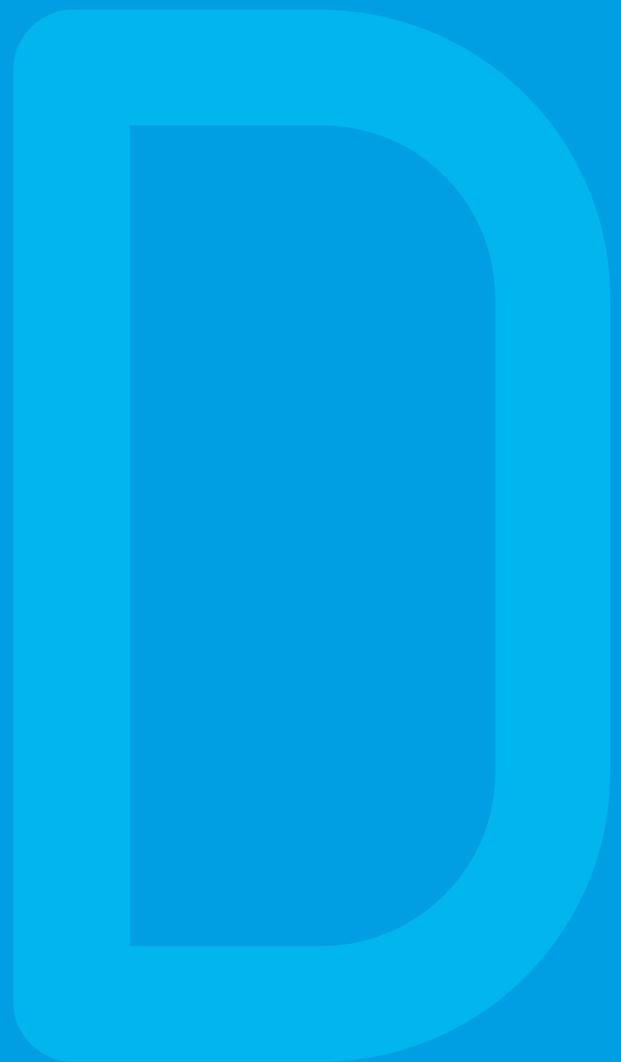
Data
Download

Employees covered by social security are 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.

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List of abbreviations

ACHSE	Allianz Chronischer Seltener Erkrankungen e.V. (Alliance of Chronic Rare Diseases)
AF	additive manufacturing
AMA	Asian Manufacturing Association
Art.	Article
BAföG	Bundesausbildungsförderungsgesetz (Federal Training Assistance Act)
GDP	gross domestic product
BMBF	Bundesministerium für Bildung und Forschung (Federal Ministry of Education and Research)
BMG	Bundesministerium für Gesundheit (Federal Ministry of Health)
BMI	Bundesministerium des Innern (Federal Ministry of the Interior)
BMVI	Bundesministerium für Verkehr und digitale Infrastruktur (Federal Ministry of Transport and Digital Infrastructure)
BMWi	Bundesministerium für Wirtschaft und Energie (Federal Ministry for Economic Affairs and Energy)
BRICS	Brazil, Russia, India, Chile, South Africa
CAD	computer-aided design
CIS	Community Innovation Surveys
DFG	Deutsche Forschungsgemeinschaft e.V. (German Research Foundation)
EFI	Expertenkommission Forschung und Innovation (Commission of Experts for Research and Innovation)
EIF	European Investment Fund
EPFL	Ecole polytechnique fédérale de Lausanne
EuGH	European Court of Justice
R&I	Research and Innovation
FhG	Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V. (Fraunhofer Society for the Advancement of Applied Research)
FiBS	Forschungsinstitut für Bildungs- und Sozialökonomie (Institute for Education and Socio-Economic Research and Consulting)
R&D	Research and Development
G8	supranational forum of the seven leading industrial nations and Russia
GG	Grundgesetz (Basic Law, Germany's constitution)
GWK	Gemeinsame Wissenschaftskonferenz (Joint Science Conference)
Hadopi	Haute Autorité pour la diffusion des oeuvres et la protection des droits sur internet
HGF	Helmholtz-Gemeinschaft Deutscher Forschungszentren e.V. (Helmholtz Association of German Research Centres)
HIS-HE	Hochschul Informations System GmbH Hochschulentwicklung (Higher Education Information System – Higher Education Information Development)
HTS	High-Tech Strategy

IAB	Institut für Arbeitsmarkt- und Berufsforschung (Institute for Employment Research)
ICT	information and communication technologies
InfoSoc	Directive 2001/29/EC on the harmonisation of certain aspects of copyright and related rights in the information society
ISCED	International Standard Classification of Education
ISO	International Organization for Standardization
KfW	Kreditanstalt für Wiederaufbau (KfW Group)
SMEs	small and medium-sized enterprises
KStG	Körperschaftsteuergesetz (Corporation Tax Act)
LMU	Ludwig-Maximilians-Universität (Ludwig Maximilians University of Munich)
Mbit	megabits
STEM	science, technology, engineering, mathematics.
MIP	Mannheimer Innovationspanel (Mannheim Innovation Panel)
MIT	Massachusetts Institute of Technology
MOOC	massive open online course
MoRaKG	Gesetz zur Modernisierung der Rahmenbedingungen für Kapitalbeteiligungen (Law on the Modernisation of the Framework Conditions for Venture Capital and Equity Investments)
MPG	Max-Planck-Gesellschaft zur Förderung der Wissenschaften e. V. (Max Planck Society for the Advancement of Science)
MUP	Mannheimer Unternehmenspanel (Mannheim Enterprise Panel)
NGO	non-governmental organization
OECD	Organisation for Economic Co-operation and Development
Ofcom	Office of Communications
PCT	Patent Cooperation Treaty
RBC	Revised Berne Convention
RCA	revealed comparative advantage
SASAM	Support Action for Standardisation in Additive Manufacturing
SUS	Strukturelle Unternehmensstatistik (structural business statistics)
TFP	total factor productivity
TRIPS	Trade-Related Aspects of Intellectual Property Rights
TUM	Technische Universität München (Technical University of Munich)
UrhG	Gesetz über Urheberrecht und verwandte Schutzrechte (Law on Copyright and Related Rights)
VerlG	Gesetz über das Verlagsrecht (Publishing Act)
NA	National Accounts
WahrnG	Gesetz über die Wahrnehmung von Urheberrechten und verwandten Schutzrechten (Law on the Administration of Copyright and Related Rights)
WGL	Wissenschaftsgemeinschaft Gottfried Wilhelm Leibniz e. V. (Leibniz Association)
WIPO	World Intellectual Property Organization
WoS	Web of Science
ZEW	Zentrum für Europäische Wirtschaftsforschung GmbH (Centre for European Economic Research)
ZIM	Zentrales Innovationsprogramm Mittelstand (Central Innovation Programme for SMEs)
NIW	Niedersächsisches Institut für Wirtschaftsforschung e. V. (Lower Saxony Institute for Economic Research)

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Economic sectors in R&D-intensive industries and knowledge-intensive industrial services³³⁶

R&D-intensive industrial sectors within the classification of economic activities, 2008 edition (WZ 2008) (4-digit classes)

Cutting-edge technology

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

High-value technology

- 20.13 Manufacture of other inorganic basic chemicals
- 20.14 Manufacture of other organic basic 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 (except 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

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

Knowledge-intensive services

Emphasis on finances and assets

- 41.1 Development of building projects
- 64.1 Monetary intermediation
- 64.2 Activities of holding companies
- 64.3 Trusts, funds and similar financial entities
- 64.9 Other financial service activities, except insurance and pension funding
- 65.1 Insurance
- 65.2 Reinsurance
- 65.3 Pension funding
- 66.1 Activities auxiliary to financial services, except insurance and pension funding
- 66.3 Fund management activities
- 68.1 Buying and selling of own real estate
- 68.3 Real estate activities on a fee or contract basis
- 77.4 Leasing of intellectual property and similar products, except copyrighted works

Emphasis on communication

- 61.1 Wired telecommunications activities
- 61.2 Wireless telecommunications activities
- 61.3 Satellite telecommunications activities
- 61.9 Other telecommunications activities
- 62.0 Computer programming, consultancy and related activities
- 63.1 Data processing, hosting and related activities, web portals
- 63.9 Other information service activities

Emphasis on non-technical consulting and research

- 71.1 Architectural and engineering activities and related technical consultancy
- 71.2 Technical testing and analysis

- 72.1 Research and experimental development on natural sciences and engineering
- 74.9 Other professional, scientific and technical activities n.e.c.
- Emphasis on non-technical consulting and research*
- 69.1 Legal activities
- 69.2 Accounting, bookkeeping and auditing activities; tax consultancy
- 70.1 Activities of head offices
- 70.2 Management consultancy activities
- 72.2 Research and experimental development on social sciences and humanities
- 73.1 Advertising
- 73.2 Market research and public opinion polling
- 82.1 Office administrative and support activities
- Emphasis on media and culture*
- 58.1 Publishing of books, periodicals and other publishing activities
- 58.2 Software publishing
- 59.1 Motion picture, video and television programme activities
- 59.2 Sound recording and music publishing activities
- 60.1 Radio broadcasting
- 60.2 Television programming and broadcasting activities
- 74.1 Specialised design activities
- 74.3 Translation and interpretation activities
- 82.3 Organisation of conventions and trade shows
- 90.0 Creative, arts and entertainment activities
- 91.0 Libraries, archives, museums and other cultural activities
- Emphasis on health*
- 75.0 Veterinary activities
- 86.1 Hospital activities
- 86.2 Medical and dental practice activities
- 86.9 Other human health activities

Glossary

BAföG (Federal Training Assistance Act):

The Federal Training Assistance Act (Bundesausbildungsförderungsgesetz, BAföG) regulates the provision of individual financial support by the public sector for the training and education of secondary and tertiary students.

Basic funds:

Basic funds refers to a university's institutional funds including other income from grants and subsidies.

Bibliometrics:

Bibliometrics is the quantitative study of scientific publications, authors and institutions, mostly using statistical methods. It is a subfield of scientometrics, a quantitative study of science and scientific processes.

Business angel:

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 part of their private assets directly in a company, without the aid of an intermediary, and receive shares in the company in return.

Carried-over losses:

Carried-over losses are the total losses incurred in previous business years that could not be offset against positive income. These losses can be carried forward and then netted against profits in subsequent business years, thus reducing the tax burden in these years.

Community Innovation Surveys:

The Community Innovation Surveys (CIS) are the European Union's most important statistical instrument for surveying innovation activities in Europe. The CIS data helps analyse the economic effects of innovation (on competition, employment, economic growth, models for trade, etc.) on the basis of a survey of a representative sample of companies.

Cumulative innovation:

Cumulative innovations are incremental innovations or ideas that build on each other. In this process, the first innovation or invention is a fundamental precondition for subsequent innovations.

Cutting-edge technology:

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

Debt capital:

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

DFG programme allowance:

The DFG programme allowances represent the second pillar of the Higher Education Pact (cf. *ibid*). Prior to the introduction of the Pact it was the responsibility of the tertiary education institutions to bear the overhead costs for the implementation of a project. Now applicants for projects funded by the German Research Foundation (DFG) receive a programme allowance to cover the indirect additional and variable costs connected with the funding. This currently amounts to 20 percent of the billable direct project costs – and will rise to 22 percent in the 2016-2020 programme phase.

Early stage:

“Early stage” describes the financing of a company's early-phase development – beginning with the financing of research and the product design (seed phase), and continuing with the formation of the company until the beginning of business operations and including product development and initial marketing (start-up phase). The seed phase is limited to research and development 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 creates the basis for the provision of administrative services independent of time and place. The goal is to improve electronic communication with public administration and to enable the Federal Government, the Länder and the municipalities

to provide simpler, more user-friendly and more efficient electronic administration services.

Equity capital:

Equity capital is the liable capital of a company: financial resources that are raised by the company's owners themselves, or provided by profits generated by, and left within, the company. Equity capital can also be obtained from external investors, i.e. in the form of venture capital.

EU Research Framework Programme:

Public support for research and development in the European Union is implemented through specific programmes, each of which addresses a certain research area and usually runs for several years. These programmes are subsumed under a larger unit, the Research Framework Programme.

EU-12 countries:

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

EU-15 countries:

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

EU-28 countries:

The EU-28 countries are the 28 Member States.

Excellence Initiative:

This is an agreement between the Federal and Länder governments to promote science and research at German tertiary education institutions with a view to enhancing international competitiveness of the latter. Launched in 2005, the initiative is being implemented by the German Research Foundation (Deutsche Forschungsgemeinschaft, DFG) and the German Council of Science and Humanities (Wissenschaftsrat, WR).

Exit:

Exit is a term used to describe the withdrawal of investors from their holding in a company by selling their share.

Federalism Reform I:

The Federalism Reform I, which came into force in September 2006, re-arranged the relations between

the Federal and Länder governments in terms of the distribution of legislative powers between them, and the responsibilities and rights of participation of the Länder in the federal legislative process. The aim was to reduce the percentage of laws that require the approval of the second legislative chamber, the Bundesrat (where the Länder are directly represented). The Federalism Reform II then came into force in August 2009; its key element was a reform of the public financial relations.

Frascati Manual:

The OECD's Frascati Manual specifies methods and criteria 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 those discussions formed the basis of the first Frascati Manual. Since then, the Frascati Manual has been revised several times; the most recent edition dates from 2002.

High technology:

Cf. R&D-intensive goods.

Higher Education Pact:

The Higher Education Pact is an agreement between the Federal and Länder governments that was launched in 2007 and is designed to continue until 2020. It aims on the one hand to secure sufficient study opportunities to meet demand, and on the other to intensify competition for research funding by means of financing from the DFG programme allowance (cf. *ibid*).

High-value technology:

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

Horizon 2020:

Grundmittel sind Haushaltsmittel der Hochschulen inklusive anderer Einnahmen aus Zuweisungen und Zuschüssen.

Hochschulpakt:

Horizon 2020 refers to the new framework programme for research and innovation which in 2014 succeeded the 7th EU Research Framework Programme (cf. *ibid*). Horizon 2020 brings together all

of the European Commission's research and innovation-relevant funding programmes.

Humboldtian ideal:

The Humboldtian ideal refers to the idea of the unity of research and teaching at tertiary education institutions, especially at universities. This idea is implemented, for example, by professors usually assuming both teaching and research duties. The aim is to train students on the basis of recent research findings and to introduce them to research at an early stage.

IAB Establishment Panel:

The IAB Establishment Panel is a representative employer survey of corporate employment determinants. The corporate survey is conducted by the Institute for Employment Research (IAB) and the Federal Employment Agency's research facility. It covers a broad range of questions on a multitude of employment- and corporate-policy themes which can be used for a variety of different research projects.

Incremental innovation:

Innovation achieved by improving an existing product is referred to as incremental innovation. By contrast, radical innovation (cf. *ibid*) refers to fundamental innovations that lead to entirely new product concepts and technical solutions.

Industry 4.0:

Industry 4.0 is a specific future-oriented project within the Federal Government's High-Tech Strategy (cf. *ibid*) designed to promote the computerisation and automatising of classical industries, e.g. mechanical engineering.

Innovation intensity:

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

Interoperability:

Interoperability is the ability of independent, heterogeneous systems to work together as seamlessly as possible, e.g. in order to make mutual use of functions and services and exchange information in an efficient and usable way, or make it available to the user, without needing to make separate changes to the systems.

Knowledge economy:

The knowledge economy encompasses R&D-intensive industries and knowledge-intensive services (cf. *ibid*).

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 targeting business expansion of a young company which is already generating turnover and whose product is ready for the market.

Lead market:

When different technological ideas with the same function are developed, the internationally successful idea will be the one that is accepted by a single market at an early stage. This is how a "lead market" emerges. Various impacting factors play a role here: the legal framework, cultural differences, the market power of alternatives, specific regional business knowledge, distribution channels, the availability of skilled workers, etc. It is therefore difficult to predict future lead markets in individual cases.

National accounts:

The national accounts (NA) are a set of instruments for observing the economy. They provide a comprehensive quantitative overall picture of economic activity. The national accounts consist of domestic product calculation, input-output accounts, national wealth accounts, employment accounts, labour volume accounts and financial accounts.

New mission-oriented R&I policy:

R&I policy is mission-oriented if research and innovation activities are promoted in order to achieve politically defined goals. A classic example of this was the USA's Apollo space programme, which began in 1961; its aim was to put a man on the moon and bring him back safely before the end of the 1960s. Whereas the majority of the missions pursued from the 1940s until the 1960s were technology-oriented, R&I policy since the 1990s has focused more on societal issues. It is therefore called new mission-oriented R&I policy.

Open access:

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

Open innovation:

The opening up of corporate innovation processes, i.e. the active, strategic use of external sources in order to increase one's own innovation potential, is called open innovation. In this process firms must be

able to internalise external knowledge and/or to externalise internal knowledge.

Open source:

Open source or open-source code refers to software that anyone may study, use, change and copy at will.

Oslo Manual:

The OECD's Oslo Manual contains specifications on the statistical coverage of innovation activities. The Oslo Manual goes beyond the R&D concept used by the Frascati Manual (cf. *ibid*), as it makes a distinction between different forms of innovation. The Oslo Manual serves as the basis for the Community Innovation Surveys (cf. *ibid*). The most recent revision of the manual dates from 2005.

Pact for Research and Innovation:

The Pact regulates increases in the funding of Germany's five non-university science and research organisations by the Federal and Länder governments. The science and research organisations in turn committed themselves to improve the quality, efficiency and performance of their respective research and development activities.

PCT application:

The international patent application process was simplified in 1970 with the adoption of the Patent Cooperation Treaty (PCT) under the umbrella of the World Intellectual Property Organization (WIPO, established in 1969). Inventors from PCT contracting countries can submit prior notification of an application to the WIPO – or other registered authorities – and submit one patent application instead of several individual national or regional applications. This enables inventors to obtain patent protection in all the 148 treaty countries. The priority date of the patent is the date on which the application is submitted to the WIPO. The applicant is subsequently given a (grace) period of 30 months (or 31 months at some authorities like the EPA) within which he or she can make the final decision on the countries in which the patent protection are to apply. National or regional patent offices are nevertheless responsible for the granting of patents.

Project allowance:

Since 2011, the Federal Ministry of Education and Research (BMBF) has granted a 20 percent project allowance for direct project funds to tertiary education institutions.

Prototype:

A prototype is a functioning, but often simplified, experimental model of a planned product or component. Sometimes it only corresponds externally or technically to the final product. The purpose of making a prototype is to be able to visualize ideas, explore aspects of a solution, or test a preliminary result. A prototype is often used in preparation for series production, although it can also be planned as a one-off item aiming only to illustrate a specific concept.

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 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*).

Radical innovation:

Radical innovations are fundamental innovations that lead to entirely new product concepts, technical solutions or services – in contrast to incremental innovation (cf. *ibid*), which refers to the improvement of an existing product or process.

Rapid manufacturing:

In the context of additive manufacturing, rapid manufacturing refers to methods and production processes which make it possible to manufacture components and series quickly and flexibly using tool-less production methods directly from the CAD data (cf. chapter B4). Materials used include e.g. glass, metal, ceramics and plastics.

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 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.

Second Basket:

The Second Law on the Regulation of Copyright in the Information Society came into force on 1 January 2008. This is the so-called “Second Basket” of amendments to the Copyright Act. One of the new regulations is that the originator receives a lump-sum payment as compensation for private copying, which continues to be allowed.

Seed phase:

Cf. Early stage.

Smart Specialisation:

Smart Specialisation is a European Union strategy for European regions that guides the development of regional innovation strategies for the funding period 2014 to 2020.

Spillover effects:

Spillover effects occur in research and innovation in the form of knowledge transfer, e.g. when a company generates economic benefits from the R&D activities of another company.

Start-up phase:

Cf. Early stage.

Start-ups:

Start-ups are newly established businesses.

Third Basket:

The so-called “Third Basket” (Dritter Korb) is part of the amendment to the Copyright Act (cf. Second Basket). The first hearings on the Third Basket began at the Federal Ministry of Justice in the summer of 2010. Several of the new regulations have already been implemented, e.g. the ancillary copyright law for publishing houses with effect from 1 August 2013, and the regulations on orphan works with effect from 1 January 2014.

Third-party funding:

Third-party funding is funding for universities or other research institutions raised from public or private sources in addition to the regular budget (basic or institutional funding).

Three-percent target:

In 2002, the European Council decided in Barcelona to increase the EU’s total R&D expenditure to three percent of GDP by 2010. In addition, two-thirds of this expenditure was to be financed by the private sector.

Total factor productivity:

Total factor productivity indicates the part of economic growth that is not based on an increase in such factors of production as labour and capital. It is thus a residual which is usually associated with technological progress or increases in efficiency.

Transnational patents:

Transnational patents are inventions that are the subject of at least one application filed with the World Intellectual Property Organization (WIPO) via the PCT route (cf. PCT application), or 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 generated (wages, salaries, interest, rent, lease income, sales profits) in a given period that is included in the national accounts (cf. *ibid*). The term is equivalent to national income (domestic product). In a business sense, value added refers to the production value generated in a given period minus the value of the preliminary work/services received from other companies in the same period.

Venture capital:

Venture or risk capital refers to initial capital for start-up businesses and young enterprises provided as equity capital. It also includes financing used to strengthen the equity-capital (cf. *ibid*) bases of small and medium-sized enterprises. This enables such companies to roll out activities and to implement innovative, even very risky projects. For investors, venture-capital investments are also associated with high risk. 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 phase (cf. *ibid*).

Recent Studies on the German Innovation System

The Commission of Experts for Research and Innovation (EFI) regularly commissions studies on topics that are relevant in terms of innovation policy. All studies can be found on the EFI website (www.e-fi.de) under the section “Studies on the German innovation system”. The findings of these studies have been integrated into the EFI Report.

1-2015

Baethge, M.; Cordes, A.; Donk, A.; Kerst, C.; Wespel, J.; Wieck, M.; Winkelmann, G. (2015): Bildung und Qualifikation als Grundlage der technologischen Leistungsfähigkeit Deutschlands 2015, Studien zum deutschen Innovationssystem, Berlin: EFI.

2-2015

Cordes, A.; von Haaren, F. (2015): Betriebliche Weiterbildung in Deutschland – Auswertungen des IAB-Betriebspanels 2003 bis 2012, Studien zum deutschen Innovationssystem, Berlin: EFI.

3-2015

Schasse, U.; Leidmann, M. (2015): Forschung und Entwicklung in Staat und Wirtschaft – Kurzstudie 2015, Studien zum deutschen Innovationssystem, Berlin: EFI.

4-2015

Müller, B.; Bersch, J.; Gottschalk, S. (2015): Unternehmensdynamik in der Wissenswirtschaft in Deutschland 2013, Gründungen und Schließungen von Unternehmen, Gründungsdynamik in den Bundesländern, Internationaler Vergleich, Studien zum deutschen Innovationssystem, Berlin: EFI.

5-2015

Neuhäusler, P.; Rothengatter, O.; Frietsch, R. (2015): Patent Applications – Structures, Trends and Recent Developments 2014, Studien zum deutschen Innovationssystem, Berlin: EFI.

6-2015

Dornbusch, F.; Neuhäusler, P. (2015): Academic Patents in Germany, Studien zum deutschen Innovationssystem, Berlin: EFI.

7-2015

Mund, C.; Frietsch, R.; Neuhäusler, P. (2015): Performance and Structures of the German Science System 2014, Studien zum deutschen Innovationssystem, Berlin: EFI.

8-2015

Donner, P.; Aman, V. (2015): Quantilbasierte Indikatoren für Impact und Publikationsstrategie, Ergebnisse für Deutschland in allen Fachdisziplinen in den Jahren 2000 bis 2011, Studien zum deutschen Innovationssystem, Berlin: EFI.

9-2015

Sirtes, D.; Riechert, M.; Donner, P.; Aman, V.; Möller, T. (2015): Funding Acknowledgements in der Web of Science Datenbank. Neue Methoden und Möglichkeiten der Analyse von Förderorganisationen, Studien zum deutschen Innovationssystem, Berlin: EFI.

10-2015

Schiersch, A.; Gehrke, B. (2015): Globale Wertschöpfungsketten und ausgewählte Standardindikatoren zur Wissenswirtschaft, Studien zum deutschen Innovationssystem, Berlin: EFI.

11-2015

Cordes, A. (2015): Regional Specialization and Labor Mobility – An Empirical Analysis of German Microdata for 2000-2010, Studien zum deutschen Innovationssystem, Berlin: EFI.

12-2015

Dachs, B.; Warnke, P.; Dinges, M.; Teufel, B.; Weber, M.; Zahradnik, G. (2015): Herausforderungen und Perspektiven missionsorientierter Forschungs- und Innovationspolitik, Studien zum deutschen Innovationssystem, Berlin: EFI.

13-2015

Fornahl, D.; Campen, A.; Gerken, P.; Heimer, T.; Knop, S.; Reinecke, I.; Schrapers, M.; Talmon-Gros, L.; Treperman, J. (2015): Cluster als Paradigma der Innovationspolitik - Eine erfolgreiche Anwendung von Theorie in der politischen Praxis?, Studien zum deutschen Innovationssystem, Berlin: EFI.

14-2015

Kroll, H.; Stahlecker, T. (2015): Prozess und Auswirkungen der Entwicklung von „Strategien intelligenter Spezialisierung“ in deutschen Ländern, Studien zum deutschen Innovationssystem, Berlin: EFI.

15-2015

Jungermann, I.; Wannemacher, K. (2015): Innovationen in der Hochschulbildung, Massive Open Online Courses an den deutschen Hochschulen, Studien zum deutschen Innovationssystem, Berlin: EFI.

16-2015

Handke, C.; Girard, Y.; Mattes, A. (2015): Fördert das Urheberrecht Innovation? Eine empirische Untersuchung, Studien zum deutschen Innovationssystem, Berlin: EFI.

17-2015

Bechthold, L.; Fischer, V.; Greul, A.; Hainzlmaier, A.; Hugenroth, D.; Ivanova, L.; Kroth, K.; Römer, B.; Sikorska, E.; Sitzmann, V. (2015): 3D Printing – A Qualitative Assessment of Applications, Recent Trends and the Technology's Future Potential, Studien zum deutschen Innovationssystem, Berlin: EFI.

18-2015

Cuntz, A.; Czernich, N.; Dauchert, H.; Meurer, P.; Philipps, A. (2015): Gesellschaftliche Dimensionen von Innovation – Zentrale Fragen und Datenlage, Studien zum deutschen Innovationssystem, Berlin: EFI.

Endnotes

A 1

- 1 Cf. EFI (2014: 20ff.).
- 2 Cf. Deutscher Bundestag (2014a: 1). Existing associations between tertiary education institutions and non-university research institutions include the Karlsruhe Institute of Technology (KIT) – linking the Forschungszentrum Karlsruhe (Karlsruhe Research Centre, a major research institution of the Helmholtz Association) with the Universität Karlsruhe – and the Berliner Institut für Gesundheitsforschung (Berlin Institute of Health, BIH), in which the university hospital Charité-Universitätsmedizin Berlin cooperates with the Max Delbrück Centre for Molecular Medicine (MDC, a research institute of the Helmholtz Association).
- 3 Cf. Deutscher Bundestag (2014a: 7).
- 4 Cf. EFI (2012: Chapter B 1), EFI (2013: 22) and EFI (2014: Chapter A 1).
- 5 Cf. http://www.bundesfinanzministerium.de/Content/DE/Standardartikel/Themen/Oeffentliche_Finzen/Foederale_Finanzbeziehungen/Laenderhaus-halte/2014-05-27-Vorschlag-Verteilung-Mittel.html?view=renderPrint (last accessed on 12 January 2015).
- 6 Own calculations on the basis of Deutscher Bundestag (2014b).
- 7 In this regard and in the following, cf. Dohmen and Krempkow (2014: 51), and cf. http://www.fibs.eu/de/sites/presse/_wgHtml/_wgData/FiBS_BAfoeG-Mittel_140924.pdf (last accessed on 12 January 2015).
- 8 In many cases, there were as yet no concrete plans on the use of funds.
- 9 Cf. BMBF (2014a).
- 10 In this regard and in the following, cf. <http://www.bmbf.de/de/25453.php> (last accessed on 12 January 2015), <http://www.bmbf.de/de/6142.php> (last accessed on 12 January 2015), <http://www.gwk-bonn.de/themen/wissenschaftspakte/hochschulpakt-2020/> (last accessed on 12 January 2015) and BMBF (2014a).
- 11 This has been proposed by Berlin's former Senator for Education and Science Jürgen Zöllner (cf. Zöllner 2013: 34f.). Zöllner relates his latest proposal to students from developing countries. Cf. Die Zeit (2014a) and Zöllner (2014).
- 12 In the context of these basic contributions, the Swiss central government also makes payments for the number of students and for research efforts. The sum of the basic contributions is a politically defined total amount for which the universities compete. In addition, the central government pays investment contributions and project-related contributions. Furthermore, Switzerland has a financial equalisation scheme between the cantons in the field of tertiary education. The “home cantons” – i.e. the cantons where the students passed their Matura, or school-leaving examination – pay an amount that varies according to faculty groups. This is a politically fixed price (that does not cover all costs). For more information on the Swiss model, cf. <http://www.sbf.admin.ch/themen/hochschulen/01641/index.html?lang=de> (last accessed on 12 January 2015), <http://www.sbf.admin.ch/themen/hochschulen/01641/01671/index.html?lang=de> (last accessed on 12 January 2015), <http://www.sbf.admin.ch/themen/hochschulen/01641/01673/index.html?lang=de> (last accessed on 12 January 2015) and <http://www.sbf.admin.ch/themen/hochschulen/01641/01779/index.html?lang=de> (last accessed on 12 January 2015) and information from the Swiss State Secretariat for Education, Research and Innovation (Staatssekretariat für Bildung, Forschung und Innovation) provided by telephone.
- 13 These include scholarships and loans to finance studies, options for organising courses of study more flexibly or on a part-time basis, sources of information, advice and preparation assistance in the run-up to the decision on what to study and during the initial study phase, a higher quality of teaching and better study organisation, early performance monitoring and a more differentiated performance feedback (cf. EFI 2010: 12).
- 14 Cf. EFI (2012: 60ff.) and EFI (2014: 30ff.).
- 15 In this regard, cf. <http://www.bmbf.de/de/25453.php> (last accessed on 12 January 2015), o.V. (2014a) and BMBF (2014a).
- 16 According to a recent study prepared by Prognos, KPMG and Joanneum Research on behalf of the BMBF, many tertiary education institutions are unable to increase their third-party funding any further without the resources of the DFG programme allowance, the BMBF project allowance, and overhead funding from the EU (cf. Prognos AG et al. 2014: 7). However, in most cases the BMBF project allowance, which – like the DFG programme allowance to date – amounts to 20 percent, only partially offsets the costs caused by third-party-funded research according to the above-mentioned study (cf. Prognos AG et al. 2014: 111).
- 17 Cf. o.V. (2014a) and BMBF (2014a).
- 18 Cf. EFI (2011: 36ff.) and EFI (2014: 21).
- 19 O.V. (2014b).
- 20 Cf. o.V. (2014b).
- 21 In this regard and in the following, cf. GWK (2014).
- 22 In this regard and in the following, cf. o.V. (2014b).
- 23 In this regard, cf. o.V. (2014b).
- 24 Cf. EFI (2012: 57) and EFI (2013: 22).
- 25 The resolution passed by the heads of the Federal and Länder governments on the decision of principle states: “The Federal and Länder governments will strive to ensure that at least the same amount of funding that has been jointly provided hitherto for the Excellence Initiative shall continue to be available in the future” (o.V. 2014b).
- 26 Cf. endnote 13.

A 2

- 27 Cf. Haltiwanger et al. (2013). The authors of the study demonstrate that, in the USA, new employment is created in particular by small and young companies.
- 28 Cf. EFI (2009).
- 29 The MIP defines SMEs as companies with a workforce of between 5 and 500.
- 30 The considerable increase in expenditure can be partly explained by massive investment, particularly in the automotive sector.
- 31 Recent data from the ZEW show that the innovation intensity of SMEs (with fewer than 500 employees) rose by 0.1 percentage points to 1.65 percent in 2013 compared to 2012. This means that it is still below the intensity in 2007. There was a similar development in internal R&D expenditure by SMEs as documented by the Stifterverband's survey: there was an increase of 4.6 percent in 2013 compared to 2012. The SMEs' expenditure on R&D had risen year-on-year by 0.8 percent in 2012 and by 9.7 percent in 2011.
- 32 The IAB data use Blossfeld's definition to classify occupations: "engineers are highly qualified professionals who are able to solve scientific and technical problems" (cf. Schimpl-Neimanns 2003).
- 33 These results are essentially confirmed if we look at the median of the distribution by industry instead of averages. The percentage in the small businesses fell from 1.5 to 1.3 percent between 1999 and 2010. In the medium-sized companies it rose slightly from 2.5 to 2.8 percent and grew comparatively strongly in large companies from 3.9 to 5.0 percent.
- 34 An establishment is not always the same as a company. A firm establishment is a locally tied organisational unit, while a company can be made up of several establishments that can be in different locations or pursue different types of economic activity within the company. In view of the size classifications chosen here, however, we can assume that the results of the analysis based on establishments can be transferred to companies.
- 35 The possible causes of the comparatively weak expenditure by SMEs include the decline in new business start-ups in the last few years – an initial effect of demographic change (cf. ZEW 2014) – and the worsened situation for financing R&D activities in the wake of the financial and economic crisis.

A 3

- 36 Cf. Dachs et al. (2015).
- 37 Cf. BMBF (2006). Medical engineering and innovative manufacturing technology were named as lead markets, for example. Examples of key technologies are ICT, new materials and mechatronics.
- 38 Cf. BMBF (2010).
- 39 Cf. for example Foray et al. (2012).
- 40 Cf. BMBF (2014b: 11).
- 41 BMBF (2014b: 4).
- 42 BMBF (2014b: 5).
- 43 Cf. Dachs et al. (2015).

- 44 In this regard and in the following, cf. BMBF (2014b: 30ff).
- 45 Cf. BMBF (2014b: 34ff).
- 46 In this regard, cf. BMBF (2014b: 40).
- 47 Cf. <http://www.buergerdialog-bmbf.de/allgemein/buergerdialog.php> (last accessed on 12 January 2015).
- 48 Cf. NAMSE (2013).
- 49 Cf. <http://www.fona.de/green-economy> (last accessed on 12 January 2015).
- 50 Cf. EFI (2013: 23).
- 51 Cf. BMBF (2014b: 44ff).
- 52 In this regard and in the following, cf. <http://www.whitehouse.gov/blog/2014/07/28/crowdsourcing-ideas-accelerate-economic-growth-and-prosperity-through-strategy-ameri> (last accessed on 12 January 2015), <http://blog.quora.com/Guest-Post-Crowdsourcing-Ideas-to-Accelerate-Economic-Growth-and-Prosperity-through-a-White-House-Strategy-for-Ameri> (last accessed on 12 January 2015), and <https://www.federalregister.gov/articles/2014/07/29/2014-17761/strategy-for-american-innovation#h-8> (last accessed on 12 January 2015).
- 53 Cf. http://europa.eu/eu-law/have-your-say/index_de.htm#toc_2 (last accessed on 12 January 2015).
- 54 Cf. http://ec.europa.eu/yourvoice/ipm/index_de.htm (last accessed on 12 January 2015).
- 55 Cf. Kommission der Europäischen Gemeinschaften (2002: 11, 19).
- 56 Cf. <http://www.eu-info.de/europa-punkt/gesetzgebungsverfahren/online-konsultationen/> (last accessed on 12 January 2015).
- 57 In this regard and in the following, cf. <http://www.nrw.de/open-nrw/opennrrw-1/open-nrw-strategie.html> (last accessed on 12 January 2015), Die Landesregierung Nordrhein-Westfalen (2014a) and Die Landesregierung Nordrhein-Westfalen (2014b).
- 58 Social innovations are not clearly defined in scientific literature. Zapf (1989: 177) describes the concept as follows: "Social innovations are new ways of achieving objectives, in particular new organisational forms, new regulations, new lifestyles that alter the direction of social change, solve problems better than earlier practices, and are therefore worth being emulated and institutionalised". According to Gillwald (2000: 1), social innovations are "socially far-reaching ways of regulating activities and practices that deviate from the previously familiar procedures". In a recent essay by Howaldt and Schwarz (2010: 54) social innovations are defined as follows: "A social innovation is an intentional, targeted reconfiguration of social practices in certain fields of action or social contexts that is initiated by certain actors or constellations of actors with the aim of solving problems or satisfying needs in a better way than is possible on the basis of established practices." A political definition is necessary to make the concept of social innovation manageable in practice.
- 59 Cf. EFI (2014: 48).

A 4

- 60 Cf. BMWi, BMI, BMVI (2014: 9). The technology mix includes fibre optics, cable, wireless and satellite technology.

Over the last few decades, competition in the German telecommunications market has led to a wide range of alternative technologies for fast internet access. This technology mix should be used efficiently in efforts to meet regional expansion targets. Well-functioning competition between these access technologies and competitive user fees will continue to play an important role in the future in the provision and further development of a universal, high-performance broadband infrastructure.

- 61 In a study commissioned by the BMWi, TÜV Rheinland estimates that 40 percent of the necessary total investment is spent on connecting the last 5 percent of households; cf. TÜV Rheinland Consulting GmbH (2013). It is important to make it clear that full provision – including the “last mile” – is a political objective that needs to be developed in the societal discourse. Against the background of the determined costs, however, related funding pledges on connecting the last mile also require political legitimization – i.e. they cannot be justified on the basis of a theoretical optimum weighing up of marginal costs on the one hand and total marginal benefits on the other.
- 62 Cf. BMWi, BMI, BMVI (2014: 10).
- 63 In mid-2014, approximately 64 percent of all German households had a high-speed connection (next-generation access) with at least 50 Mb per second downstream, cf. BMVI (2014: 4). Given the current conditions and market-driven developments, up to 80 percent of the population are expected to have bandwidths of at least 50 Mb per second by the end of 2018. Cf. BMVI (2014: 9).
- 64 A recent study by the Karlsruhe Chamber of Industry and Commerce (IHK) comes to the conclusion that 50 Mb per second will no longer be sufficient for 60 percent of companies in as little as five years, cf. IHK Karlsruhe (2014). A study completed in 2009 for the federal state of Baden-Württemberg came to similar conclusions: about a third of the companies surveyed believed that their business-related needs would be in excess of 50 Mb per second in ten years. Cf. Gebauer et al. (2009: 34).
- 65 For example, in December 2013 less than one percent of all broadband connections in Germany were realised using fibre-optic cable all the way to the building or to the home (FTTB/FTTH). FTTB stands for fibre-to-the-building, FTTH for fibre-to-the-home. By way of comparison, the corresponding figures for Korea and Japan are 65 and 69 percent respectively, followed by Sweden with 38 percent. Cf. OECD (2013), <http://www.oecd.org/internet/broadband/oecdbroadbandportal.htm#> (last accessed on 12 January 2015). On the other hand, the mobile-phone sector is well developed, according to a study commissioned by the BMVI. LTE availability in households, at over 86 percent, is only slightly behind the OECD leaders Sweden and the USA. Cf. BMVI (2014: 5).
- 66 Cf. EFI (2014: Chapter B 1).
- 67 Cf. BMWi, BMI, BMVI (2014: 13).
- 68 Guaranteeing data security offers great opportunities for companies to position themselves in international competition – even for many firms operating outside the field of data encryption technologies.
- 69 Hansen (1996: 457 ff.).
- 70 Cf. Rosnagel (2007).

- 71 The Committee of Inquiry (Enquete-Kommission) on “Internet and Digital Society” notes on the subject: “Particularly in the field of social networks, some foreign providers with no registered office in Germany do not always comply with national data-protection regulations. At the same time there is a lack of enforcement at the national level to effectively implement the law in the case of foreign service providers if they have no domicile in the country.” Cf. Deutscher Bundestag (2012).
- 72 Cf. draft General Data Protection Regulation, <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52012PC0011> (last accessed on 12 January 2015). Details finden sich bei der Free Software Foundation, vgl. <http://fsfe.org/activities/os/def.de.html> (last accessed on 12 January 2015).
- 73 Details can be found at the Free Software Foundation, cf. <http://fsfe.org/activities/os/def.de.html> (last accessed on 12 January 2015).
- 74 Cf. for example European Interoperability Framework (EIF), <http://ec.europa.eu/idabc/en/document/2319/5644.html> (last accessed on 12 January 2015).
- 75 Cf. Deutscher Bundestag (2013a).
- 76 Cf. BMWi, BMI, BMVI (2014: 20).
- 77 Cf. EFI (2014: Chapter B 3).
- 78 Network externalities lead here to what is known as a penguin effect (or excess inertia): early participants benefit little from a network or standard, because not enough other actors are (yet) participating. Especially when initial investment is high, a wait-and-see attitude develops on the part of the potential adopters, and the standard or network can fail, regardless of its actual potential on the market. Cf. for example Choi (1997).
- 79 For example, by creating the research network “Automation and Digitisation” involving the Technical University of Munich (TUM), the Ludwig Maximilians University of Munich (LMU), the German Research Centre for Artificial Intelligence (DFKI) and the Fraunhofer Institute for Applied and Integrated Security (AISEC).
- 80 In the resolution setting up the Committee of Inquiry, which was passed by the parliamentary groups of CDU/CSU, SPD, FDP and Bündnis 90/Die Grünen, the parties agreed that the Committee should develop practical recommendations for action by legislators. The Committee comprehensively fulfilled this remit by incorporating the knowledge of 17 experts and the general public. Cf. <http://webarchiv.bundestag.de/cgi/show.php?fileToLoad=2944&id=1223> (last accessed on 12 January 2015).
- 81 Cf. also more radical recommendations of the OECD Council on Digital Government Strategies; cf. OECD (2014a).
- 82 Cf. BMI (2014).

A 5

- 83 Own translation. Cf. CDU, CSU and SPD (2013: 17).
- 84 According to written information provided by Federal Office of Economic Affairs and Export Control (Bundesamt für Wirtschaft und Ausfuhrkontrolle).

- 85 According to written information provided by Federal Office of Economic Affairs and Export Control (Bundesamt für Wirtschaft und Ausfuhrkontrolle).
- 86 Cf. BMWi (2014a). The corresponding parliamentary procedure is expected to be completed in early 2015. Cf. <http://www.bmwi.de/DE/Themen/Mittelstand/Mittelstandsfinanzierung/invest,did=655264.html> (last accessed on 12 January 2015).
- 87 According to Sigmar Gabriel, press conference on the IT Summit in Hamburg on 21 October 2014, cf. <http://www.bmwi.de/DE/Mediathek/videos,did=665366.html> (last accessed on 12 January 2015).
- 88 Cf. EFI (2012).
- 89 Cf. Hessian Ministry of Finance (Hessisches Ministerium der Finanzen) (2014).
- 90 Called for in the Bundesrat's draft legislation "Draft Bill for the Further Simplification of Tax Law 2013" (StVereinfG 2013), but rejected by the Bundestag. Cf. Deutscher Bundestag (2014c).
- 91 Cf. Alliance for Venture Capital (Allianz für Venture Capital), <http://www.bvdw.org/medien/allianz-fuer-venture-capital-afvc?media=5819> (last accessed on 12 January 2015).
- 92 Cf. EFI (2012).
- 93 Cf. ministry draft by the Federal Ministry of Finance to amend the Investment Ordinance and the Pension Fund Investment Ordinance, http://plattform-compliance.de/Entwurf_Anlageverordnung_230514.pdf (last accessed on 12 January 2015).
- 94 Cf. EFI (2012).
- B 1**
- 95 Cf. Porter (1998: 78). This definition differs from the concept used in several German states, in which all firms and institutions that are active in a certain field are considered a cluster, independent of their regional location.
- 96 Another programme on the national level is the GoCluster programme. It was launched by the Federal Ministry for Economic Affairs and Energy in 2012 and has a budget of EUR 4 million until 2015. Any German innovation cluster can apply to the programme, which aims to transform the most efficient national innovation clusters into international clusters of excellence. To achieve this, various support measures are offered to cluster managers, cluster players or representatives from government, science and business, e.g. networking activities with innovation clusters from Germany and Europe, and seminars on matters of clusters and cluster management. Cf. <http://www.clusterplattform.de/CLUSTER/Navigation/EN/NationalLevel/go-cluster/go-cluster.html> (last accessed on 12 January 2015).
- 97 Cf. <http://www.clusterplattform.de/CLUSTER/Navigation/EN/FederalLevel/federal-level.html> (last accessed on 12 January 2015).
- 98 Cf. Porter (1998).
- 99 Cf. European Commission (2007).
- 100 Own calculations based on information from the BMBF on budgets and the classification of measures as being cluster-oriented. According to written information provided by BMBF.
- 101 Cf. Audretsch and Feldman (1996), Feldman and Kogler (2010).
- 102 Cf. EFI Report 2014, B 1 Research and Innovation in University Medicine.
- 103 Cf. among many: Audretsch and Feldman (1996), Breschi and Lissoni (2005), Jaffe (1989), Jaffe et al. (1993).
- 104 The literature alternatively uses a variety of names – such as technopoles, clusters, districts or valleys – to define a collection of firms within one specific industry or technology and concentrated within the same geographic area. Among these different names, the notion of cluster has attracted most attention from both academic researchers and policy makers.
- 105 Cf. Arthur (1988, 1989).
- 106 Agglomeration economies are likely to be bounded: beyond a certain size, the location may become congested, land may become expensive, and diseconomies of agglomeration may occur. In some cases – think of the Silicon Valley – the benefits of being located there seem to outweigh the cost at any size.
- 107 Cf. Agrawal and Cockburn (2003).
- 108 Cf. Feldman and Kogler (2010).
- 109 Cf. Saxenian (1994).
- 110 Cf. Neffke et al. (2014).
- 111 Cf. Agrawal et al. (2010), Klepper (2007).
- 112 Cf. Powell et al. (2009).
- 113 Ciccone (2002) finds agglomeration effects for France, Germany, Italy, Spain and the UK.
- 114 Based on data from 30,000 French firms (1996-2004). Cf. Martin et al. (2011).
- 115 Cf. Ciccone and Hall (1996).
- 116 Cf. Frenken et al. (2015).
- 117 Cf. Frenken et al. (2015).
- 118 Cf. Kerr (2010).
- 119 Cf. Duranton (2007).
- 120 Cf. Lee and Rodriguez-Pose (2014).
- 121 Cf. Harhoff (1999).
- 122 Cf. Feldman and Kogler (2010).
- 123 Cf. Aghion et al. (2009), Klette and Moen (1999), Matsuyama (1997). Some economists therefore recognise few justifications for cluster policies. They argue that it is an extremely difficult policy to implement because of the coordination problems to be resolved, and that the benefits gained are usually very slight. Cf. Chatterji et al. (2013) and Duranton (2011).
- 124 Many of the evaluations of cluster policies are conducted on behalf of public authority are interim evaluations. They are therefore primarily management tools with the purpose of improving and advancing the ongoing policy measure. The results are mostly based on interviews with agents from the clusters. Profound impact analyses are hardly ever executed at this stage. However, this is indeed difficult at this stage since effects typically only occur after several years. Furthermore, the data needed for valid impact analyses is often not available.
- 125 These include selection effects and the problem of identifying pure treatment effects. The term selection effect describes the situation where the selection of individuals for an analysis is not representative of the population to be analysed. No pure treatment effect denotes the situa-

- tion when the effect of the treatment cannot be separated from simultaneously occurring effects. Cf. Feldman et al. (2014).
- 126 Cf. Brenner et al. (2013), Brossard and Moussa (2014), Falck et al. (2010), Martin et al. (2011) and Nishimura and Okamuro (2011a), (2011b).
- 127 Cf. Martin et al. (2011).
- 128 Cf. Brenner et al. (2013), Engel et al. (2012), Viladecans-Marsal and Arauzo-Carod (2012).
- 129 Cf. Carlsson (2010), who distinguishes between design-driven (aircraft or automobile) and discovery-driven (semi-conductor or biotech) industries and clusters.
- 130 Cf. Bresnahan et al. (2002).
- 131 Cf. <http://www.unternehmen-region.de/de/36.php> (last accessed on 12 January 2015) and according to information provided by the BMBF.
- 132 Cf. BMBF (2005, 2012a, 2012b).
- 133 Cf. Rothgang et al. (2014).
- 134 Cf. Rothgang et al. (2014: 117ff. and 160ff.).
- 135 Cf. Cantner et al. (2013).
- 136 Cf. Fornahl et al. (2015).
- 137 Cf. Cantner et al. (2013).
- 138 Cf. Frenken et al. (2007) and Neffke et al. (2009).
- 139 Whether or not the clusters were successful in attracting additional financial resources cannot be answered because this issue was not part of the evaluation. However, the perception of the evaluators was that financial activities towards funding innovation and technology transfer became more important after a few years of policy operation. There are cross-field variations in which the biotech clusters are the most active in developing new finance structures. Personal communication by Michael Rothgang, RWI.
- 140 Cf. RWI et al. (2010: 66).
- 141 Including the GoCluster programme.
- 142 Smart specialisation strategy is a new policy approach adopted by the EU to structure and implement operational programmes devoted to R&D and innovation within the framework of the new cohesion policy (cf. Foray et al. 2009). Cf. Kroll and Stahlecker (2015) for an overview of the smart specialisation strategies created and implemented by German regions.
- B 2**
- 143 For Stewart (2013: 230f.), and Holland and Tirthali (2014), “massive” means that many active participants interact with each other on different communication media. This creates global networks, which in turn represent added value from MOOCs (cf. <http://halfanhour.blogspot.ca/2013/01/what-makes-mooc-massive.html>, last accessed on 12 January 2015).
- 144 The abbreviation is interpreted in different ways depending on the context. It ranges from narrow interpretations – regarding an unlimited number of participants, open and free-of-charge access, and exclusively online teaching as essential – to broad interpretations that already use the term MOOC if there are more than 100 participants, the choice of topic or form of participation is open, and blended learning is used. Cf. HRK (2014: 10) for more details.
- 145 For example, courses were already being offered online and included self-teaching instruments before the present MOOC revolution; there were also comparatively large courses – and in Germany even free courses, e.g. from Fernuniversität Hagen (distance-learning university) and the Volkshochschulen (adult education centres). Today, the adult education centres are experimenting with MOOCs primarily in the training of their own lecturers (cf. Rohs and Giehl 2014). Lecture podcasts, which have been used for some time in e-learning, often represent a starting point for MOOCs. Lecture podcasts and instructional videos are therefore a component of almost all the MOOCs studied (Jungermann and Wannemacher 2015). Usually, the video sequences in MOOCs are only seven to twelve minutes long and interrupted by quizzes and the like, so that they do also differ markedly from conventional lecture podcasts. Further important elements of MOOCs are complementary course reading, exercises, essays, quizzes and finally discussion forums or similar communication channels (Jungermann and Wannemacher 2015). As far as the learning successes of different types of course types and production methods are concerned, Ng and Widom (2014: 37) point out that the learning outcomes of traditional lecture podcasts – simple films of lectures in the lecture hall and their subsequent cropping into small videos – are much worse than videos shot in small sequences in a studio (without an audience).
- 146 Cf. PCAST (2013: 2).
- 147 Another new aspect of MOOCs is that – at least for part of the courses – there is more intensive and faster communication between the students and the lecturers than in traditional distance-learning courses using radio, video or the internet. The main reasons for this are improved software, which has been enhanced particularly in the context of the newly developed MOOC platforms, high-bandwidth internet connection for providers and users, and improved internet connections for a growing number of people worldwide. Cf. PCAST (2013: 3).
- 148 Cf. Jungermann and Wannemacher (2015: 5) for an overview.
- 149 Cf. Jungermann and Wannemacher (2015).
- 150 Cf. Jungermann and Wannemacher (2015: 19).
- 151 Online teaching was defined in the questionnaire as “Courses with at least 80 percent online content”, Cf. Jungermann and Wannemacher (2015: 64).
- 152 As a survey conducted by the European University Association (EUA) has found, the situation in Germany thus does not differ markedly from that in other European countries. Only half of the universities surveyed stated that they had an e-learning strategy, and only a quarter said that they made intensive use of e-learning. One-eighth of the universities asked stated that they offered MOOCs. The survey also revealed a defensive attitude towards MOOCs on the part of the university staff questioned (42 percent had mixed feelings about MOOCs, 30 percent had little knowledge of – or no interest in – MOOCs, and only 10 percent regarded MOOCs as an opportunity). Cf. European Commission (2014a).
- 153 Cf. Jungermann and Wannemacher (2015: 13).
- 154 Cf. Stewart (2013: 229f.), Holland and Tirthali (2014: 32).

- 155 Cf. Holland and Tirthali (2014: 25, 30).
- 156 Cf. Ng and Widom (2014: 34).
- 157 Cf. Holland and Tirthali (2014: 25).
- 158 The flipped classroom is a teaching method in which the roles of homework and teaching are interchanged. The students study the subject matter at home, while the practice is conducted in the university or college. This frees up time and space in the on-site teaching, enabling reviews of questions, joint discussions, and greater depth in the processing of the teaching material.
- 159 Cf. Ng and Widom (2014: 35, 40).
- 160 By making a selective choice of partner universities, the platforms also use existing university brands to strengthen their own brand position. The platforms also ensure the quality of the courses by introducing uniform minimum standards (e.g. a minimum number of course videos).
- 161 The three leading international platforms are the for-profit platforms Coursera and Udacity and the not-for-profit platform edX. The latter developed from a joint initiative of Harvard University and MIT. Together they invested approximately USD 60 million in research funds with the aim of improving their research into the teaching and learning process. The data collected by edX during the MOOCs are therefore freely accessible for research projects at all the partner universities (according to information provided by telephone by J. Heinlein (edX) on 18 November 2014). The two for-profit platforms Coursera and Udacity received their seed capital from venture-capital firms and pursue a more classically e-commerce style of business model, aiming, among other things, to generate profits by selling user data.
- 162 In 2014, the currently leading platform Coursera, together with 111 partner universities, offered approx. 750 courses for a total of nine million users. edX had 2.8 million users in 2014 and Udacity 2.5 million users (cf. Jungermann and Wannemacher 2015: 5). This means that all the platforms have grown tremendously over the last few years. In 2013, Coursera only had just under five million users with 87 partner universities and 400 courses. edX had approx. 1.3 million users in 2012, Udacity about 750,000 users in 2013 (cf. <http://www.heise.de/tp/artikel/40/40462/1.html>, last accessed on 12 January 2015). Based on the total number of users at the three largest providers, which rose from 7 million in 2013 to 14.3 million in 2014 – these providers grew within just one year to a level of more than 200 percent of the level in 2013. In the meantime, there are also several MOOC providers in Europe, like the French platform France Université Numérique (FUN), the Spanish Miriada X, a subsidiary of the British Open University called FutureLearn, and the not-for-profit platform OpenupEd, which was launched by the European Association of Distance Teaching Universities (EADTU) (cf. Jungermann and Wannemacher 2015: 5). Among the German platforms, iversity has reached 330,000 enrolled users and openHPI 53,000 enrolled users (cf. Jungermann and Wannemacher (2015: 7).
- 163 Cf. Jungermann and Wannemacher (2015: 18ff.).
- 164 Minerva University in San Francisco is an example of a radically changed strategy (cf. <http://www.minervaproject.com>, last accessed on 12 January 2015). The structure study exclusively online, but live together at seven different study sites in the course of their studies (cf. also Die Zeit 2014b).
- 165 For an overview of the MOOCs at EPFL, see <http://moocs.epfl.ch> (last accessed on 12 January 2015).
- 166 For an overview of the joint project of Graz University of Technology and the University of Graz (iMOOX), cf. <http://www.imoox.at/wbtmaster/startseite/> (last accessed on 12 January 2015).
- 167 For an overview of MIT's MOOCs at edX, see <https://www.edx.org/school/mitx/allcourses> (last accessed on 12 January 2015).
- 168 This is partly because many courses are offered in German, which inevitably limits the number of potential participants worldwide. According to the survey (n= 34), almost half of the courses (48 percent) are offered in German and the rest “in one or several other languages” (cf. Jungermann and Wannemacher 2015: 35f.). The participation of foreign students in German-speaking courses can even be attributed, at least in part, to an explicit interest in learning the language. This is illustrated by the enrolment survey of 260 registered participants in a German-speaking MOOC on “Informatics for Economists” by Abraham Bernstein, which was offered via Coursera. When asked about their motivation, 44 percent of the participants stated that they were starting the MOOC with the aim of learning German or improving their skills in the German technical language of informatics. 55 percent of the participants stated that German was not their native language; between 38 and 46 percent of the participants also said that they did not speak, write or read German very well (according to written information provided by C. Rupietta, University of Zurich, 12 December 2014).
- 169 As part of the HIS-HE survey, organisers of MOOCs were asked about participant figures (cf. Jungermann and Wannemacher 2015: 45). Multiple replies were possible to this question. A total of 30 lecturers in charge of 36 courses replied. The participant figures were as follows: 1 to 499 participants: 25 percent (9 MOOCs), 500 to 999 participants: 11 percent (4 MOOCs), 1,000 to 4,999 participants: 19 percent (7 MOOCs), 5,000 to 9,999 participants: 22 percent (8 MOOCs), 10,000 to 24,999 participants: 6 percent (2 MOOCs), 25,000 to 49,999 participants: 3 percent (3 MOOCs), 50,000 or more participants: 3 percent (3 MOOCs).
- 170 Cf. <http://www.fh-potsdam.de/projekt/project-action/show/Project/the-future-of-storytelling-mooc/> (last accessed on 12 January 2015).
- 171 Cf. <http://www.heise.de/tp/artikel/40/40824/2.html> (last accessed on 12 January 2015) and <https://www.coursera.org/learn/competitivestrategyzh> (last accessed on 12 January 2015).
- 172 Cf. <http://www.tum.de/en/studies/continuing-education/general-public/moocs/> (last accessed on 12 January 2015).
- 173 Cf. <http://www.en.uni-muenchen.de/students/moocs/courses/index.html> (last accessed on 12 January 2015).
- 174 LMU's courses are offered in English. By far the most popular course has been Competitive Strategy, which has been offered in a slightly modified form as an “MOOC on demand” since June 2014. Unlike other MOOCs, it has

- no pre-defined time window; participants can organise the course according to their own needs (according to information provided by telephone by the LMU on 3 December 2014).
- 175 TUM's first MOOC was launched in January 2014. A total of over 50,000 students had enrolled by November 2014 (according to written information provided by the TUM on 17 November 2014).
- 176 Cf. CRUS (2013).
- 177 According to written information provided by the EPFL on 10 November 2014.
- 178 Cf. <http://moocs.epfl.ch/applications> (last accessed on 12 January 2015).
- 179 The most common formats are currently lecture podcasts (i.e. video recordings of lectures given in the lecture hall) and exercises, followed by discussion forums. They are often combined in the context of blended learning with complementary course reading and tests (given online or on-site), and sometimes involve peer grading (cf. Jungermann and Wannemacher 2015).
- 180 Only 34 percent of the university and college leaders who replied stated that MOOCs from other universities and colleges should be adapted so that they could be recognised as part of a course; 51 percent had not yet formed an opinion on the subject, and 15 percent were opposed. The authentication of examination results was singled out in particular as an unsolved problem (cf. Jungermann and Wannemacher 2015: 24, 28).
- 181 This is illustrated for example by the enrolment survey of MOOC participants mentioned in endnote 175. Before beginning their courses, only about 58 percent of the participants planned to do every exercise and thus formally complete the course. This also follows from the motives mentioned in endnote 175. For example, nearly half of the participants said they had started the MOOC with the aim of learning German or improving their skills in the German technical language of informatics (according to written information provided by C. Rupietta, University of Zurich, 12 December 2014).
- 182 Cf. Jungermann and Wannemacher (2015: 25).
- 183 Cf. HRK (2014: 22).
- 184 36 percent of the lecturers interviewed said that state funding was not important (Jungermann and Wannemacher (2015: 50). The TUM Board of Management approved a total of EUR 250,000 for the production and implementation of MOOCs in 2013 (cf. interview with H. Pongratz, <https://www.lehren.tum.de/lehren-an-der-tum/news/interview-moocs-pongatz/>, last accessed on 12 January 2015). The LMU spent EUR 60,000 (not including staff costs) on the production of MOOCs in 2013. Cf. <http://www.heise.de/tp/artikel/40/40824/1.html> (last accessed on 12 January 2015).
- 185 Cf. Dellarocas and Van Alstyne (2013).
- 186 In this regard, cf. for instance Dellarocas and Van Alstyne (2013), HRK (2014), <http://www.duz.de/duz-magazin/2013/07/verderben-videos-die-lehre/182Endnotenverzeichnis.docx> (last accessed on 12 January 2015).
- 187 Such popular courses could take on the forms of a super-textbook including lectures, exercises, homework, tests, grades, study guide and individualised feedback, based on “artificial intelligence” or “human intelligence on call” (cf. Cowen and Tabarrok 2014: 521). In some areas of the tertiary education sector, such offers can lead to the emergence of a so-called superstar economy (Rosen 1981) as a new market form (similar to the music or sports markets, for example). In other words, a small number of stars offer the MOOC courses that are the most popular in terms of content, didactics and user-friendliness, and dominate the market for MOOCs – as can already be observed in the market for textbooks with standardised content and large numbers of students. For example, in the USA today, only four textbooks cover 50 percent of the entire textbook market on the “principles of economics”. All other textbooks usually have less than one percent (cf. Cowen and Tabarrok 2014 for more detail). Since such conditions lead to excellent income prospects for the best teams, this can also create strong incentives to improve the quality of the courses offered.
- 188 Like textbooks, the contents of MOOCs are subject to copyright. Income from textbooks in Germany is divided between the authors and the respective publishing houses. However, the production of MOOCs involves to a greater extent resources from the respective university or college and the MOOC platforms. So here, any revenue would have to be divided between the originator(s), the university or college, and the platforms. Different ways of dividing up the revenue can lead to different incentives to improve the infrastructure or the lecturers' personal commitment.
- 189 The not-for-profit MOOC platform edX, for example, has given an assurance that its learning materials will remain free of charge and freely accessible (according to information provided by telephone by J. Heinlein of edX on 18 November 2014). For detailed information on the topic of open access, cf. EFI (2013: 24ff.).
- 190 The Digital Agenda provides for the introduction of a general exemption from copyright for scientific and education purposes with the aim of improving the copyrighted use of protected content by science, research and education (BMW, BMI, BMVI 2014: 27). Such an exception limits copyright for the above purpose.
- 191 In recent years, budgets have only been increased, if at all, to maintain constant lecturer/student ratios as student numbers have risen, but not to improve the quality of the education provided. Cf. Baethge et al. (2015: 37ff).
- 192 To make this possible, universities or colleges would first need to accept that not every lecturer and every university or college has to offer everything themselves, which would allow new, quality-improving production structures to emerge (in this regard cf. also next endnote). It would require clear rules on transferring ECTS points for students and on teaching loads for lecturers. Other issues that are still largely unclarified include the certification and recognition of MOOC results and possible ways of bundling MOOC results into diplomas and university degrees. Initial moves towards a systematic credit system have begun in the USA, and more will certainly follow. For example, a course of study consisting entirely of MOOCs was launched in 2013 at the Georgia Institute of Technology in cooperation with AT&T (cf. <http://www.omscs.gatech.edu/#np-3268>, last accessed on 12 January 2015).

- 193 In this context, the development of journalism in the 19th century points to new ways of improving quality with MOOCs in the tertiary education sector. At that time, systematic improvements in quality were made possible by means of cooperative production structures and “syndication” (cf. Dellarocas and Van Alstyne 2013: 28). Similar solutions could lead to quality improvements in tertiary teaching, too, not only with reference to the standardised canon of knowledge, but also in teaching that is closer to the research front. PhD programme courses could also improve in quality if each was produced by the best people in the field and made available to the cooperation partners. The local contribution could focus more on discourse, the development of individual questions of interest, the comparison of different doctrines and individual research projects. In this way innovative solutions could generate quality gains across all stages of training and further education at universities and colleges.
- 194 Cf. Baethge et al. (2015: 59).
- 195 Cf. for example Hoeschler and Backes-Gellner (2014) on long-term psychological consequences of dropping out in the case of bachelor’s degree students.
- 196 Cf. EFI (2014: 30ff.).
- 197 Furthermore, universities with different initial reputations and of different sizes will have to respond with different strategies.
- 198 Cf. EFI (2012: 60ff.).
- 199 Cf. Autorengruppe Bildungsberichterstattung (author group on educational reporting) (2014: Tab. F2-23web). Non-traditional first-year students do not have an academic tertiary education entrance qualification, but acquire their tertiary education entrance qualification after vocational training via the so-called “third educational pathway” (for more details cf. Baethge et al. 2015: 57).
- 200 Against this background it is not surprising that EPFL’s MOOC strategy, for example, is also supported by the Swiss Agency for Development and Cooperation (SDC) of the Swiss Federal Department of Foreign Affairs.
- 201 Cf. EPFL (2013: 52).
- 202 In this context MOOCs can also be used to specifically strengthen the relationship between alumni and their universities or colleges, for example if the institutions make MOOCs available to their alumni as an exclusive source of knowledge.
- 203 Cf. EFI (2013: 24ff.).
- B 3**
- 204 The three-step test specifies that uses of protected works (1) are only permitted for special cases and on condition that (2) the normal exploitation of the work is not adversely affected and (3) the originator’s legitimate interests are not adversely affected to an unreasonable extent. Cf. Ohly (2014: 37ff.).
- 205 Cf. Ohly (2014: F14ff.).
- 206 Cf. Ohly (2014: F16ff.) and Spindler (2014: 38ff.).
- 207 Cf. Ohly (2014: 7ff.) and www.copyrightcode.eu (last accessed on 12 January 2015).
- 208 Cf. BMWi (2014b).
- 209 However, the value and the quality of new works cannot always be precisely defined or measured, because they are experience goods. Cf. Baumol (1986), Stoneman (2010). Art is “what people think art is,” as Frey (2000: 23) says for an important part of copyright-protected works.
- 210 Cf. Akerlof et al. (2002) and Liebowitz and Margolis (2005).
- 211 Li et al. (2014) recently published a study that finds a positive price effect caused by the strengthening of copyright law in Britain at the beginning of the 19th century. The positive price effect alone is not enough to establish a self-contained causal link from copyright law to larger supply. This result seems to be supported by a further study which shows an increase in income for the affected authors (cf. MacGarvie and Moser 2013). In a separate study, Giorcelli and Moser (2014) come to the conclusion that the introduction of copyright law in post-Napoleonic Italy also led to a strengthening of incentives and creativity – but again only in the case of moderate copyright terms. Another, as yet unpublished paper shows that more new authors were active in this period. This result would then also indicate that – starting on the basis of a weak copyright law – the extension of the copyright term was accompanied by an expansion in the supply of literary works.
- 212 Cf. Heald (2008) and Reimers (2014). A directive (Directive 2011/77/EU) extending the copyright term protecting the performers and producers of phonograms from 50 to 70 years was adopted by the European Parliament on 12 September 2011. A large number of economic and legal research institutes in Europe had come out against the measure. Cf. Bournemouth Statement (2008) and Newbery (2008).
- 213 Cf. Ohly (2014: 80).
- 214 Cf. Beldiman (2004: 187, 193ff.).
- 215 Cf. Ohly (2014: 47ff.).
- 216 Cf. De la Durantaye (2014).
- 217 Cf. Ohly (2014), Spindler and Leistner (2006). The three-step test specifies that uses of protected works (1) are only permitted for special cases and on condition that (2) the normal exploitation of the work is not adversely affected and (3) the originator’s legitimate interests are not adversely affected to an unreasonable extent. Cf. Ohly (2014: 37ff.).
- 218 Cf. Ohly (2014: 62ff.) on the current legal situation: usually, intermediaries (e.g. file-sharing platforms) are liable under German law as Störer, which may be translated as interferers or co-liable parties. This form of liability is based on the analogous application of section 1004 of the German Civil Code (BGB). Two main prerequisites are required for “interferer liability”. First, the interferer (or co-liable party) must have made a causal contribution to the violation. Second, s/he must have violated reasonable duties to review and monitor. In practice, the music-file-sharing platform Napster was banned in 2001 after several court cases, one of which had been initiated by the Recording Industry Association of America (RIAA), and subsequently had to abandon services. In the course of the proceedings Napster was also required to pay a sum of USD 10 million in lost royalties to copyright holders.

- In 2006, a court settlement was reached between Kazaa – another significant online file-sharing portal – and four of the major music publishers, in which the platform undertook to pay USD 100 million. The file-sharing and file-hosting company Megaupload – one of the world’s largest service providers in this field alongside RapidShare and MediaFire – was also banned by the US courts in 2012. Legal proceedings are pending against the operators. The economic damage to the copyright holders is estimated at nearly half a billion US dollars. Cf. <http://www.fbi.gov/news/pressrel/press-releases/justice-department-charges-leaders-of-megaupload-with-wide-spread-online-copyright-infringement> (last accessed on 12 January 2015).
- 219 Cf. Scotchmer (1991).
- 220 One possible reason why illegal behaviour is so common in the music field is that individual titles have been registered.
- 221 Cf. Ofcom (2013: 21, Tab. 2.3.1b). Note: currency translation is based on an exchange rate of £1 = €1.18.
- 222 Cf. Ofcom (2013: 30, Fig 3.5a).
- 223 In this context, recent empirical research on digital markets emphasises that the extent of illegal use (“piracy”) is partly dependent on the size and quality of the legal supply. An exaggerated way of putting it might be to say that the industry will create its own piracy if its offerings are intransparent and unattractive. Danaher et al. (2012) titled an article in Marketing Science with the catchy phrase: “Converting pirates without cannibalising purchasers”. The authors begin the article with two quotes. First: “We can’t compete with free. That’s an economic paradigm that doesn’t work” (James Gianopoulos, Co-Chairman of Twentieth Century Fox). Second: “You’ll never stop [piracy]. What you have to do is compete with it” (Steve Jobs, CEO, Apple Inc.). However, Danaher et al. examine not only the relationship between digital selling and selling products on physical carriers. They also look into whether legal digital offerings discourage consumers from illegally consuming digital products. Here, too, they use a quasi-experimental context: in December 2007, NBC withdrew digital offerings from the Apple iTunes platform. This content was then made available on the platform again in 2008. NBC’s decision to remove content from iTunes led to an 11.2 percent increase in the demand for illegal offerings – the equivalent of about 49,000 downloads per day. Illegal consumption only fell slightly after the offerings were returned to iTunes, however, which suggests that inertia and habit are important components of user behaviour. At the same time, supply reduction on iTunes did not lead to an increase in demand for DVD products on Amazon.
- 224 The first step of online right enforcement procedures (“graduated response”) consists, for example, of sending alerts by email, aiming to draw the users’ attention to their illegal behaviour and referring them to alternative, legal offerings. If violations by the user continue (after legally defined deadlines), the sanctions are gradually intensified. For example, the internet access can be blocked (cf. Box 10).
- 225 Cf. Arnold et al. (2014) and Giblin (2014). Arnold et al. (2014) report: “Our econometric results indicate that the law has no substantial deterrent effect. In addition, we find evidence that individuals who are better informed about the law and piracy alternatives substitute away from monitored P2P networks and illegally access content through unmonitored channels.”
- 226 “(...) There is little to no evidence that graduated responses are either ‘successful’ or ‘effective’. The analysis casts into doubt the case for their future international roll-out and suggests that existing schemes should be reconsidered.” Cf. Giblin (2014).
- 227 Cf. Ohly (2014: 76): “The copyright holder has a right to the reimbursement of the dunning costs vis-à-vis the infringer. This right used to be based on ‘agency without authority’ (negotiorum gestion); in the meantime it is regulated by law under section 97a, subsection 3, sentence 1 of the German Copyright Act (UrhG). On the one hand, the duty to reimburse costs ensures that copyright holders are not left to shoulder the costs of issuing the warning and of pre-formulating the cease-and-desist declaration alone; on the other hand, it encourages mass warnings motivated by a mere interest in collecting fees. [...] The fees are often in the higher three- or even four-digit range.”
- 228 This proposal was first made by Ohly (2014: 76).
- 229 A study conducted by Ofcom (2013) in Britain also emphasises the need to focus especially on activities in which the users do not make their living (primarily) from generating and marketing content.
- 230 Cf. Brynjolfsson et al. (2013).
- 231 Cf. Giblin (2014).
- 232 The “practically effective” aspect of copyright protection depends not only on the design of the copyright law and its interpretation by the judiciary, but also on the status and dissemination of copying technology and the effectiveness of law enforcement by private or public actors. In order to do justice to this wide range of aspects, Handke et al. (2015) use a range of different indicators to measure practical copyright law in the respective countries. These include the following indicators at the country level: broadband or DSL penetration, per-capita revenue from the levy on empty storage media, the Business Software Alliance’s software piracy index, and the 301 Special Report of the U.S. Government.
- 233 Users rate the new releases in the film and music industries covered by IMDb/MusicBrainz databases using a scale from 0 to 10 and from 0 to 5, respectively.
- 234 The innovation indicators on new releases (quantity) and user ratings of works (quality) in the music industry are based on data from Discogs and MusicBrainz. Turnover figures are based on data from IFPI and calculations made by Handke et al. (2015). The innovation indicators on new releases and user ratings of titles in the film industry are based on data from the Internet Movie Database (IMDb). Turnover figures are based on calculations made by Handke et al. (2015). A public-use file including statistics on the film industry can be downloaded from the EFI website, www.e-fi.de.
- 235 The top 1,000 active users with their own content on YouTube in the USA earn an average of USD 23,000 a year with advertising (cf. <http://www.selb-staendig-im-netz.de/2014/07/07/geschaeftsmodelle/youtube-einnah>

- men-beispiele-und-wie-viele-videoaufrufe-noetig-sind/, last accessed on 12 January 2015). The top 25 active users earn between USD 1.7 and 7 million a year, and their videos have been viewed between 1.27 and 5.4 billion times (cf. <http://www.celebritynetworth.com/articles/celebrity/the-25-highest-earning-youtube-stars/>, last accessed on 12 January 2015). The top 19 German bloggers say they earn between EUR 53 and EUR 6,633 per month (cf. <http://www.selbstaendig-im-netz.de/2014/08/20/blogs/trafficeinnahmen-von-19-deutschen-blogs-im-juli-2014/>, last accessed on 12 January 2015).
- 236 Cf. Handke et al. (2015).
- 237 Cf. Ohly (2014). In modern musical forms, digital sampling and mixing different songs to create something new (“mashup”) plays a significant practical role. In the literary field, popular novels like the Harry Potter or Twilight series are widely “continued”; the results are exchanged on the internet. This “appropriation art” has meanwhile developed into a branch of the fine arts.
- 238 Cf. Handke et al. (2015: 120): “The difference between user-generated and professional [note: professionally produced] content lies in whether the content (images and/or sound) is marketed outside the internet platform at a positive price. This is not the case with a purely amateur video – e.g. showing a cat playing – that has been filmed by a private individual. The video is not offered for sale by the copyright holder. In the case of professional [note: professionally produced] content, the contents are offered for sale at a certain price by the copyright holder, perhaps only in a different media format; in other words, this is commercial content. In-between the two there is a hybrid form in which images and sound from user-generated content are combined with professional [note: professionally produced] content.”
- 239 Cf. Ohly (2014): “Such an exemption from law could be designed for commercial purposes by charging a fee; another possibility might be a obligatory compensation fee for the operators of platforms where private adaptations are played.”
- 240 Cf. Sec. 29.21 of the Canadian Copyright Act.
- 241 The exhaustion doctrine in Europe states that in the EU the right of distribution is exhausted after the first sale on the market. This means that copies on physical media and digitally disseminated copies can be sold freely on subsequent levels of trade and sale. Cf. among others the following judgment by the ECJ: <http://curia.europa.eu/jcms/upload/docs/application/pdf/2012-07/cp120094de.pdf> (last accessed on 12 January 2015). The motivation behind the exhaustion principle is that the manufacturers cannot monitor and control such downstream markets by prohibiting resales or demanding a compensation for the latter. The exhaustion principle thus protects, among other things, the free internal market and in this way also represents an essential regulatory principle of copyright law.
- 242 Cf. international comparisons of national laws and regulations in Ohly (2014).
- 243 The ancillary copyright law was introduced by the Eighth Act Amending the Copyright Act dated 7 March 2013 with effect from 1 August 2013. The ancillary copyright enshrined in sections 87f to 87h of the Copyright Act grants the press publishing houses the exclusive right to make press products available to the public for commercial purposes. Google subsequently stopped including news from the German press publishers in its own information offerings (e.g. “Google News”). An antitrust action brought by the press publishers was rejected by the Federal Antitrust Office (cf. Die Zeit 2014c). The press publishers have now announced their intention not to charge Google’s use of titles, news, etc. (cf. FAZ 2014).
- B 4**
- 244 Computer Aided Design (CAD) is a method for drafting and designing technical drawings or objects with the assistance of suitable software: a CAD programme or CAD file. CAD is used in almost all technical fields where very high-precision scale drawings – also three-dimensional drawings – are required, e.g. mechanical engineering, vehicle construction, building, architecture or dental technology.
- 245 Cf. Gebhard (2014: 2).
- 246 Cf. Komorowsky (2014: 1, 7).
- 247 Cf. <http://www.inventor-magazin.de/trends-der-additiven-fertigung-teil-2-nikolai-zaepernick-eos> (last accessed on 12 January 2015).
- 248 Cf. http://www.ipa.fraunhofer.de/fileadmin/www.ipa.fhg.de/pdf/Informationsverarbeitung/Broschuere_Generative%20Fertigung.pdf (last accessed on 12 January 2015).
- 249 Cf. Winterhalter et al. (2014).
- 250 Cf. Bechthold et al. (2015: 15ff.) and <http://www.gartner.com/newsroom/id/2819918> (last accessed on 12 January 2015).
- 251 Cf. Bechthold et al. (2015: 1), McKinsey (2013), Barnatt (2013), Anderson (2012), Markillie (2012).
- 252 Cf. Astor et al. (2013: 140) and information provided by telephone by Fraunhofer IGD on 19 December 2014.
- 253 AM goods are defined as “additive manufacturing systems, system upgrades, material and aftermarket products, such as software and lasers.” AM-related services are defined as “revenues generated from parts produced on AM systems by service providers, system maintenance contracts, training, seminars, conferences, expositions, advertising, publications, contract research and consulting services.” Cf. Wohlers (2014: 109ff.).
- 254 Wohlers Associates, a market-research firm, chooses a narrow market definition, which delimits AM goods as follows: “additive manufacturing systems, system upgrades, material and aftermarket products, such as software and lasers.” AM-related services are defined as “revenues generated from parts produced on AM systems by service providers, system maintenance contracts, training, seminars, conferences, expositions, advertising, publications, contract research and consulting services.” Cf. Wohlers (2014: 109ff.).
- 255 Cf. Wohlers (2014: 116).
- 256 Cf. Astor et al. (2013: 41).
- 257 The authors of the BMWi study (Astor et al. 2013) analyse AM on the basis of a broader definition. This definition comprises three levels: 1. Data capture (measuring existing objects, manual modelling using CAD); 2. Data

- processing (e.g. geometry extraction from point clouds, cleaning up and reduction of models); 3. Output and interaction (perspective representation, stereoscopic visualisation, prototyping and/or printing). Each of the three levels can be assigned to corresponding product groups.
1. Data capture: cameras, scanners, electromagnetic and acoustic sensors, evaluation software, modelling software;
 2. Data processing: converter software, modelling software, simulation software, data storage and management;
 3. Output and interaction: displays, projectors, visualisation software, printers, simulators, interaction devices.
- Cf. Astor et al. (2013: 12ff.). By contrast, the study by Wohlers Associates does not analyse the entire process chain, but focuses primarily on companies that can be assigned to the third level (output and interaction). As a result, the number of companies covered, and the turnover calculated on this basis, differ significantly from those in the study by Astor et al. (2013).
- 258 The authors of the study assume a level of foreign demand that is growing much more strongly than domestic demand. Cf. Astor et al. (2013: 127ff.).
- 259 Cf. Astor et al. (2013: 150).
- 260 The German companies in the AM field can be divided into the following categories in terms of workforce size: 1 to 9 employees: 174 companies; 10 to 24 employees: 294 companies; 25 to 49 employees: 194 companies; 50 to 99 employees: 121 companies; 100 to 249 employees: 107 companies; 250 and 499: 41 companies; 500 to 999 employees: 18 companies; more than 1,000 employees: 16 companies. However, hardware, software and services in the AM field do not account for 100 percent of these companies' business activities; in the majority of undertakings they only represent a part of the respective portfolio of products and services (see definition in endnote 255). Cf. Astor et al. (2013: 105ff.).
- 261 Cf. Astor et al. (2013: 1).
- 262 Cf. Astor et al. (2013: 140).
- 263 Cf. Astor et al. (2013: 57f.).
- 264 These include such companies as Stratasys and 3D Systems. In 2012, Stratasys merged with the Israeli device manufacturer Objet and moved its headquarters to Israel. Cf. Wohlers (2014).
- 265 These companies are the German AM equipment manufacturers with the highest turnover. Cf. written information provided by Fraunhofer IGD on 5 January 2015. Cf. also Astor et al. (2013: 39f.) and Wohlers (2014: 122).
- 266 Trumpf AG became active in the AM field as early as 2000, but withdrew a few years later. The company returned to the AM business at the beginning of 2014 and announced the formation of a joint venture with the Italian laser manufacturer Sisma S.p.A. in May 2014. Trumpf AG has a 55 percent stake in the new company. Its aim is to develop robust and productive AM devices (3D printers) for the series production of metal parts. Cf. <http://www.de.trumpf.com/nc/de/presse/pressemitteilungen/pressemitteilung/rec-uid/267871.html> (last accessed on 12 January 2015) and written information provided by Fraunhofer IGD on January 6, 2015.
- 267 Cf. <http://www.whitehouse.gov/the-press-office/2014/06/18/fact-sheet-president-obama-host-first-ever-white-house-maker-faire> (last accessed on 12 January 2015).
- 268 Cf. Bechthold et al. (2015: 60) and http://www.manufacturing.gov/nmni_pilot_institute.html (last accessed on 12 January 2015).
- 269 Overall, the U.S. government plans to build a national network of 15 Manufacturing Innovation Institutes with a one-off investment of one billion US dollars. Cf. <http://www.whitehouse.gov/the-press-office/2013/05/09/obama-administration-launches-competition-three-new-manufacturing-innova> (last accessed on 12 January 2015) and <http://www.whitehouse.gov/the-press-office/2012/08/16/we-can-t-wait-obama-administration-announces-new-public-private-partners> (last accessed on 12 January 2015).
- 270 Cf. http://manufacturing.gov/nmni_pilot_institute.html (last accessed on 12 January 2015).
- 271 Cf. Wohlers (2014: 198ff.) and Bechthold et al. (2015: 60f.).
- 272 Cf. Anderson (2013) and Campbell et al. (2011).
- 273 Cf. <http://3druck.com/blog/chinesische-bemuehungen-gender-3d-druck-technologie-2518505/> (last accessed on 12 January 2015).
- 274 Cf. <http://machinedesign.com/3d-printing/chinese-look-dominate-3d-printing> (last accessed on 12 January 2015).
- 275 Cf. Anderson (2013).
- 276 Cf. European Commission (2012, 2014b, 2014c).
- 277 For example, the current EU Research Framework Programme "Horizon 2020" includes the following sub-programmes relating to AM: technology focus: nano/materials, e.g. additive manufacturing for table-top factories, high definition printing of multifunctional materials; production/application: e.g. manufacturing processes for complex structures, manufacturing of customised parts; laser-based equipment assessment (begun under the 7th EU Research Framework Programme). Cf. European Commission (2014d). The background to this funding approach is that up to now the Commission has tended rather to follow a technologically neutral and problem-oriented approach (according to written information provided by the European Office of the German Engineering Federation (VDMA), January 2015).
- 278 Cf. <http://www.vdma.org/documents/3586442/3754129/EU-Foerderung%20fuer%203D-Druck.pdf/6ca67ae9-4f14-4449-bf21-3470aea45e23> (last accessed on 12 January 2015).
- 279 SASAM submitted a roadmap on standardisation in the AM sector in February 2014. Cf. <http://www.sasam.eu/> (last accessed on 12 January 2015).
- 280 Approx. EUR 21 million was provided in funding for AM between 2003 and 2013 (Deutscher Bundestag 2013b). The current funding programmes involve considerably higher funding volumes in some cases.
- 281 The "Gemini Project – Business Models for Industry 4.0" will run from 2014 to 2017 and provide EUR 2.3 million for seven partner institutions. Gemini is part of the "Autonomics for Industry 4.0" funding programme. Cf. <http://autonomik40.de/1883.php> (last accessed on 12 January 2015) and written information provided by Fraunhofer IGD on January 7, 2015.

- 282 Promotion of research in the AM field: BMBF funding measure called WING (short for “Innovative Materials for Industry and Society”); project: additively manufactured high-performance components made of titanium alloys and titanium aluminide – process control, characterisation, simulation. Project costs: EUR 2.65 million (Federal Government’s share of funding: 100 percent), project period: 1 August 2014 until 31 July 2017 (according to written information provided by the BMBF on 21 November 2014). Promotion of cooperation between companies and research institutions: BMBF funding measure called “Bioactive implants”; joint project: biodegradable composite materials for the generative manufacturing of bioactive bone-replacement implants (ActiveBone). Project cost: EUR 2.87 million (Federal Government’s share of funding: 59 percent), project period: 1 November 2012 until 30 October 2015 (according to written information provided by the BMBF on 21 November 2014).
- 283 Cf. http://www.iws.fraunhofer.de/de/presseundmedien/presseinformationen/2013/presseinformation_2013-20.html (last accessed on 12 January 2015) and <http://www.unternehmen-region.de/de/7649.php> (last accessed on 12 January 2015).
- 284 Cf. <http://www.bmbf.de/press/3496.php> (last accessed on 12 January 2015).
- 285 The delimitation of the AM field in scientific literature is based on keyword-related search terms. It covers terms such as rapid prototyping, rapid tooling, rapid manufacturing, stereo lithograph, solid imaging, direct metal laser sinter, and laminated object manufacturing. Scopus was used as the database (status: December 2014). Definition and calculations by Fraunhofer IGD.
- 286 Due to the 30-month priority period in the PCT procedure, only patent families and registrations up to June 2012 are fully covered for 2012 at the present time (status on December 2014). It can therefore be assumed that the number of patent families in 2012 is actually higher than is shown in the chart.
- 287 Looking in more detail, there were 4,336 publications by scientists in the USA in this period. They were followed by China-based scientists with 2,331 publications and Germany-based scientists with 1,429 publications. UK-based scientists were in fourth place with 1,381 publications. The pool of data used for the whole period between 2000 and 2014 included 16,840 scientific publications in the relevant field that are documented in the Scopus database. Since calculations do not use fractional counting, publications with several authors in different countries are counted several times.
- 288 The Hirsch Index is a bibliometric measure that determines scientific importance on the basis of a scientist’s publications. Citations of the works by other authors play a special role in this context. The Hirsch Index can be adapted to show the quality of research conducted by, e.g., a research group, a university or a country. In the aggregation at the country level, all the publications of authors based in one country (plus the “international” publications involving the participation of authors from different countries) and their citations are assigned to one or several countries (no fractioning of citations). Calculations are based on Scopus Citation Tracker.
- 289 The information provided on a patent specification stating the applicant’s residence makes it possible to allocate individual applications to countries. If several applicants in different countries are involved in a (first) patent application, these are counted in fractions.
- 290 The search was based on keywords in the fields of geometry extraction, modelling (modelling and other properties), hybrid 3D model generation, geometry-data management, mapping processing, simulation/CAE, application-oriented accumulation, virtual output technologies, rendering, graphics programming, interaction, special environments (VR, AR, mobile) and 3D-printing/rapid prototyping.
- 291 A patent family is a group of patent documents that are related to each other – like a family. All the documents are based on the same first application (priority). Observing a patent family makes it possible, among other things, to gain an overview of the international (territorial) coverage of intellectual property rights. Cf. <https://depatisnet.dpma.de/depatisnet/htdocs/prod/de/hilfe/recherchemodi/patentfamilien-recherche/index.html> (last accessed on 12 January 2015).
- 292 Cf. Bechthold et al. (2015: 7).
- 293 Cf. Gebhard (2014: 2).
- 294 Cf. Eisenhut and Langefeld (2013).
- 295 Cf. Eyers and Dotchev (2010).
- 296 The same applies to the production of three-dimensional tissue, e.g. skin, blood vessels, tracheae or heart valves from biocompatible materials and body cells. Medical researchers are already working on using bioprinters to make organs. However, artificially manufactured organs, e.g. a kidney, are not expected to be transplanted for several decades yet. Cf. Bechthold et al. (2015: 34) and <http://www.heise.de/tr/artikel/Organe-aus-dem-Drucker-2096965.html> (last accessed on 12 January 2015).
- 297 Cf. <http://www.chicagobusiness.com/article/20140322/ISSUE01/303229986/printers-let-hearing-aid-manufacturer-automate-yet-customize> (last accessed on 12 January 2015).
- 298 Cf. Massy-Beresford (2014).
- 299 Cf. Franke and Piller (2004).
- 300 Cf. Ratto and Ree (2012).
- 301 Cf. Lipson and Kurman (2013), as well as Ritzern and Jurgenson (2010).
- 302 Cf. *The Economist* (2013).
- 303 Cf. VDI (2014: 18).
- 304 Cf. <http://www.pcmag.com/article2/0,2817,2470038,00.asp> (last accessed on 12 January 2015).
- 305 Cf. <http://money.cnn.com/2013/06/19/technology/makerbot-stratasys-merger/> (last accessed on 12 January 2015).
- 306 Cf. Lipson and Kurman (2013).
- 307 Cf. Shapeways (2014).
- 308 Cf. Kurutz (2014).
- 309 Cf. Acatech (2013).
- 310 Cf. EFI (2014: 54) and Bechthold et al. (2015: 33ff.).
- 311 Cf. UK Department for Education (2013).
- 312 Cf. Stiftung neue Verantwortung (2014).

- 313 Cf. Abdullah and Wirth (2013), Osborn (2013), Bechthold et al. (2015: 73ff.).
- 314 Cf. Rüberg (no date). Gartner Inc., a US-based market-research company, estimates that the illegal reproduction of goods using AM will lead to massive violations of intellectual property rights in the coming years. Gartner estimates that losses caused by rights violations will total at least USD 100 billion in 2018. Unlike in the past, the illegal reproduction of goods will no longer take place in Asian emerging markets, but in Western countries. Cf. <http://www.gartner.com/newsroom/id/2603215> (last accessed on 12 January 2015).
- 315 The discussion continues on whether software is a product – and therefore subject to the German Product Liability Act (Produkthaftungsgesetz) – or a service – and therefore not subject to the Product Liability Act. Osborn proposes defining CAD files for the mass market as products and CAD files for individual use as services. Cf. Osborn (2013).
- 316 Cf. Schwandt (2013).
- 317 Cf. BMWi, BMI, BMVI (2014: 13).

C

- 318 The systematic selection of international reference countries is based, inter alia, on the size of the economies and on the national R&D intensity in the OECD and BRICS countries.

C 1

- 319 Cf. Baethge et al. (2015).
- 320 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. ISCED subdivides education into the following training levels: ISCED 0 – pre-primary education, kindergarten. ISCED 1 – primary education, first stage of basic education. ISCED 2 – lower secondary education, second stage of basic education (years 5 to 10). ISCED 3 – upper secondary education, (technical) higher education entrance qualification, without vocational qualification or apprenticeship. Vocational qualification from a vocational school/college. Completion of one-year healthcare school. ISCED 4 – post-secondary non-tertiary education, (technical) higher education entrance qualification with apprenticeship. (Technical) higher education entrance qualification and vocational qualification from a vocational school/college, completion of a one-year healthcare school. ISCED 5B – first stage of tertiary education (B), training as a master craftsman or technician or equivalent vocational school qualification. Completion of a two- or three-year healthcare school. Graduation from a private academy (Fachakademie) or a university of cooperative education (Berufsakademie). Graduation from a public administration college. Graduation from a technical college in the former GDR. ISCED 5A – first stage of tertiary education (A), degree at a university of applied science (UAS) (including engineering degree, bachelor's/ master's degree at a UAS, without completing a public

administration college qualification). University degree and corresponding final examinations). ISCED 6 – second stage of tertiary education, PhD. Cf. Müller (2009: 43), OECD (2011: 31).

C 2

- 321 Cf. Schasse et al. (2014, 2015).

C 3

- 322 In this regard and in the following, cf. Rammer and Hünermund (2013).
- 323 In the following, cf. Rammer et al. (2015).
- 324 Cf. Blind (2002).

C 4

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

C 5

- 326 Chapter C 5 is based on a study prepared for the Commission of Experts by the ZEW. Cf. Müller et al. (2015).
- 327 However, the data from the individual countries are not fully comparable. Cf. Müller et al. (2014) for more detail on this.
- 328 In this regard and on individual points, cf. Müller et al. (2013).
- 329 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.
- 330 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 6

- 331 Cf. Neuhäusler et al. (2015: 7).

C 7

- 332 Cf. Mund et al. (2015).

C 8

- 333 This section and the following figures are based on Gehrke and Schiersch (2015).
- 334 Cf. Gehrke and Schiersch (2014: 74) for a methodical explanation of the RCA indicator.
- 335 In Korea, cutting-edge technology is dominated by only one sector (production of electronic and optical devices) with a value-added share of slightly over 6 percent. In

Switzerland, by contrast, cutting-edge technology is characterised almost equally by two sectors: the manufacture of pharmaceutical products, and the production of electronic and optical devices.

D

336 Cf. Gehrke et al. (2013).

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