RESEARCH, INNOVATION
AND TECHNOLOGICAL
PERFORMANCE IN GERMANY

COMMISSION OF EXPERTS
FOR RESEARCH
AND INNOVATION

EFI

REPORT

2008 2009 2010
2011 2012 **2013**
2014 2015 2016
2017 2018 2019

ISBN 978-3-00-041794-8

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We wish to thank
Prof. Dr. Alain Beretz, Mr. Daniel Hager, Prof. Jörg Menno Harms, Dr. Carlos Härtel, Prof. Dr. Susanne Ihsen, Prof. Dr. Henning Kagermann, Dr. Dorothee Kuon, Prof. Dr. Jean-Marie Lehn, Prof. Dr. Wolfgang Marquardt, Prof. Dr. Till Requate, Dr. Stefan Walz and Dr. Hubert Weis, all of whom contributed their expertise to the report.

In addition, we wish to thank all those persons who helped prepare the studies on the German innovation system, as well as the Fraunhofer-Gesellschaft, the Helmholtz Association of German Research Centres, the Leibniz Association and the Max Planck Society for providing visual material for the illustration of the EFI Report.

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

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This report is also the result of the highly competent and dedicated work of the staff of the office of the Expert Commission – and the staff of the Commission members.

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FOREWORD

In their Annual Report 2013, the Commission of Experts for Research and Innovation presents current analyses, assessments and recommendations on designing the German research and innovation system.

With regard to its R&I policies, Germany has made substantial progress, which has been highly acknowledged internationally. In 2011, Germany almost reached the three-percent target for national R&D intensity. Research and innovation of German companies contributed significantly to the stabilisation of the German labour market and to Germany's continuing export success. Science organisations and tertiary education institutions are benefitting from the measures implemented in recent years. To stay on this road to success, Germany will have to strengthen research and innovation also in the future.

Yet there are not only successes to be recorded. Not all of the objectives for the ongoing legislative period have been met: although the introduction of R&D tax credits and improved conditions for venture capital had been enshrined in the Federal Government's coalition agreement, these measures have not been implemented. Besides this, there are pressing political tasks relating to organising cooperation between the Federal and state governments (Länder), as well as pressing issues in other policy areas.

In Chapter A1, the Expert Commission takes the occasion of the upcoming autumn 2013 federal elections as an opportunity to identify fields of action that should receive special attention in the next legislative period.

The Expert Commission also contributes to current discussions relating to R&I policies. Chapter A2 discusses the pros and cons of open access publishing and advocates a second publication right to improve public access to scientific findings.

The Expert Commission welcomes the introduction of a unitary European patent and a corresponding patent jurisdiction, which has now been adopted (Chapter A3). This reform represents an improvement for small and medium-sized enterprises (SMEs) in particular. Yet the harmonisation of Europe's patent system is by no means complete. The costs of patenting will have to be lowered, and it is also important to ensure that strict quality standards are applied to the assessment of patents filed. In the long run, these are prerequisites for creating socially desirable incentives for innovation.

The current start-up landscape in Berlin (Chapter A4) demonstrates how entrepreneurship in Germany can flourish. With its thriving IT and internet sector, the city has a favourable competitive position within the innovative internet economy. This is important not only for the city of Berlin, but also for Germany as a business location. Berlin exemplifies how the internet economy can generate significant value creation and employment opportunities within a short period of time. To foster the positive development of Germany's internet and IT industry, it is particularly important to improve framework conditions for financing growth of new enterprises.

In the field of innovation financing, crowdfunding (Chapter A5) is an interesting recent development. Crowdfunding is a new, internet-based form of financing. In the view of the Expert Commission, crowdfunding offers new enterprises and SMEs an attractive alternative, or supplement, to financing from other capital owners, such as business angels. The Expert Commission presents suggestions on further developing the potential of crowdfunding in Germany and limiting the risks of this form of financing.

In Chapter A6, the Expert Commission expressly recommends using randomised experiments to evaluate innovation activities. Such procedures could generate significant efficiency gains and thus lead to considerable improvements in the use of scarce R&D subsidies.

In the first of their four key studies, the Expert Commission discusses the coordination of Germany's climate, energy and innovation policies (Chapter B1). In these areas, the Federal Government pursues targets that partially overlap. Hence it is necessary to strengthen coordination so as to create synergies and avoid counterproductive interactions. The Expert Commission particularly recommends expanding the European Emissions Trading System (EU ETS) as well as fundamentally reforming the promotion of renewable energy sources and creating a pan-European market for Renewable Energy Certificates. The security of planning for businesses should be increased through binding long-term policy targets and stringent implementation. In the view of the Expert Commission, the successful implementation of the Energy Transition will require improved coordination and the pooling of skills. Here, a national energy platform comprising representatives of federal ministries and the federal states as well as major corporations could play an important role.

The key topic discussed in Chapter B2 is the ongoing internationalisation of research and development. There are indications of a new division of labour between highly developed industrialised countries and emerging economies. Germany still enjoys an excellent reputation both as an investor and as a location for R&D activities. Yet R&D in Germany could be made even more attractive by introducing R&D tax credits. The Expert Commission expresses concerns regarding the increasing specialisation in industrial research in Germany. This is a trend that results in short-term benefits but can lead to a "competence trap" in the long term: promising new fields of competence are not fully tapped, or not exploited in time. Hence, in future, Germany should focus on developing new competences in cutting-edge technologies through broad basic research and effective technology transfer – thereby ensuring that Germany remains attractive for foreign enterprises as an innovation location.

Chapter B3 discusses the role of innovation-oriented procurement by the public sector. To date, Germany has not been making full use of its potential for innovation-oriented procurement. Too often, public procurement makes use of established solutions or solutions with minor innovative potential, thereby inhibiting the development and distribution of innovative products and services. The Expert Commission is in favour of supporting new initiatives by the European Commission – especially the initiative for implementing pre-commercial contract awarding and the renewal of the EU Directive on European procurement law – as well as corresponding measures at the national level. Here, government policies should be guided by the aim of optimising the provision of services for public benefit through the procurement of innovative products and services.

The fourth key study (Chapter B4) discusses the role of women in Germany's R&I system. A shortage of skilled workers in the STEM professions is increasingly becoming a bottleneck for Germany's innovative power and international competitiveness. Skills and innovation potential of the employment population that have been previously underutilised must therefore be better exploited. The Expert Commission sees considerable need for action to enable women to contribute to a greater extent to research and innovation in Germany.

Especially in view of the narrowing leeway for fiscal policy, the Expert Commission urges the Federal Government to strongly commit to a long-term research and innovation policy. The success of recent years should make us confident. A waning commitment on the part of the Federal Government, the Länder governments and the private sector carries the risk of consciously losing innovation-generated economic growth potential.

Berlin, 27 February 2013

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SUMMARY

SUMMARY

CURRENT DEVELOPMENTS AND CHALLENGES

A 1 PRIORITIES AND RECOMMENDATIONS FOR RESEARCH AND INNOVATION POLICIES OF THE NEXT LEGISLATIVE PERIOD

With the federal elections approaching in autumn 2013, the Expert Commission discusses major developments of the last years and identifies priority fields of action that should be addressed by the political stakeholders in the coming legislative period. The Expert Commission recommends:

– setting ambitious R&D and educational budget targets for the year 2020;
– enabling participation of the Federal Government in institutional financing of university research and education;
– applying a uniform financing key to non-university research institutions;
– expanding the Freedom of Science Act to tertiary education institutions;
– developing funding concepts for research following expiry of Higher Education Pact, Pact for Research and Innovation and Excellence Initiative;
– supporting innovation financing via R&D tax credits for companies;
– improving framework conditions for venture capital financing;
– further modernising patent and copyright systems;
– developing and implementing a systematic approach for R&I policy evaluation;
– focussing the High-Tech Strategy 2020;
– improving coordination of climate, energy and innovation policies;
– facilitating immigration of highly qualified foreigners;
– taking more advantage of the potential of women in business and research.

A 2 OPEN ACCESS

The Expert Commission is convinced that the efficient organisation of the creation and distribution of research findings promotes the transfer of knowledge. Open access, i.e. free online access to research findings, increases competition and further taps the potential of the internet as a means of distributing knowledge. Thus the open access approach should be promoted. Yet this should also include protecting the interests of researchers involved. The development and expansion of open access journals and repositories should be further supported via public funding, with the aim of making open access publishing appealing to researchers. In the design of new structures it should be ensured that these are viable in the long term and as efficient as possible.

The Expert Commission recommends integrating a contractually bound, indispensable second publication right into the Copyright Act for academic writers whose publications originate in research activities that were largely financed by public resources. This right shall take effect within a reasonable period of time after initial publication. If scientists hold the right to second publication, they should be obliged in the case of publicly funded projects to publish their research findings online and free of charge upon expiry of the term.

EU PATENT SYSTEM A 3

The European Parliament's decision to introduce a unitary European patent and corresponding patent jurisdiction certainly improves on the previously existing European "bundle of patents". SMEs in particular are likely to benefit from these new regulations. Yet the Expert Commission considers it essential to further harmonise the EU patent system. In the medium term, all EU member states should fully replace the EPO bundle patent with the unitary European patent.

Fees should be designed attractively in order for the new system to be favoured over the old bundle patent system, while at the same time effectively limiting incentives for increased filing of low-quality patent applications. To maintain current high standards and to deal with an expected increase in the number of patent applications, the European Patent Office requires corresponding equipment and administrative support structures. The highest standards should be applied to the selection and specialised training of judges and to the ongoing support of patent courts, which are due to be established as part of the Central Division. Moreover, the expertise and current benefits of the German system need to be integrated into the new system.

INTERNET AND IT START-UPS IN BERLIN A 4

In recent years, Berlin has seen an increasing number of internet and IT start-ups financed by venture capital. This start-up boom owes more to social and cultural factors than to exceptionally favourable political-administrative framework conditions. With its thriving IT and internet scene, the city has a favourable competitive position within the innovative internet economy. This is important not only for the city of Berlin, but also for Germany as a business location. Berlin is an example of how the internet economy can generate significant value creation and employment opportunities within a short period of time. To foster the positive development of Germany's internet and IT industry, it is particularly important to improve framework conditions for financing growth of new enterprises.

A 5 CROWDFUNDING

Crowdfunding is an innovative online-based form of financing. It offers new businesses and SMEs an attractive alternative to bank and venture capital financing. To date, crowdfunding is largely unaffected by existing prudential regulation.

Framework conditions for crowdfunding activities have been significantly improved in the United States in recent years. In view of this, Europe should also seek to harmonise its regulatory framework at a European level if it is to avoid losing ground. Furthermore, it will have to be clarified how, on the one hand, investors can be protected, and how, on the other hand, platform operators can be protected from fraudulent investors – without government intervention impeding the growth potential of crowdfunding markets in Germany and Europe. Strengthened investor protection could be achieved by introducing a cap on allowable investment amounts by individual private investors or by demanding explicit involvement of experienced and accredited investors in a financing project.

A 6 EVALUATION OF INNOVATION POLICY MEASURES BASED ON RANDOMISED EXPERIMENTS

To increase the dynamics of R&D growth in Germany, a variety of policy measures are currently in place. Yet a systematic evaluation that complies with most recent scientific standards is still lacking. Randomised evaluations should therefore be included as one of the standard tools in the evaluation portfolio of public R&D funding in the future. A randomised introduction of policy measures for evaluation purposes is particularly useful in areas where a relatively large number of applicants is anticipated and where an oversubscription of funds can be expected due to limited budgets. The Expert Commission specifically recommends commencing an evaluation on the basis of a randomised allocation of funds in the context of the ZIM, a funding programme designed for supporting innovative SMEs. The findings of such evaluations could lead to considerable efficiency gains and thus to a much better use of scarce R&D subsidies. The randomised introduction of policy measures in the field of R&I policies is still rarely used in Europe. Here, German R&I policy could take a leading role.

CORE TOPICS

COORDINATING CLIMATE, ENERGY AND INNOVATION POLICIES B 1

Germany pursues climate, energy and innovation policy objectives that overlap to some extent. In terms of regulation, these policies will have to be coordinated in order to create synergies and avoid counterproductive interactions.
Key instruments for climate and energy policies are the European Union Emissions Trading System (EU ETS) and Germany's Renewable Energy Sources Act (EEG). In addition, there are a number of instruments that aim to increase energy efficiency. Moreover, the field of climate and energy is one of the five requirement areas of the Federal Government's High-Tech Strategy 2020 and thus constitutes a German innovation policy priority matter. As regards the functioning and coordination of the existing climate, energy and innovation policy instruments, the Expert Commission sees deficits in terms of cost efficiency and a lack of incentives for developing new technologies. Against this background, the Expert Commission suggests the following measures:

– European emissions trading should be extended to cover all emission sources. Moreover, minimum prices for emission rights should be introduced.
– In the field of renewable energy, the Expert Commission agrees with the recommendations of the German Council of Economic Experts and the German Monopolies Commission to introduce Renewable Energy Certificates.
– An increase in energy efficiency should be implemented using a tradable energy saving ratio, flanked by additional measures in the area of buildings.
– The ratio of diffusion promotion and direct R&D funding in the field of renewable energies should be shifted in favour of R&D funding.
– Climate and energy policies should be coordinated through a national platform that would comprise not only relevant departments of the Federal Government, but also representatives of the *Länder* and relevant companies.

INTERNATIONAL R&D LOCATIONS B 2

The ongoing internationalisation of research and development (R&D) is leading to a new division of labour between highly developed industrialised countries and emerging economies. Large R&D intensive multinational enterprises base their decision on the location of R&D sites not only on the criteria of market attractiveness, and production and logistics costs, but also to an increasing extent on a country's innovative potential and its human capital endowment. Today, a growing number of German companies have R&D branches and manufacturing plants abroad. Overall, Germany's cross-border R&D flows are balanced and Germany continues to enjoy an excellent reputation as an investor, but also as a location for R&D activities.

Yet, when analysing the R&D priority areas of German companies abroad, and R&D spending by foreign companies in Germany, a high concentration on specific sectors of the manufacturing industries that are characterised by a medium R&D intensity becomes apparent. Existing strengths are thus further enhanced. This leads to a "competence trap": existing fields of competence are further expanded, while promising new fields of competence are only rarely tapped.

Therefore, Germany will have to give more attention to creating new areas in the field of cutting-edge technology and will also have to ensure that Germany remains attractive as an innovation location for foreign multinational enterprises in these areas. The Expert Commission thus recommends the following measures:

- The Federal Government should base its educational policies and its basic research on a broad approach to prepare Germany for the technological developments of the future. At the same time, effective technology transfer is required to lay the foundations for the future utilisation of newly created knowledge.
- To ensure that R&D activities in the field of cutting-edge technology are conducted in Germany, it is necessary to keep publicly funded applied research in the country. At the same time it is imperative to attract additional R&D from abroad. Restraint should be exercised in the public funding of applied research activities by German non-university research institutions abroad.
- Germany's current locational tax drawbacks will have to be amended and R&D tax credits will have to be introduced if Germany is not to fall behind in international competition.
- Decision makers from politics and science should engage in a regular, systematic dialogue with research-intensive companies from abroad. The topic of international exchange should be monitored and developed by existing committees such as the Innovation Dialogue, the Science and Industry Research Union, as well as regular intergovernmental committees and bilateral innovation policy platforms.

B 3 INNOVATION-ORIENTED PUBLIC PROCUREMENT

In the European Union and in Germany, proposals for designing innovation-oriented procurement as an innovation-promoting policy instrument are being discussed. The interest in the effects of innovation-oriented procurement is largely driven by the considerable volume of public demand. In the view of the Expert Commission, Germany is not sufficiently exploiting the potential of innovation-oriented procurement. It is too often the case that public procurement makes use of established solutions or solutions with minor innovative potential, thereby disadvantaging or inhibiting the development and distribution of innovative products and services by German firms. The Expert Commission therefore recommends the following:

- The Federal Government should support measures initiated by the EU Commission to promote innovation-oriented procurement, particularly the initiatives for the implementation of Pre-Commercial Procurement (PCP) and the renewal of the directive on public procurement in Europe. Yet, in the implementation of this reform, the Federal Government must take care that these measures do not lead to a permanent restriction of competition.
- Public procurement in Germany is highly fragmented and should be coordinated more closely. Furthermore, it is important to raise awareness among procurers about the opportunities of innovation-oriented procurement. The Expert Commission therefore welcomes the creation of a competence centre that offers advice and assistance to public procurers in the field of procurement.
- It is essential to collect and publish relevant data in order to monitor the effectiveness of measures promoting innovation-oriented public procurement and to take corrective action if necessary. The Alliance for Sustainable Procurement, initiated by the Federal

Government, should therefore develop explicit recommendations for an improved statistical collection of data relating to innovation-oriented procurement.
– The Federal Government's planned projects for the promotion of innovation-oriented procurement should be monitored and evaluated from the start.

TAKING MORE ADVANTAGE OF THE POTENTIAL OF WOMEN IN THE RESEARCH AND INNOVATION SYSTEM B 4

A shortage of skilled workers, particularly in the STEM professions, is increasingly becoming a bottleneck for Germany's innovative power and locational competitiveness. Skills and innovation potentials that have been previously underutilised must therefore be better utilised in the future. This applies to women in STEM subjects and women in senior positions in the academic and business world. Although today more women than men earn an academic degree, this success is not continued on the labour market. Instead, Germany loses the potential of the ever-growing number of well-educated women in their transition to the labour market and in their occupational progression – in fact: the higher the career level, the more women are lost. Also, when compared with other countries, too few women can be convinced to study and work in the field of engineering in Germany.
In order to make better use of the innovative potential of women, the Expert Commission sees considerable need for action:

– Schools should put particular emphasis on fostering girls' interest and enthusiasm for mathematical and technical issues.
– Combining work and family must be facilitated by expanding childcare facilities. In the long run, this will create the necessary incentives for making better use of the innovation potential of women in general, and women in engineering professions in particular.
– At the same time, companies and research institutions have to strengthen their efforts in order to ensure greater representation of women in leading positions. Gender-biased recruitment and selection processes must be detected and avoided – in the best interest of the companies and research institutions themselves.
– Ultimately, the Expert Commission also considers the introduction of quotas for leading positions in academia and business as an appropriate means of accelerating the transition towards greater gender equality.

CURRENT DEVELOPMENTS AND CHALLENGES

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A CURRENT DEVELOPMENTS AND CHALLENGES

A 1 PRIORITIES AND RECOMMENDATIONS FOR RESEARCH AND INNOVATION POLICIES OF THE NEXT LEGISLATIVE PERIOD

With the federal elections approaching in autumn 2013, the Expert Commission comments on major developments of recent years and identifies priority fields of action that should be addressed by the political stakeholders in the next legislative period.

Taking stock: major positive developments – high international reputation

With regard to its R&I policies, Germany has made important progress, which has been highly acclaimed internationally.

– A significant increase in national R&D intensity has been achieved in recent years, following a period of stagnation that started in 1991. With a national R&D intensity of 2.9 percent in 2011, Germany managed to close in on the United States, while almost reaching the Federal Government's three-percent target. Other indicators also suggest that Germany has improved its position considerably – particularly with regard to the export of R&D-intensive goods.
– Based on new funding instruments (especially those of the Leading-Edge Cluster and the Excellence Initiative), competition between German regions and between German tertiary education institutions has been strengthened. Available funding for non-university research has been increased, and the German Research Foundation's research support funds have also been increased.
– Several other promising approaches have been implemented, among them the "Research Campus – Public-Private Partnership for Innovation" funding scheme. The Expert Commission attaches great importance to this initiative in particular as the projects supported by this public-private partnership could increasingly tap new impulses from research for economic purposes.
– At the international level, the Federal Government's realignment of R&I policies towards a mission orientation, and strengthened coordination of

BOX 01

Priorities for R&I policies of the next legislative period

– setting ambitious R&D and educational budget targets for the year 2020;
– enabling participation of the Federal Government in institutional financing of university research and education;
– applying a uniform financing key to non-university research institutions;
– expanding the Freedom of Science Act to tertiary education institutions;
– developing funding concepts for research following expiry of Higher Education Pact, Pact for Research and Innovation and Excellence Initiative;
– supporting innovation financing via R&D tax credits for companies;
– improving framework conditions for venture capital financing;
– further modernising the patent and copyright systems;
– developing and implementing a systematic approach for R&I policy evaluation;
– focussing the High-Tech Strategy 2020;
– improving coordination of climate, energy and innovation policies;
– facilitating immigration of highly qualified foreigners;
– improving utilisation of the potential of women in business and research.

the key players within the High-Tech Strategy's research union, is regarded as a sound governance model for the R&I system.

Only little progress in other key areas

The above mentioned achievements should not give great occasion to celebrate, as major political issues have not been adequately addressed, and policies of the current legislative period have failed in key areas. Here, the most important areas include:

– Venture capital financing has not yet experienced a breakthrough in Germany. Even if it is the case that Germany's political stakeholders recognise the importance of the topic, the implementation of changes in the framework conditions keeps failing due to resistance within some of the federal ministries. In this area, a primacy of politics seems to be lacking altogether.
– The introduction of R&D tax credits, which had been announced in the coalition agreement, has not been implemented. It seems that the political will for implementing this measure is lacking.
– The correction of the Federalism Reform I, an issue now deemed as necessary by almost all of Germany's political parties, is still pending. General agreement has been achieved at least with regard to the Federal Government's support of tertiary education institutions. Yet it seems that the reform and its design have been turned into a political football by the parties.
– The reform of the German education system is progressing with difficulty.[1] The most recent results (December 2012) on the situation in primary schools[2] confirmed that Germany has only an upper middle ranking. In the long run, such a position is dangerous as it will hinder the further development of Germany as an innovation location.
– To date, major weaknesses in key areas of cutting-edge technology have not been addressed convincingly, among them information and communication technology (ICT) and life sciences.

Priorities and recommendations for the next legislative period: measures for the long-term development of R&I at national and EU levels

In spite of considerable fiscal challenges, the Federal Government must continue to pursue its ambitious targets in education, research and innovation and ensure that these targets are clearly defined. The Federal Government has to be re-enabled to participate in the institutional funding of tertiary education institutions and schools.

– Germany will be faced with major fiscal challenges with the introduction of the debt ceiling in 2016 and the expiry of the Solidarity Pact in 2019. Important R&I institutions, such as tertiary education institutions and non-university research institutions, will be affected by the expiry of the Excellence Initiative (post 2017), the Joint Initiative for Research and Innovation, and the Higher Education Pact 2020 (post 2015). The Eurozone crisis is likely to further aggravate existing budgetary constraints. Against this background, it is essential to make a long-term commitment to the priority areas of education, research and innovation. The Federal Government aims to achieve the three-percent target for national R&D expenditure and the seven-percent target for national education expenditure by 2015. If Germany wants to be on par with the leading innovation nations, it will have to commit to a more ambitious target[3] and invest 3.5 percent of its GDP in R&D and 8 percent of its GDP in education. In the years to come, public expenditure will have to be at least stable at this level.
– Also at the EU level, greater priority must be attached to research and innovation. The downsizing of agricultural subsidies in favour of investment in Europe's future is progressing very slowly and sometimes not at all. The resources available for R&D will have to be used more efficiently; while the budget for the EU Framework Programme for Research 2014–2020 may not be subjected to cuts.[4] Moreover, industry participation in projects of the framework programme will have to be increased. EU research policy should be committed to the goal of "smart specialisation". The Expert Commission would like to reiterate its proposal to launch an Excellence Initiative for consortia of European tertiary education institutions, which would receive administrative

support from the European Research Council (ERC).[5] Financial support of the ERC must be secured and increased.
- Article 91b of the Basic Law has to be amended to enable the Federal Government to financially support the Länder governments with regard to research.[6]
- Education can be considered as the Achilles' heel of Germany's R&I system; even more so than research. The Expert Commission expressly welcomes the federal states' competition in the field of education. Yet it must be avoided that differences in educational outcomes – due partially to financial constraints – are cemented in the long term. The Federal Government should be re-enabled to participate in the financing of education measures and should push for the comparability of educational outcomes in particular.

Science system

Competition must be further strengthened in the entire science system, and the system has to become more flexible.

- The Expert Commission reiterates its proposal according to which federal and *Länder* governments should support non-university research institutions on the basis of a uniform financing key, apportioned at an approximate 70:30 ratio.[7] To strengthen future research of tertiary education institutions in international competition and to avoid non-university research institutions being disadvantaged, the Expert Commission recommends gradually expanding the provisions of the Freedom of Science Act to tertiary education institutions, to be implemented in close collaboration with the federal states.
- There is an urgent need to develop policies to support tertiary education institutions after the expiry of the Excellence Initiative. In this regard, Germany must continue to strive to establish select universities at the international forefront of research and scientific training.
- Federal and *Länder* governments must continue to pave the way for a vertical and horizontal differentiation of the tertiary education sector, e.g. by allowing for experimental clauses and maximum autonomy of institutions, while also providing financial incentives for profile-building activities.[8]
- The transfer of knowledge and findings must be strengthened in order to make research contributions available to the private sector and provide impulses for the progress of the science system.[9] Knowledge transfer is a topic that is met with only little interest and support on the part of university managements. Here, it is essential to achieve a culture shift and overcome the "ivory tower" mentality that still prevails at some of Germany's tertiary education instutions.
- Patent exploitation at non-university research institutions and tertiary education institutions has to be improved significantly. The existing systems have to be made more flexible so as to cater for the needs of researchers at the individual institutions.[10]
- Framework conditions for foundation financing and foundation law in Germany have to be developed further so as to strengthen private financing within the science system. The Expert Commission thus welcomes the current slackening of the endowment ban, which could facilitate the creation of endowed chairs at tertiary education institutions.[11]

Research and innovation in the private sector

Germany's economy is powerful and innovative. Nevertheless, there is considerable need for enhancing the development of R&I in the private sector.

- The introduction of R&D tax credits must be initiated at the very start of the new legislative period. R&D tax credits are the appropriate tool for supporting R&D activities of SMEs in particular. When introducing R&D tax credits, the Federal Government's project funding should be systematically aimed at specific thematic fields. These two instruments are not substitutes, but instead complement each other.
- Germany widely supports the founding of new enterprises through public funding. Special attention should now be placed on enhancing private investment incentives so as to bridge the gap between initial public start-up support and the consistent commercial implementation of new forms of value creation. Here, the public sector should not take on the role of financier, but instead provide smart, future-oriented framework conditions for venture capital financing. Among other things,

this could be achieved by introducing a less restrictive tax treatment of loss carryforwards and a legally clear-cut classification of venture capital firms' activities.[12]

Tax competition and protective rights to promote R&I

The Federal Government can heavily influence Germany's framework conditions for innovation by designing patent and trademark protection systems and developing copyright law.

– The Federal Government should act upon avoiding and limiting opportunistic tax competition – such as the setting up of "patent box systems" – at EU level and beyond. Germany should fully support international efforts (e.g. by the OECD) to regulate the valuation of intangible assets and transfer prices.[13]
– The introduction of the unitary EU patent is a success for the common internal market.[14] Yet, in the long run, a patent system will generate innovation incentives only if it carefully assesses submitted applications and if it sets high quality standards for inventions. The development of the patent system thus continues to be a key task of R&I policy for the years to come.
– The digitalisation of the economy and society is progressing continuously. Copyright law policies should be aimed at supporting innovation and not at preserving existing structures. Efforts to provide the printed media with inventory protection do not sufficiently take into account technological progress and may indeed hinder innovation activities. What is needed is a reasonable balance between facilitating the availability of scientific information and protecting copyright.[15]

R&I policy processes and instruments

In the upcoming legislative period, R&I policy instruments will have to be systematically evaluated and refined.

– Scientifically sound R&I policy measure evaluations[16] and the provision of data for research will have to be advanced further. Evaluations should be regarded as an opportunity for gaining new insights and for improving existing funding instruments.
– The Expert Commission recommends conducting a system evaluation of all non-university research in Germany at an early stage of the new legislative period. Furthermore, the recommendations by the German Council of Science and Humanities on developing federal department research *(Bundesressortforschung)* should also be implemented.[17]
– The High-Tech Strategy 2020 has to be further developed. While the overall rationale is well targeted, there are still several areas that have not been developed in detail yet. The Science and Industry Research Union is an important committee for coordinating R&I policies at the interface of politics, science and business. All of the relevant stakeholders should be represented in this committee. Moreover, the integration of SMEs and new enterprises in the development of R&I policies should be further promoted. Attempts towards integrating citizens into the process of R&I policy-making – such as the "citizens dialogue" hosted by the Federal Ministry of Education and Research (BMBF) – have been encouraging and should be systematically pursued.
– Germany's strong position in the manufacture of innovative products has to be further strengthened – without losing sight of the future value creation potential of innovative services. R&I policy has to be designed in a sustainable way and be able to facilitate structural change; R&I policies should not try to protect the status quo of established companies or industries.
– In recent years, Germany's climate, energy and innovation policies have frequently overlapped, and the implementation of the Energy Transition has been progressing slowly. The promotion of renewable energy will have to be fundamentally redesigned. Furthermore, the Expert Commission recommends closer coordination of the responsible federal ministries as well as the bundling of competences.[18]
– The use of digital technologies is progressing continuously – also in Germany. Yet, based on international standards, Germany still suffers comparative disadvantages in the field of production and in the use of information and communication technology (ICT). The Energy Transition and public support for electromobility could be used beneficially to soften Germany's disadvantages, such as those in the field of ICT.[19]

Opening Germany's borders to the world's innovation elite

Germany must continually open its borders and facilitate the immigration of qualified workers.

- The immigration of skilled workers such as scientists, entrepreneurs and highly qualified experts must be facilitated. Germany is in urgent need of a political and social consensus on the necessity of attracting and integrating highly skilled workers from abroad. Countries such as Canada have established targeted systems to systematically attract and integrate highly qualified personnel. Germany can learn from these countries.[20]
- The Expert Commission suggests providing simplified immigration regulations – e.g. in terms of residence and work permits – for non-German entrepreneurs who aim to substantially invest and create jobs in Germany.[21]
- Efforts to improve the integration of foreign workers in the German labour market must be strengthened at all skill levels. The Expert Commission welcomes the improvements in the immigration regulations for graduates, qualified workers and those participating in training, as well as the improvements in information policies.[22]
- The recognition of foreign professional qualifications – e.g. in the context of the "Integration through Qualification" programme – has not led to the desired results yet.[23] Efforts to improve the recognition of foreign professional qualifications have to be further strengthened.

Improving the utilisation of the potential of women in business and science

In all areas of business, research and innovation, gender equality has to be enhanced.

- Germany is still characterised by an insufficient utilisation of the potential of women in all areas of research and innovation. Here, political stakeholders, businesses, associations and research institutions are called upon to participate in solving this issue.[24]
- In the field of engineering, an increased participation of women in academic degree courses, doctoral programmes and subsequent occupational paths must be ensured – particularly with regard to professorships.[25]
- Raising girls' interest in research and technology will have to be a priority issue in pre-school and school education.[26]
- Ultimately, the Expert Commission also considers the introduction of quotas for leading positions in the research system and the private business sector as an appropriate means to accelerating a transition towards greater gender equality.[27]

OPEN ACCESS A 2

Outstanding role of publications in the R&I process

Research and development processes in business and science are often cumulative, i.e. they build on the findings of previous research. In many disciplines, the most important means of distributing information are publications in scientific journals. The most frequently used method of ensuring the quality of publications are assessment procedures in which external, anonymous experts provide a written review on the quality of an essay, thereby supplying the journal's editor with valuable information. Based on this, the editor will decide whether, and under which conditions, an article is to be published in the journal. Commercial publishing houses will then publish the approved text, either in print or electronic form. In some cases, the distribution of publications is carried out by the scientific organisations themselves. In recent decades, the concentration of suppliers in the commercial scientific journal market has increased significantly.[28]

Calls for open access are getting louder

The ongoing market concentration is accompanied by significant price increases for products offered by publishing houses (such as journals or full-text downloads). In the fields of medicine, science and technology, prices of publications have quadrupled in certain areas over the last 20 years, while budgets of academic libraries are stagnating.[29] The expected passing on of cost advantages resulting from digital publishing of research findings[30] is not yet to be observed. Against this background, calls are getting louder for introducing new procedures in the organisation of the scientific communication system. Central to these demands is the concept of "open access", which is the process of making research findings available on the internet free of charge (cf. Box 2).[31]

The open access movement has emerged since the mid-1990s against the backdrop of steep price increases by major publishers of scientific journals. Advocates of the open access approach have pointed out that the public sector participates in three ways in financing the production of scientific journals:[32]

– Publishers mostly receive essays from authors gratuitously as these are usually funded by the public sector[33]
– Publicly funded experts are often integrated into the process as part of the publishing houses' quality assurance procedures. In most cases, these experts also provide their services free of charge.[34]
– Finally, scientific journals are frequently purchased by libraries that are often financed by the public sector. Especially frequently cited journals are difficult to replace,[35] which makes it relatively easy for publishers to enforce high prices. Commercial publishing houses also use the instrument of product bundling as a means of marketing less known journals alongside the particularly renowned ones.

For large publishing houses, this is a profitable business. Elsevier for instance achieved a return of sales of 37 percent in 2011; in the same year, Wolters Kluwer achieved 13 percent, and Wiley 15 percent.[36]

The large specialist publishers are increasingly subjected to criticism, and calls for open access are getting louder and louder. The following prominent examples may illustrate these trends:

– In a memorandum by the Faculty Advisory Council of Harvard University in April 2012, 2,100 scientists were called upon to publish their articles in the university's own open access repository (DASH), in external open access journals, or journals with relatively low subscription fees.[37] The initiators considered this as a necessary measure; they argued that it was impossible to support the pricing policy of the large publishing houses any further. They stated that some of the journals cost USD 40,000 per year and that two publishing houses had raised their prices for digital publications by 145 percent within the matter of six years. According to the Faculty Advisory Council the subscription contracts with at least two major publishers should be terminated.
– About 13,000 scientists from around the world have declared on the website thecostofknowledge.com that they would no longer work with Elsevier, unless the publishing company changes its general policy.[38]
– In May 2012, the mathematics department of the Technical University of Munich announced that "due to unreasonable costs and subscription conditions" it would cancel all Elsevier journal subscriptions as of 2013.[39]

Advocates of the open access approach argue that, besides financial considerations, free availability has a positive effect on a scientific paper's visibility and impact. In accordance with international standards, open access publications usually contain an abstract, metadata, and keywords and are thus easily found via search engines and library catalogues.[40] Target audiences can obtain open access publications instantly and gratuitously through any internet connection. Hence they do not have to consider whether they should allocate their scarce time and financial resources to gain access to a particular publication. This results in immediate high visibility of open access publications, as readers have the option of immediately examining whether a text is relevant for their academic purposes. Supporters of open access argue that open access can thus raise attention for interdisciplinary papers in particular. Moreover, open access promotes the participation of researchers from developing countries and emerging economies in academic discourse.[41]

The relatively high visibility of quality-assured open access publications suggests that open access publications have a stronger influence on the work of scientists and are cited more frequently than paid subscription publications. This assumption is supported by a number of empirical studies, although the methods used are not without controversy.[42] Furthermore, the assumption of an increased citation rate may not apply to all subject areas.

BOX 02

Open Access – the "golden path" and the "green path"

The "golden path" to open access refers to a procedure in which a scientific paper is first published as an open access publication. As a rule, this also includes a quality assurance process such as peer reviewing or editorial reviewing. In this scenario, the author usually concludes a contract with the publisher, which specifies conditions and rights of use. In August 2012, the internet platform Directory of Open Access Journals listed more than 10,000 open access journals for which a peer review or an editorial review is a prerequisite for publication.[43]

The financing model behind open access publishing differs from that of conventional journals. Some of the open access publishers charge publication fees to the author or the author's institution. Many open access journals are edited by organisations such as scientific organisations and are financed through membership fees.[44] In many of these cases, publication fees are not charged. Yet the financing of the journals is shifted from the reader to the author of scientific papers or the members of the scientific organisation, respectively. Thus the "golden path" to open access is not necessarily cheaper than the conventional system. In general, efficiency can be gained if the costs of the overall system are reduced due to an increase in competition and the decision not to produce printed versions.

The "green path" refers to the making available of scientific papers – primarily of preprints and postprints[45] – in freely accessible databases, called repositories,[46] and/or on the researchers' websites as a means of self-archiving. Preprints, i.e. manuscript versions of papers that have been submitted to journals or anthologies, usually do not undergo quality assurance procedures. This means that, as a rule, authors still have the rights of use, which means that there are generally no legal objections that would hinder self-archiving.[47] The situation is different in the case of postprints that have undergone quality assurance procedures and have been approved for publication. Depending on the publishing houses' willingness to permit second publication, legal issues may ensue here. Today, some of the academic publishers permit the second publication of postprints with a certain time delay.

Freely accessible databases can be divided into institutional and subject-specific repositories. Institutional repositories bundle the scientific activities of institutions, while subject-specific repositories collect scientific papers according to discipline. Establishing a repository also incurs costs, which must be taken into account when assessing the overall system.

In practice, there are open access strategies that cannot be clearly assigned to either the "golden" or the "green" path.[48] For example, some of the publishing houses provide free access to fee-based publications once a certain period of time has elapsed. Some of the publishers provide free access to digital publications while at the same time distributing a fee-based print version of the same publication. Another option employed by publishing houses is the fee-charged distribution of print versions alongside free digital versions.

Some publishing houses provide their readers with free access to individual articles in an otherwise fee-based journal, provided that the authors pay a fee.

Measures to promote open access

Already in October 2003, the German Science Organisations[49] and twelve other national and international signatories published the Berlin Declaration on Open Access to Knowledge in the Sciences and Humanities.[50] Since then, almost 400 institutions have signed the declaration.[51] The declared objective is to distribute knowledge through the internet by promoting the principles of open access. The Berlin Declaration does not only refer to scientific research findings as such, but also to source data, source material, digital images and graphics, as well as scientific material in multimedia formats.[52] The signatories of the Berlin Declaration have committed themselves to support the transition towards an open access system through diverse activities.[53] Germany's four large non-university research organisations (Fraunhofer-Gesellschaft, Helmholtz Association, Leibniz Association and Max Planck Society)

BOX 03

Open access activities of Germany's four main research institutions

Adopted in July 2008, the objective of the Fraunhofer-Gesellschaft's Open Access Policy is to "ensure that full-text versions of all papers and articles written by its employees are made freely available in the international digital media."[54] Fraunhofer-Gesellschaft has its own institutional repository, *e-Prints*, which is part of the *Fraunhofer-Publica* publication database.[55] Researchers at the Fraunhofer-Gesellschaft are encouraged to make their works also available as e-Prints following first publication in conventional journals.[56] To enable scientists to publish their works via the golden path, the Fraunhofer-Gesellschaft launched its Open Access promotion fund.[57] In addition to this, the Fraunhofer-Gesellschaft provides a support centre that offers comprehensive advice on scientific publishing and aims to facilitate networking activities.[58]

In September 2004, the Assembly of Members of the Helmholtz Association expressly committed itself to open access, stating that "publications from the Helmholtz Association shall in future, without exception, be available free of charge, in so far no conflicting Agreement with the publishers or others exists."[59] 2005 saw the launch of the Helmholtz Open Access project, which aims to facilitate the Helmholtz research centres and their scientists in implementing the open access approach.[60] The majority of the 18 existing Helmholtz centres have their own institutional repository[61], and a number of Helmholtz scientists are involved as members of editorial boards of open access journals.[62] The absorption of publishing fees is being discussed at the individual Helmholtz centres; the libraries of the Helmholtz centres have concluded cooperation agreements and general agreements with several publishing houses concerning the publishing of their open access journals.[63]

The Leibniz Association adopted their Guidelines on Open Access in November 2007.[64] According to these guidelines, "research findings from the Leibniz Association [...] shall be digitally published and publicly accessible whenever possible."[65] Leibniz-*Open* serves as the main open access portal of the Leibniz institutes. It is based on a network of open access repositories from various disciplines that are operated by the infrastructure facilities of the Leibniz Association.[66] In addition to this, several Leibniz institutes have their own open access journals and publication platforms respectively.[67]

The Max Planck Society (MPG) has committed itself to the MPG Open Access Policy. The key objective of this policy is to "make its scientists' research findings available for the benefit of the whole of humanity, free of charge whenever possible (Open Access)".[68] The Max Planck Society operates its two key repositories, *eDoc* and *PubMan*, under the umbrella of the Max Planck Digital Library (MPDL).[69] Publication fees that may occur for articles published by Max Planck scientists in certain journals via the golden path are financed through the MPDL's overall budget.

have embarked on a number of measures to promote open access (cf. Box 3).

The German Research Foundation (DFG) and the European Union (EU) have been funding the launch and development of open access journals for several years now. Both the DFG and the EU have launched relevant support programmes in this area (cf. Box 4).

Thus project participants are encouraged by their respective donors to make the findings of their projects freely available to the public. Since 2006, participants of DFG projects are required to offer their research findings also on the internet, i.e. digitalised and free of charge.[70] In the context of the Horizon 2020 programme, the European Commission (EC) established the principle that all articles that are attributable to funding by the Horizon 2020 programme must be made available to the public as of 2014. This may be achieved via the golden path or the green path.[71]

Concerns about open access

For the benefit of any researcher's career path it is essential to publish articles in prestigious scientific journals. This means that a golden path publication

BOX 04

DFG and EU programmes to promote open access

The German Research Foundation (DFG) offers three support programmes to provide financing support to research facilities and individual researchers upon application.[72] The DFG's Open Access Publishing Programme supports tertiary education institutions in shouldering publication costs of open access journals.[73] The Scientific Journals Programme allows individual scientists who serve as editors or co-editors of a DFG open access journal to apply for grants in order to cover technical and editorial work.[74] Finally, the DFG programme "Electronic Publications in the Provision of Scientific Literature and Information" aims to support model and pilot projects that contribute to advancing the open access system through technical and/or organisational innovations and innovative business models.[75]

In the context of the 6th and 7th Research Framework Programme, the European Union has launched several initiatives in recent years, aimed at developing a suitable infrastructure for open access. Programmes include the Digital Repository Infrastructure Vision for European Research (DRIVER),[76] DRIVER II,[77] Open Access Infrastructure for Research in Europe (OpenAIRE),[78] as well as OpenAIREplus.[79]

is only attractive to scientists if the respective open access journal ranks among the leading publications of a specialist area. Although this is in fact the case[80] with a number of open access journals, it is still true that in many areas researchers continue to depend on publications in conventional scientific journals.

Yet the green path may also entail legal issues, as many publishers are not willing to permit second publications. Against this background, the German Association of University Professors and Lecturers (DHV) rejects any obligation for scientists to publish their works in a particular form or order.[81] According to the DHV, scientists alone shall decide whether they wish to publish their works in the context of open access publications or in conventional journals.

The German Publishers and Booksellers Association *(Börsenverein des Deutschen Buchhandels)* questions the financial viability of the overall move to open access and expresses concerns regarding a permanent transformation of the existing publishing structure.[82] The association points out that the editorial activities of the public sector are inherently expensive and less efficient than those of the private sector. Furthermore, a shifting of costs from the reader to the author and publishing institution – as is the case with the golden path – could also lead to an undesirable shifting of costs from the demand side to the supply side. This means that smaller institutions with a high proportion of frequently published scientists would be exposed to cost increases. Yet the private sector, which makes strong use of scientific publications while at the same time publishing very little, would be largely exempt from costs. The German Publishers and Booksellers Association further points out that the green path would lead to costly parallel structures: the development of parallel repositories would in fact oppose a cost-effective provision of scientific findings.

Summary and recommendations

The Expert Commission is convinced that an efficient organisation of the creation and distribution of research findings promotes the transfer of knowledge. Yet, from the perspective of R&I policies, the costs of the entire system of creating and transferring findings have to be taken into account. Open access increases competition and further taps the potential of the internet as a means of distributing knowledge. Thus the open access approach should be promoted. Yet this should also include protecting the interests of researchers involved. The development and expansion of open access journals and repositories should be further supported via public funding, with the aim of making open access publishing appealing to researchers. In the design of new structures it should be ensured that these are viable in the long term and as efficient as possible. Yet, in recent years it has emerged that an ever increasing number of repositories exist in parallel. This trend calls into question whether the system costs for the publication and distribution of research findings can decrease significantly over time.

The Expert Commission recommends integrating a contractually bound, indispensable second publication right into the Copyright Act for academic writers whose publications originate in research activities that were largely financed by public resources. This right shall take effect within a reasonable period of time after initial publication.[83] If scientists hold the right to second publication, they should be obliged in the case of publicly funded projects to publish their research findings online and free of charge upon expiry of the term.[84]

A 3 THE EU PATENT SYSTEM

Current situation

On 11 December 2012, the European Parliament agreed on the introduction of unitary EU patent protection.[85] The EU member states have thus taken a considerable step towards reaching their objective of overcoming the fragmentation of the EU patent system. The Expert Commission takes this opportunity to once again comment[86] on the status quo and to point to important legal and economic issues relating to the EU patent system.

The EU already provides for a European bundle patent, which dates from the European Patent Convention (EPC) of 1972. This bundle patent exists alongside national patents, which are granted by the individual EU member states' patent offices in accordance with national legislation. Since 1978, the European Patent Office (EPO), established in 1978 with headquarters in Munich, has been in charge of the examination and granting of European patents. However, upon granting, the European patent then disintegrates into several individual national protective rights, which are subject to evaluation in the respective target countries. Patent infringement claims and revocation actions relating to patents granted by the EPO are then brought before the national courts and negotiated under applicable national patent law.

Despite the existence of the EPO, there is still no patent that is valid in all EU member states and that can be enforced or contested in court according to uniform legal criteria. The fragmentation of the European patent system is impeding the harmonisation of the internal market. Despite the absence of translation requirements in most EPC states, the European patent system still results in high costs for patent application and enforcement on a country-by-country basis.[87] These costs represent a considerable hurdle for small and medium-sized enterprises in particular. What is more, the assigning of patent legislation to national courts may result in several court proceedings and, in some cases, may also result in conflicting court orders relating to one and the same patent in different member states.

The majority of patent disputes within the EU are negotiated in Germany.[88] Hence Germany's patent jurisdiction has been able to build up relevant competences over the last decades. From the perspective of conflicting parties, Germany's patent jurisdiction is also characterised by significant comparative advantages. These include (i) the swift resolution of cases, (ii) relatively low costs of litigation, which allow even SMEs to participate in litigation, (iii) a high level of technical competence among judges, which is reflected in the "technical quality" of decisions, (iv) the concentration on a few highly specialised courts, (v) the parsimonious use of external expert opinions, which are usually cost-intensive.[89]

The status quo

The package for the creation of a unitary EU patent protection comprises two proposed regulations.[90] The first regulation is concerned with the enhanced cooperation of 25 EU member states to create a European patent with unitary effect, which shall provide the sovereign territories of the participating countries with unitary protection. The examination and granting shall be effected by the European Patent Office, as is the case with bundle patents, which will continue to exist. The second regulation specifies requirements for the translation of patent documents. According to this regulation, future patent applications may be filed in English, French or German.[91] Italy and Spain did not approve of the proposed language regime and are thus not participating in the enhanced cooperation.

The EU patent package further includes an interstate agreement between all EU member states participating in the enhanced cooperation for the creation of a European Patent Court, also referred to as the Unified Patent Court.[92] In future, this court shall be the exclusive jurisdiction for any dispute regarding the validity or infringement of a European patent with unitary effect. It will also be responsible for handling disputes over European bundle patents. A Court of Appeal based in Luxembourg will serve as the Supreme Court. The Court of First Instance shall comprise a Central Division, as well as several local and regional divisions.[93] In June 2012, the European Council agreed on Paris as the seat of the Central Division. A section of the central division will also be established in Munich. This is where future patent disputes in the field of engineering will be negotiated – an area from which the highest proportion of German patent applications are recorded. A section based in London will be responsible for patent disputes in the field of chemistry, including pharmaceuticals and biotechnology. Up to four local divisions in Germany are planned to be established. The decision on the actual location of the divisions in Germany has not yet been made.

The Central Division is, inter alia, responsible for actions for revocation and compulsory licences. The Central Division is also in charge of negotiating infringement claims, provided that the defendant is domiciled outside the EU. Hearings in the central division are held in the language in which the patent was granted.[94] The local and regional divisions are not only in charge of infringement actions, injunctions and actions for damages or compensation, but also for actions for revocation. The local and regional divisions of the new court system have the discretion to negotiate infringement and revocation procedures in joint or separate proceedings. This means that the divisions can decide on the counterclaim for revocation when they request to allocate a technically qualified judge. Alternatively, the local and regional divisions can separate the revocation action from the infringement action by referring the former to the Central Division. In sole discretion, they can either immediately decide on the infringement action, or stay the proceedings until the central division has decided on the patent's validity.[95] The dispute may also be entirely referred to the Central Division, provided that the parties agree.

Until the European patent with unitary effect can be adopted in full, there are still major hurdles to overcome at European and national levels. For instance, the fees stipulated in the regulations will have to be determined with regard to patent application, examination and maintenance. This will be decided by a Select Committee, which comprises member state representatives. The Committee is expected to be established in spring 2013. In addition to determining applicable fees, the Committee will also determine the distribution key for participating member states. Moreover, the Agreement on the Unified Patent Court needs to be ratified by at least 13 contracting states – including Germany, the UK and France, as these are the countries with the highest number of valid European patents. As regards Germany, it is very likely that the Agreement will not be ratified until late 2013, when the new legislative period commences. It remains to be seen if and when the Agreement will be ratified by all 13 member states. Ultimately, the issuing of a European patent with unitary effect can begin once the unified patent litigation system has been fully established. This process is due to be completed in 2015.

Meanwhile, Spain and Italy have brought actions before the European Court of Justice (ECJ) against the enhanced cooperation in the area of the unitary patent.[96] While the European Court's final decision is still pending, the relevant Advocate General advised the ECJ in December 2012 to dismiss the actions brought by Spain and Italy. It is expected that the ECJ will follow this recommendation. Once regulations have entered into force, it is expected that Spain will be bringing another action with regard to the regulations' compatibility with European law.

Assessment

Against the background of decades of negotiations, the newly adopted patent package has been regarded as a breakthrough by many observers. For the creation of a single European market, the package indeed represents a significant improvement on the European bundle patent that is currently in place. Irrespective of the fees that are yet to be determined, it is expected that the elimination of patent fees in the individual countries will result in significant cost decreases for the EU-wide protection of patents. European SMEs in particular are expected to benefit from this. Yet it is also feared that the number of applications for low-quality patents will increase due to lower costs.

The unitary system will also result in considerable decreases in court fees for all companies involved in patent litigation cases.[97] The reason for this is that now only one procedure will be required for the

Europe-wide enforcement of rights emerging from a patent, which has not been the case in the past. For German enterprises, the launch of local patent divisions allows for immediate access to the European patent litigation system at reasonable costs. Language barriers, which often prevented SMEs and other companies from exercising their patent claims in other member states, have now been eliminated. For the European patent with unitary effect, conflicting decisions of national courts regarding one and the same patent will be a thing of the past, since decisions by the unified patent court apply to the entire territory of the participating member states.

Yet the agreed EU patent package is still in need of improvement. The unification of the European patent system has yet not been fully achieved, since the European patent with unitary effect is an optional supplement to national patent law and the existing European bundle patent. In future, companies can choose between four partially overlapping types of patent protection: (i) nationally granted patents, (ii) national patents emerging from a European bundle patent and subject to the regulations of the Unified Patent Court, (iii) national patents emerging from a European bundle patent and not subject to the regulations of the Unified Patent Court,[98] and (iv) European patents with unitary effect.[99] The introduction of the European patent with unitary effect thus significantly increases the complexity of the European patent system.

Once the Unified Patent Court has been established, a number of new institutions will be involved in European patent law, which will make it even more difficult to establish a unitary EU-wide jurisdiction. In the medium term, this will reduce legal certainty for patent-active companies. Thus, alongside the newly established Unified Patent Court, the European Court of Justice will also be involved in jurisdiction through preliminary references. In all those countries that have not ratified the Agreement on the Unified Patent Court, or those that are not participating in enhanced cooperation, the national courts will continue to decide on patent disputes. The European Patent Office's Boards of Appeal, as well as national courts and national administrative bodies, continue to hold jurisdiction in administrative appeals and procedural matters.[100] Thus the new regulations and institutions can only be regarded as a temporary solution.

Questions should also be raised with regard to the provisions for the submission and referral of actions to the Central Division in Paris. First, it might well be the case that defendants who seek to permanently avoid the jurisdiction of a particular local division will transfer their registered office to a non-EU country. This would enable them to systematically bypass the local divisions, as they would be directly transferred to the central division, thereby benefitting from the anticipated procedural delays. Second, it is feared that alleged infringers who have been charged could make frequent use of the option of requesting a referral to the Central Division. Again, this would be to the detriment of general legal certainty and at the expense of patent holders. In order to minimise these risks, companies could decide to make more use of national application procedures – and the accompanying national courts – so as to protect their patents.

By providing the option of joint or separate proceedings for infringement and revocation actions, the Agreement on the Unified Patent Court combines aspects of the "separation principle" from German and Austrian patent law with the linked system used in many other EU member states. Thus the advantages and disadvantages of both systems are reflected in the rules and regulations of the new European patent scheme. On the one hand, the separation of proceedings – which is explained with the different competences of the individual court locations – could result in courts issuing injunctions for potential infringements while a counterclaim for revocation in infringement proceedings relating to the respective patent is still being pleaded at another court. On the other hand, defendants could strategically use the suspension of infringement proceedings to benefit from delays in court procedures. The combination of both systems can be regarded as a compromise solution that is yet untested. This means that the new system will entail additional uncertainty for all parties involved.

It is feared that the establishment of the Unified Patent Court's Central Division in Paris, and the tendency of other EU member states to refrain from establishing local or regional divisions but instead strengthening the Central Division, will decrease the relevance of the German patent litigation courts in favour of the Central Division. This also means that the skills developed over years in Germany, and the aforementioned advantages of the German system, might get lost within the framework of a European jurisdiction. Furthermore, capacity building in the new institutions will be time-consuming and require extensive resources. Although the decision to negotiate disputes relating to mechanical engineering at the Court of Munich means that existing experience is drawn on, Germany will still lose out on the opportunity to build and develop competences in other areas of high technology – such as chemistry, biotechnology and information technology – because in future, the relevant patents will be increasingly negotiated elsewhere.

Recommendations

The Expert Commission welcomes the creation of a European patent with unitary effect and the creation of a single patent jurisdiction as a logical consequence of the common European market. It is expected that SMEs in particular will benefit from the new provisions. One of the key factors for the future acceptance and hence the success of the unitary European patent will be the design of the patent fee system. Fees should be attractive enough for the new system to be preferred to the old system of bundle patents, while at the same time remaining at a level that would effectively limit incentives for increased numbers of low-quality patent applications.

In the event that reduced fees will lead to an increased number of patents filed, the European Patent Office will become even more important as the examining institution that serves to secure patent quality. The current high standards shall be guaranteed also in the future by providing the EPO with suitable infrastructure and administrative support. In addition, the EPO should regularly report on quality control and other measures and publish the results of the regular quality checks that are already being conducted at this stage. Given the large number of applications for low-quality patents, the most important task of the EPO will be to identify and reject such applications.[101]

Due to the system's strong focus on the Central Division, it is foreseeable that many patent disputes that in the past would have (also) been dealt with by German courts, will in future be negotiated outside of Germany and heard by the Central Division. It is therefore essential to ensure that only the highest standards are applied to the selection and specialised training of judges and in the ongoing administrative support of the court. Moreover, Germany's technical expertise, acquired over the course of a century, and the advantages of the German system need to be integrated into the new system. The future development of the European patent system must be accompanied by the systematic development of vocational training, further training and research in the field of patent protection. Training and research should be conducted on an interdisciplinary basis and should be designed according to pan-European standards instead of current national standards.

Ultimately, one should by no means expect the new system to lead to a breakthrough. Instead, it is essential to continuously work on the harmonisation of the EU patent system. Therefore the Expert Commission recommends fully replacing the EPO bundle patent in all of the territories of the EU member states with the European patent with unitary effect. The acceptance of the new patent will determine whether national patent protection can play a significant role within the new system in the long term.

INTERNET AND IT START-UPS IN BERLIN A 4

The media are currently depicting Berlin as the internet capital of Europe.[102] And indeed it is the case that in recent years Berlin has seen an increasing number of internet and IT start-up businesses financed through venture capital.

Yet it is not necessarily easy to find consistent facts and figures to support the image of Berlin as Europe's internet capital, as suggested by the media. Depending on the delimitation of industries and depending on the definition of the concept of entrepreneurship, some statistics place Munich at the top of the start-up rankings, while others place Berlin at the top.[103] What distinguishes the Berlin start-up scene from the start-up scenes of other German metropolitan regions can only partially be explained by the number of new enterprises; it is the structure and the specific features of Berlin's start-up scene that sets the city apart from Munich. Thus, for instance, Berlin's start-up scene is strongly focussed

Photoelectron and photo-ion spectroscopy.

Electron microscope image of salt droplets embedded in gel-like structures.

on products that attract the attention of the general public, such as apps and games, e-commerce and social media. In addition to this, Berlin's entrepreneurs closely collaborate with each other and with their investors, which is reflected in the large number of venture capital financed enterprises. Finally, Berlin's start-up scene is also characterised by a very high degree of internationalisation.

In recent years in Berlin, the use of venture capital has increased more than in any other city in Germany. In 2011, venture capital providers invested EUR 116.8 million in new Berlin-based enterprises. Since 2009, investments have in fact more than doubled. No other city in Germany has been able to attract such high amounts of early-stage venture capital.[104]

Investments are not only being made in the internet and IT industry, but increasing amounts of resources are also flowing into health care enterprises.[105] The fact that growing numbers of investors are establishing branches in Berlin is further evidence of Berlin's increasing attractiveness.[106]

Berlin's start-up boom owes more to social and cultural factors than to exceptionally favourable political-administrative framework conditions. For many years, Berlin has been characterised by its low apartment and commercial real estate rents and its overall low cost of living. Complemented by its rich cultural and recreational offers, the city has developed a strong appeal to artists, university students and, ultimately, founders of high growth potential companies.

In retrospect it can be said that the lack of a broad industrial base and the absence of large corporations – which would compete on the labour market – have also been supporting factors in the unfolding of Berlin's start-up boom. Thus, founders in Berlin do not have to compete with as many as seven DAX companies in attracting qualified staff, as it is the case in Munich. Berlin's labour market, in combination with the four major state-owned universities and a number of other tertiary education institutions, guarantees a continuous flow of well-educated young people.[107] Berlin's international appeal provides the opportunity to hire people from different countries. When compared with other German cities, this makes it easier to establish companies with an international outlook.

Meanwhile, Berlin's start-up boom has created momentum that seems to reinforce itself. Today, renowned internet companies such as Soundcloud, Wooga, 6 Wunderkinder, Zalando, Betterplace, ResearchGate or Rocket Internet have their headquarters in Berlin, which will certainly attract additional numbers of entrepreneurs and capital providers.[108]

With its thriving internet and IT scene, the city has a favourable competitive position within the innovative internet economy.[109] For Germany alone, it is expected that the economic output of the internet industry – based on EUR 75 billion in 2010 – will total EUR 118 billion in 2016. The internet sector thus represents an important source of growth.[110]

Berlin is an example of how the internet economy can generate significant value creation and employment opportunities within a short period of time. The majority of internet businesses employ but a small number of workers, and yet several start-ups have been able to multiply their staff levels over a period of only a few years, thanks to their dynamic growth.[111] It remains to be seen if this positive trend will continue in the long term.

To foster the positive development of Germany's internet and IT industry, it is particularly important to improve framework conditions for financing growth of new enterprises[112] The Federal Government should create an infrastructure for entrepreneurs and investors with structures that can compete internationally and persist in the long run. The Expert Commission has already presented an outline of the design of such infrastructure in their preceding Annual Reports.[113]

CROWDFUNDING A 5

Crowdfunding is an innovative form of financing for projects or small enterprises, designed to accumulate financial contributions from numerous individuals within a relatively short period of time. Crowdfunding activities are often conducted via the internet, e.g. by the use of social networks and other online platforms. Crowdfunding can take many different forms (cf. Box 5); financial contributions can e.g. be in the form of donations. Due to the large audience

BOX 05

Main crowdfunding business models[114]

Donations
Donation-based crowdfunding differs from traditional fundraising as internet and online network fundraising is often faster and more cost-effective than traditional approaches. This model often appeals to the users' social or altruistic conscience. Non-monetary incentives, such as long-term donation-based sponsorships, can complement incentives for potential donors to participate in crowdfunding.

Pre-sales
In this crowdfunding model, participants directly contribute to the financing of a project or an enterprise by pre-ordering a particular product or service. This model enables the respective company to gain a first insight into the structure of demand, which proves particularly beneficial for SMEs and start-ups that do not have their own marketing and market research division.

Loans
A crowdfunding loan is quite similar to a bank loan or a micro-credit, the difference being that crowdfunding loans do not generally require collateral deposits. If the business venture proves successful, invested crowdfunding contributions (including interest) are proportionally returned to the participants and, depending on the agreed contract, also partially returned to the crowdfunding platform.

Equity capital investments
This business model, also known as crowdinvesting, is similar to business angel financing that provides financing for companies and start-ups in particular. By means of their financial contributions, participants become private investors and risk-sharing stakeholders of a company. In many cases this takes the form of silent partnership or share acquisition.

reach of online campaigns, large sums can be raised even through the contribution of many small amounts. This model was successfully employed by Barack Obama during his first presidential campaign. Another crowdfunding model is the pre-ordering of and the pre-payment for a product in development. In this model, the developer not only raises financial resources for product development, but also acquires valuable information on consumer demand for the new product. In return for their financial commitment, individuals may profit from a product's financial success, i.e. through interest-based loans or equity participation – and participate in shaping the content of individual projects or even the company's strategic direction. If online audiences' preferences are integrated into the corporate brainstorming and decision-making process, this can be regarded as "active" crowdfunding, which combines crowdfunding with aspects of crowdsourcing.[115]

For start-up businesses and SMEs in particular, crowdfunding can be an attractive alternative to financing through banks, venture capital firms or business angels. Demand for this financing model has increased considerably – not least because of the recent financial crisis and the associated difficulties in accessing traditional financing. Moreover, online-based fundraising models can also support the marketing activities of start-ups. This is often done via specific online platforms[116] that present the business idea or the project to potential investors.

Currently such platforms are largely used for financing projects and enterprises in the cultural and creative industries. To give a recent example: the movie adaptation of the German television series *Stromberg* was partially financed by issuing a "culture share" through the internet. This crowdfunding model combines the donation model with the crowdinvesting model.[117] The remaining financing gap is to be bridged by public film funds and sponsoring.[118] In France, even public cultural institutions make use of crowdfunding: for the purpose of purchasing an Ingrès painting, the Lyon Museum of Fine Arts is currently collecting funds which will amount to EUR 750,000.[119] Lyon thus follows the example of the *Louvre* in Paris, which managed to purchase a work by Cranach using resources collected through a crowdfunding campaign.

There have also been recent examples of crowdfunding in start-up financing for high-value technologies and knowledge-intensive services. Thus, during the onset of the financial crisis in 2008, British software company trampoline systems used crowdfunding to make up for the sudden cessation of parts of the company's venture capital financing.[120] The software company managed to collect more than GBP 1 million in the matter of one year. In Germany, nanoparticles manufacturer Particular GmbH, a spin-off of the Laser Zentrum Hannover eV, secured the financing of marketing and HR measures through an equity-based crowdfunding campaign and collected almost EUR 100,000 within a few days. In the case of Particular GmbH, the funds raised through crowdfunding were supplemented by public funding from the Federal Ministry of Economics' EXIST programme.

It was not until 2011 that the first crowdfunding platforms were launched in Germany. According to figures from an industry association,[121] around 20 crowdfunding platforms were being operated in Germany in 2012; twice as many as in the previous year.[122] Yet, when compared internationally and when measured against the size of the German economy, the number of crowdfunding platforms is still relatively low. Around 60 percent of the world's crowdfunding platforms are being operated in Anglo-American countries. By mid-2012, France (28 platforms), the Netherlands (29 platforms), and the UK (44 platforms) had launched more crowdfunding platforms than Germany.[123] Indications of strong international competition can currently be observed; not only with established financial intermediaries, but also among platforms.[124]

In 2011, there were approximately 200 crowdfunding platforms in Europe, generating a volume of about EUR 300 million in funds. More than half of these crowdfunding platforms employed donation-based or non-profit models. The remaining platforms employed loan and equity-based crowdfunding models, as well as various hybrid models. An average project, or campaign, raised about EUR 500 per donation, about EUR 4,500 per loan-based contribution, and an average of about EUR 50,000 per equity capital investment. In some of the cases, the equity-based crowdfunding model raised amounts that reached the European regulatory limit of EUR 100,000 – especially in such cases where professional investors were involved in financing. According to figures from an industry association, a significant growth in financing volume is expected for the coming years in all crowdfunding models.[125]

At this point in time it is difficult to assess the future role of crowdfunding in Germany as compared with other financing alternatives – and the extent to which this new financing form has already contributed to early-stage financing of innovative start-ups.[126] The Expert Commission believes that equity-based crowdfunding could play an increasingly important role particularly in early-stage financing of start-up businesses. To date, this financing phase has been largely characterised by contributions from family members, friends or business angels. The number of potential financiers and the efficient use of internet-generated feedback from users and potential customers are factors that point to the increasing importance of crowdfunding in early-stage financing.

If crowdfunding is to become a successful financing instrument, it will be essential to provide suitable framework conditions. Existing crowdfunding platforms in Germany are still largely unaffected by prudential regulation – despite the fact that equity-based crowdfunding models, which seem to be most relevant in the financing of innovative start-ups, are particularly exposed to legal uncertainty. This is the case because this crowdfunding model borders on professional financial services and investment brokerage. For founders of this type of crowdfunding platforms, it is both time-consuming and costly to fully take account of all the legal issues that may arise. This is one of the reasons why some founders deliberately choose other, less innovation-friendly business models, such as the donation-based crowdfunding model.

When compared with traditional forms of financing, the crowdfunding model has one general disadvantage: the fact that information on the object of financing is disclosed to a large number of potential financiers risks the business idea being imitated. This risk can only be mitigated if IP rights are allocated in advance. To avoid legal issues, many crowdfunding platforms only accept projects and ventures for which potential issues relating to IP have been conclusively clarified.

The German Financial Supervisory Authority (BaFin), the federal regulatory authority in Germany, recently addressed the topic of crowdfunding, concluding that the crowdfunding models currently being used in Germany do not systematically deposit transactions within the meaning of the German Banking Law.[127] If this were the case, platforms would require a general licence for banking and financial services.[128] However, participation rights or silent partnerships in crowdfunding ventures are subject to prospectus requirements if they exceed the funding limit of EUR 100,000 per year. This obligation would apply to the platform operators but rarely to the platform itself. To date, this funding limit has only seldom been reached in the German crowdfunding sector.

At EU level, several directives are under way or in the planning phase, including the Prospectus Directive[129] and the AIFM Directive. When it comes to implementing these directives at national level, it will have to be ensured that regulations aim to support the development of a crowdfunding industry in Germany as a whole, instead of unilaterally protecting the rights of investors. Nonetheless, it will be difficult to equally accommodate all the different types of crowdfunding with one relevant directive. Here, a specific Crowdfunding Directive might also be worth considering – similar to the provisions for funding portals in the context of the Jumpstart Our Business Start-ups (JOBS) Act 2012, which created a legal basis for crowdfunding in the United States.[130] The US directive entails raising the ceiling for crowdfunding financing to USD 1 million – a multiple of the limit at which the prospectus requirements in Europe take effect (i.e. EUR 100,000, as described above).

Recommendations

- For start-ups and SMEs, crowdfunding offers an attractive alternative to or supplement for financing by the government, banks, venture capitalist providers or business angels. Crowdfunding thus has the potential to stimulate innovation. Crowdfunding is a very recent phenomenon and still remains under-researched. Outstanding issues include e.g. the question of how the current government funding of start-ups and SMEs can be combined with this new financing form, and the ways in which crowdfunding affects the acquisition of follow-up financing. It is in the interest of all stakeholders to gather comprehensive data to facilitate enhanced transparency regarding the pros and cons of crowdfunding.
- Examples from other European countries suggest that the entrepreneur's chosen legal structure can hinder equity-based crowdfunding activities. In other countries, crowdfunding activities of start-ups that are based on more private-bound legal structures often require notarial formalities, or widely diversified equity is altogether prohibited in crowdfunding ventures. In contrast, the existing German regulations on silent partnership seem to be a locational advantage and are therefore deemed positive by the Expert Commission.
- The new provisions of the United States' JOBS Act have significantly improved framework conditions for crowdfunding activities in the United States, thereby also improving the environment for innovative SMEs and start-ups. To prevent Europe from falling behind the United States, it is ever more important to harmonise regulations at a European level or at least strengthen coordination of national crowdfunding-related regulations. Among other things, this concerns the monetary ceiling for prospectus requirements.
- It will have to be clarified how, on the one hand, individual investors can be protected and how, on the other hand, platform operators can be protected from fraudulent investors – without government intervention impeding the growth potential of crowdfunding markets in Germany and Europe.[131] Strengthened investor protection could be achieved e.g. by introducing a cap on allowable investment by individual private investors or by demanding explicit involvement of experienced and accredited investors in a financing project.[132]

EVALUATION OF INNOVATION POLICY MEASURES BASED ON RAMDOMISED EXPERIMENTS A 6

The core of the problem

In Germany, as in many other countries, a variety of policy measures are in place to increase the dynamics of R&D growth. Yet a systematic evaluation of such measures which complies with most recent scientific standards is still lacking. There is still a shortage of solid findings on the causal impact of different policy measures. An area that is particularly under-researched is the extent of windfall profits in comparison with causal effects of innovation policies. As it is paramount that scarce public funds are used both efficiently and effectively, a solid analysis of the causal effects of public R&D policy measures becomes even more compelling. Although in recent years, a number of studies have contributed to improving the evaluation of R&D support measures, systematic causal evaluations are still lacking in innovation research. In other policy areas, such as labour market research, considerable progress has been achieved over the last decades in analysing the causal effects of public policy measures. This has lead to the identification and subsequent termination of major inefficiencies.[133] Between 2000 and 2005, approximately EUR 45 billion were invested in active labour market policies,[134] many of which were evaluated as being ineffective and were thus revoked during the 2009 reforms. The Expert Commission thus recommends that future innovation policy should also place a stronger focus on evidence-based innovation policies and systematic empirical analyses of causal effects.

Whether it is labour market, health or innovation policy measures: a general problem with such evaluations is that the counterfactual scenario cannot be observed once policy measures have been implemented. This means that it will never be possible to estimate how the beneficiaries of a public policy would have behaved in the absence of this policy intervention. As the beneficiaries are actually receiving public support, they cannot be observed in their non-supported status and therefore they cannot be used as a benchmark for assessing the effect of the policy intervention. For innovation policy evaluations this e.g. means that it is not possible to observe how patenting activities of companies with public support would have developed in the absence of this support. In such a case, the causal effect of policy measures can only be evaluated by comparing the patents of a group of supported companies (the "treatment group") with the patents of a group of similar peer companies that have not received support (the "control group"). This is a method similar to the experimental designs employed in the evaluation of new drugs (cf. Box 6).

For evaluations of innovation policies based on the comparison of treatment and control groups, the main difficulty is to precisely identify a group of non-supported control companies that are similar in all but one variable, that is, the support measure. For observable characteristics such as company size, age, or industry, it may still be relatively easy to find similar companies. It is more difficult, however, to identify companies that are similar in characteristics that are unobservable but nonetheless highly relevant for the effect of a R&D support measure. Such unobservable characteristicis could e.g. be leadership skills among R&D management, R&D staff's skills and motivation, as well as organisational learning capacities or a company's flexibility. If companies are not totally identical with regard to these important, yet unobservable characteristics, it will not be possible to assess whether a higher innovation output of a supported company, as compared with that of a non-supported company, is caused by the support measure. In fact it is possible that the innovation output of the supported company fully originates from differences in unobservable characteristics and is altogether unrelated to the policy measure. If for instance the group of supported companies is characterised by better leadership and more motivated R&D staff in comparison with the control group, differences in innovation output may be fully attributable to these soft factors alone, while the R&D policy measure might not have generated any effect at all. In such a case, public policy measures may simply be exploited as windfall profits because well-managed, highly motivated R&D staff are also more skilled in exploiting funding opportunities. As a consequence, a policy measure's causal effect would be completely different for de facto non-supported companies than for supported companies: if the public policy measures were extended to other companies, the effect would equal zero in the simplest case scenario and could even be negative in a worst case scenario. Hence it is essential to identify a suitable control group for the evaluations of causal effects of public policy measures.

Evaluations based on randomised assignments of companies to control and treatment groups

In the view of the Expert Commission it is a very promising way for the evaluation of specific R&D policy measures to randomly assign enterprises to the group of supported and non-supported enterprises. The random assignment ensures the existence of suitable control groups for high-quality evaluations.[135] A sufficient number of cases (enterprises) that are generally eligible for funding[136] must be randomly assigned to a control group and a supported group (treatment group), in order to ensure that these two groups are almost certainly statistically identical in all observable and unobservable variables – with the exception of the "supported" and "non-supported" characteristic. Differences in innovation output

BOX 06

Randomised evaluations in the field of drug development

Evaluations based on the principle of random assignment ("randomisation") can be compared with medical tests on the efficacy of a drug: one group of patients is administered a drug (treatment group), and a second group of patients is administered no drug or a placebo (control group). If the patients are strictly randomly assigned to both groups, it can be assumed that the two groups are identical with regard to their observable and unobservable characteristics. Hence differences between the two groups regarding the course of disease can be attributed most certainly to the causal effect of the drug. Thus it can be ruled out that differences in therapeutic success merely stem from the fact that e.g. persons with a different initial diagnosis or different financial resources or different socio-economic status might have systematically decided for or against the treatment. However, differences in the patients' state of health do not allow for conclusions on the drug's efficacy if, for instance, only wealthy individuals living in a comprehensive care environment would have opted for treatment, while everyone else would have refrained from treatment. In such a scenario it could not be distinguished whether the positive course of disease is attributable to the use of the drug or to the more favourable care environment. In fact, it might even be the case that the overall effect is attributable to the favourable care environment, while the drug itself might be altogether ineffective. Thus, if patients are not randomly assigned to treatment and control groups, the positive course of disease does not allow for any conclusions on the drug's effectiveness.

can then be interpreted as causal results of the policy measure and not just as the result of differences in innovativeness stemming from other variables. A randomised assignment of applicants to control groups and treatment groups – similar to clinical trials preceding the launch of a new drug – would make it possible to identify the causal effect of a new support measure in the field of innovation policy. After this *causal* effect has been identified, it will be possible to determine the effectiveness and efficiency of a policy measure. Subsequently, it will be possible to derive economic conclusions for the future design of support programmes.

Random assignment procedures and rationing

In this context, random assignment procedures should not be mistaken for non-specific innovation support policies, i.e. distributing funds in an arbitrary and non-selective way. Random assignment procedures do not abandon eligibility and application criteria or qualified, expert-based selection processes.[137] Instead, the group of (suitable) applicants will be subjected to a lottery or a similar random assignment procedure. In general available funding sources are limited, and thus it is also in current assignment procedures rarely the case that all of the potentially suitable candidates receive funding. This means that randomised procedures do not produce additional losers. The only difference is that all those suitable candidates who did not succeed are assigned on a strictly random basis by means of a lottery procedure, i.e. all of the equally qualified candidates face the same likelihood of being affected by rationing. Nowadays, lottery procedures are by no means uncommon in other policy areas affected by rationing. In the field of medicine for example, a certain proportion of university places are allocated based on a lottery draw[138], or Berlin's education authorities allocate scarce places for secondary and upper-secondary schools by means of lottery draws[139], or revenue offices randomly select small and medium-sized enterprises to conduct routine audits.[140] In the field of innovation policy, random assignment would allow causal evaluations of policy measures. Hence, in the long term, all enterprises – and not only the selected ones – would benefit from these procedures because limited funding sources would be used more efficiently.[141]

The evaluation practice currently used in German and European innovation policy is often solely based on identifying statistically observable differences between supported and non-supported enterprises, or analyses interdependencies based on econometric methods by adding various control variables.[142] Here the problem is that observed differences are not necessarily causal results of the policy measure, but rather of the fact that, from the outset, different types of companies did or did not apply for funding. While the inclusion of observable control variables may reduce the scope of the problem, it does not provide an overall convincing solution to the problem, because major differences in unobservable characterisitics may still exist, e.g. stronger leadership skills among R&D management or more favourable organisational learning capacities. Based on realistic assumptions, such criteria cannot be captured even by extensive data collection. Therefore, an improved innovation output of supported enterprises cannot be interpreted as a causal result of the policy measure.

While newly developed, more elaborate econometric methods[143] may be better suited to solving the problem of causality, these methods are still limited due to high data requirements and considerable statistical uncertainty. It is therefore not surprising that the assessment of policy measures in the evaluation literature varies greatly depending on the evaluation method used.[144]

In comparison, evaluations based on random assignment procedures are highly persuasive and valid, as results are easily understood (cf. Box 7). The causal effect of a policy measure ("treatment effect") is the difference in innovation output of two groups: a group of supported enterprises and a group of non-supported enterprises. Any additional, highly complex statistical practices and assumptions that would complicate a straightforward interpretation of results – but are common and necessary in the econometrically advanced practice of evaluation – can thus be omitted. However, it is important to ensure the strictly random assignment of enterprises to treatment and control groups. In addition, both groups have to be sufficiently large to allow for statistically powerful conclusions about the effectiveness of a measure.

Depending on the initial situation of the policy measure to be evaluated, it might make sense to randomly assign all applicants to a control group and a treatment group. Alternatively, only a certain proportion of applicants may be included in the lottery draw, as it is e.g. the case in the assignment of university places in medicine. Thus, in randomised evaluations in the field of innovation policy it could be decided e.g. to confine random assignment only to a certain proportion of applicants if one can be sure in advance that the respective measure will have maximum effect for a top group of clearly eligible applicants, but not for all applicants in general. The small top group would be selected first, while random assignment would be confined to the larger remaining group or to a group of borderline cases. When applying such a mixed approach, one has to bear in mind that statistically valid conclusions on the effect of the funding instrument can only be made for these borderline cases and, even more importantly, that these borderline cases may not be compared with the top group. In view of this, the best possible evaluation results might be achieved through total randomisation of all cases for a limited period of time. Total randomisation can also be useful whenever no or only a few reliable preselection criteria are available. Moreover, policy evaluations based on randomised award procedures following the launch of a policy measure have the advantage that they not only determine whether supported companies outperform non-supported companies, but that they can also be used to compare different designs of a funding instrument with the aim of identifying those designs that are relativley more cost-efficient or more effective – provided that the number of cases is sufficiently high. If necessary, it can then be decided in the policy-making process which of the criteria should be given more relevance. Thus policy evaluations based on randomised award procedures following the launch of a policy measure can provide comprehensive information to improve public R&D policies in certain areas.

Concerns about randomised evaluation procedures

In political practice, the introduction of evaluation procedures using random assignment is often met with ethical concerns and concerns relating to public procurement law – despite its diverse methodological advantages. Thus it is argued that a random assignment to supported and non-supported groups would not be compatible with the applicable public procurement law. However, this line of thought neglects the fact that oversubscribed support programmes also require additional selection criteria (such as the "first come, first served" principle or regional allocation criteria) – the effects of which can be somewhat arbitrary indeed. Moreover, ethical concerns have been expressed regarding a lottery draw system, arguing that such procedures would fuel injustices. However, these critics seem to ignore that it is not the lottery procedures but the rationing itself that causes some of the individuals or enterprises not to be supported. In fact, the lottery draw system even ensures that the probability of not being supported is the same for all applicants. On the contrary, random assignment procedures in fact prevent applicants from having higher initial chances than others, owing to traditional selection criteria that are sometimes questionable in terms of their content or statistical basis. Such issues and concerns can be largely eliminated through the prudent implementation of ramdomised procedures and through clear communication policies, as has been demonstrated in other countries such as the Netherlands.[145]

Several European countries recently started introducing random assignment procedures for single policy measures in science and innovation. Examples include the issuing of innovation vouchers to SMEs in the Netherlands[146] and in several pilot regions in the UK. The evaluation of these new measures, which aim to stimulate technology transfer between industry and science, shows a short-term increase in the number of contractual cooperation agreements. The results also provide a clear picture of the extent of windfall profits: i.e., it has been shown that about one out of nine projects would have been implemented even without the voucher.[147] The Netherlands also introduced random assignment procedures in the context of innovation loans and research grants for young scientists. Thus, in future, it will also be possible to draw reliable conclusions on the effect of such programmes.

BOX 07

Randomised evaluations in US education policy

Policy evaluations based on random assignment procedures have been an instrument of US education policy for several years.[148] Thus, for instance, a highly cited study in the state of Tennessee[149] discusses the long-term effects of introducing small class sizes versus full-time or part-time teacher aides on educational outcomes. At the launch of the measure, students were randomly assigned to classes of different sizes, and classes with or without full-time or part-time aides respectively. The study concludes that, on average, students perform significantly better in small classes (also in the long term), while the integration of a part-time teacher aide has no effect on students' performance. These reliable and reproducible findings from the evaluation of the policy contributed to political discourse which largely resulted in more than a dozen US states subsequently reducing class sizes and dispensing with the costly use of teacher aides and thereby ensuring greater efficiency of allocated funds.[150]

Randomised evaluation procedures: applications and its limits

Although randomised evaluation procedures can be widely applied, they are not equally suitable for all policy areas.[151] As a rule, randomised procedures are more suited to support programmes in science and innovation policy designed for a large number of participants, as only this will guarantee a sufficient statistical power. A sufficient number of supported and non-supported enterprises is an essential prerequisite for producing statistically powerful results regarding potential differences existing between control and treatment groups, and for reliable estimations of the causal effect of the measure. Hence, for certain programmes, such as support programmes for large-scale technology projects, randomised evaluation procedures will remain unsuitable. However, for programmes with a large number of applicants, the introduction of randomised procedures should be taken into consideration. Against the background of ethical and political acceptance concerns, support measures that are typically oversubscribed seem to be particularly suited to randomisation. In these cases in which the number of generally suitable candidates exceeds the total budget planned, it is an inevitable by-product of the programme that some of the applicants will walk away empty-handed. Based on this, randomised procedures can primilary help to reduce ethical concerns relating to randomised awarding. Furthermore, it is important that a programme's objectives are clearly and explicitly defined if randomised evaluation procedures are to be employed. Only then will it be possible to unequivocally measure a programme's success. Thus, policymakers have to ensure that a programme's objectives are measurable and clearly defined before the launch of the scheme, thereby establishing relevant criteria for assessing that the programme is a success.

Against this background, there are currently several Federal innovation support programmes for SMEs that are generally suited to randomised evaluation procedures, among them e.g. the Central Innovation

Programme for SMEs ("ZIM" programme) or the "KMU-innovativ" programme. The same applies to existing start-up support programmes and the awarding of research grants to individual scientists, such as the EXIST start-up grant or the DFG's foreign scholarship programmes for young scientists. In all of these fields, randomised procedures could generate important insights into a policy measure's effectiveness and would help to gain valuable experience in dealing with randomised evaluation procedures. In terms of the economic value of findings, randomised evaluations could be highly beneficial to the Federal Government's support scheme for small and medium-sized enterprises due to the high funding volume in this policy area. For the year 2013, and presumably for the year 2014 as well, funds amounting to approximately EUR 500 million per year have been allocated in the federal budget for the ZIM programme.[152] Here, even a slight improvement in the allocation of funds could generate a substantial effect.

Yet the use of randomised evaluation procedures is also limited, despite all the advantages it has to offer. One of the major limitations in the use of evaluation findings is that it is not always possible to generalise results. Ideally, each new instrument design and each instrument applied to a new context should be introduced based on its own random assignment. The effect of an instrument on selected applicant enterprises, even if they are selected very carefully, can only rarely be transferred to those enterprises that have never applied for funding previously or that have only applied for funds elsewhere. Ultimately, this problem does not solely apply to randomised evaluations, but to any kind of evaluation procedures, i.e. it is a general problem that does not invalidate randomised evaluation procedures as such. It is often argued that another disadvantage of evaluations involving treatment and control groups lies in a potential knowledge spillover between supported and non-supported enterprises, resulting in an underestimation of the effect of the intervention when comparing the two groups. Again, this is a problem that may also occur in conventional evaluation procedures. Besides, the long-term collection of high-quality data is a prerequisite not only for randomised procedures, but for any evaluation process, because the validity of results essentially depends on the quality of the outcome measures, and the short-term and long-term comparisons. Additionally, a high-quality database of the population of potential funding recipients must be provided as part of a careful evaluation preparation. This will ensure that the lottery procedures and the assignment to control and treatment groups are laid out and determined on a statistically solid basis. Upon expiry of the funding period, relevant data from both supported and non-supported applicants must be collected and provided.

Policy recommendations

The Expert Commission recommends including evaluations based on randomised assignments as a standard tool in the evaluation portfolio of public R&D funding. A randomised introduction of policy measures is particularly suitable for areas where a relatively large number of applicants is anticipated and where an oversubscription of funds can be expected due to limited budgets. Randomised procedures entail the opportunity to gain valuable information about the effectiveness and potential future designs of an efficient support measure, thereby also facilitating the decision on whether a particular funding instrument should be consolidated and extended to other areas. Randomised evaluation procedures could thus lead to considerable efficiency gains and a better use of funds – provided that findings are integrated into the political decision-making process.

The Expert Commission recommends launching an evaluation on the basis of a randomised allocation of funds in the context of the ZIM funding programme supporting innovative SMEs. The objective is to generate knowledge regarding opportunities for increasing efficiency of this policy measure, and to accumulate experience in dealing with randomised evaluations. At a later stage, the experience gained can be systematically transferred to other fields of application.

Randomised award procedures for new policy measures are still rarely used in Europe. By embarking on such an intelligent, evidence-based approach to research and innovation policy, Germany could take on a leading role in this area in Europe.

CORE TOPICS 2013

B

B CORE TOPICS 2013

B 1 COORDINATING CLIMATE, ENERGY AND INNOVATION POLICIES

B 1–1 INTRODUCTION

Germany has committed itself to ambitious climate and energy goals (cf. Table 1). Here, a key policy element is climate protection, i.e. the reduction of greenhouse gas emissions. The aim is to reduce greenhouse gas emissions by 40 percent by the year 2020 and by 80 to 95 percent by the year 2050 compared with 1990 levels. Germany's climate protection goals provide the rationale not only for explicit emission reduction targets, but also for other energy policy objectives, such as the advancement of renewable energy and an increase in energy efficiency. For each of these objectives the question arises how they are justified and how they can be implemented by means of regulation.[153] A fundamental economic justification for policy objectives and regulation is market failure, i.e. a situation in which the market-based coordination of economic activities does not lead to a socially desirable allocation of goods and resources.

Success and acceptance of regulation in the climate and energy market largely depends on keeping the overall economic costs of reaching the established goals as low as possible. This means that regulation should be cost-efficient, while at the same time providing incentives for developing cost-cutting technical innovation as well as new services and business models. To accomplish this, climate and energy policy regulation should be designed in a way that is consistent with market behaviour, i.e. measures should be targeted at decentralised price mechanisms to coordinate economic activities. The use of additional innovation policy instruments can also be justified here, which leads to the fact that the regulatory areas of climate, energy and innovation policies overlap. Hence it is essential to closely coordinate policies so as to create synergies and avoid counterproductive interactions.

The following section aims to critically review the Federal Government's climate and energy policy objectives and their implementation, assess the need for supplementary innovation policies and identify coordination requirements in overlapping regulatory areas.[154] For this purpose, the areas of climate and energy policy as well as climate and energy-related innovation policies shall be analysed individually. In the next step, coordination requirements for these three policy areas will be discussed in more detail.

CLIMATE POLICY B 1–2

1. Rationale for climate policy

Climate policy goals follow a clear welfare-economic rationale since greenhouse gas emissions are associated with negative externalities (cf. Box 8). Therefore, the amount of greenhouse gas emissions exceeds the desirable amount. Climate change caused by anthropogenic greenhouse gas emissions is a global challenge that has not been mastered at international level due to the free rider problem. By setting ambitious unilateral emission reduction targets, the EU aims to take a leading role in climate protection, while also encouraging other countries – especially important emerging economies such as China and India – to commit to collaboration in climate protection in the medium term.

The EU sees itself not only as a pioneer in terms of quantitative climate protection goals, but also in implementing these in a cost-efficient way through market-conforming regulation. In this context it is

Climate and energy policy targets according to the Federal Government's energy concept TAB 01

	Climate	Renewable Energy		Energy efficiency[155]			
	Reduction of greenhouse gas emissions compared with 1990	Share of gross final energy consumption	Share of gross electricity consumption	Reduction of primary energy consumption compared with 2008	Reduction of electricity consumption compared with 2008	Increase of energy productivity in relation to final energy consumption	Reduction of final energy consumption in the area of transport compared with 2005
2020	40%	18%	35%	20%	10%	Average: 2.1% p.a.	10%
2030	55%	30%	50%	–	–		–
2040	70%	45%	65%	–	–		–
2050	80–95%	60%	80%	50%	25%		40%

Source: own depiction following Hansjürgens (2012) based on *Bundesregierung* (2010).

important to differentiate between static and dynamic regulation efficiency (cf. Box 9). The successful implementation of the Federal Government's climate and energy policy objectives – often referred to as the Energy Transition – crucially depends on keeping the financial burden as low as possible.

Unless there are market failure indications that go beyond the externality of greenhouse gas emissions, cost-efficient climate policy is characterised by a clear-cut criterion: the equalisation of the marginal abatement costs across all emission sources. If this criterion is met, emissions will be abated where it costs the least. To accomplish this, emission taxes or tradable emission certificates should be considered as market-conforming policy instruments.[156] Both instruments indicate to market participants the existence of uniform emission prices, which will lead to balanced marginal abatement costs (cf. Box 10).

2. Regulation of CO_2 emissions: analysis of the current situation

With the introduction of the European Emissions Trading System (EU ETS) in 2005, the EU launched a cost-effective market-conforming instrument to reduce CO_2 emissions of energy-intensive plants

BOX 08

Externalities of greenhouse gas emissions

Externalities are generally defined as the effects of economic activities on third parties for which no compensation is made. Greenhouse gas emissions caused by human activities lead to negative externalities. The burning of oil, coal and gas emits the greenhouse gas CO_2. Increased CO_2 levels in the atmosphere lead to an increase in CO_2 concentration, which reinforces the natural greenhouse effect and leads to a rise in the global average temperature. As a result of global warming or climate change, sea levels rise and extreme weather events occur more frequently. Negative consequences of climate change, such as floods and droughts, affect many people around the world. Since those who emit greenhouse gas do not consider these consequences in their individual decisions, more greenhouse gases are emitted than would be socially desirable.

BOX 09

Static and dynamic efficiency of emission reduction policies

Static efficiency: Static efficiency means that an emission reduction target is achieved with a given technology at the lowest possible costs. This is the case whenever the costs incurred by preventing an additional emission unit are equal for all emitters. In the regulatory practice, not only direct costs, but also transaction costs have to be taken into account. These include e.g. information and monitoring costs.

Dynamische Effizienz: The criterion of dynamic efficiency focusses on reaching an emission reduction target over time at minimal cost. The crucial point here is whether market participants are provided with sufficient incentives for investing in new technologies so as to reduce future emission reduction costs.

BOX 10

Emission taxes and emissions trading

Emission taxes: If an emission tax is in place, each emission unit will be linked to a monetary obligation. Thus the overall economic costs of emissions can be integrated into the market price mechanism. All those activities that are associated with emissions will become more expensive. In their individual cost-benefit calculus, economic players will choose their emission levels in a way that ensures that the costs and benefits of further emission units are balanced. In order to reach established emission reduction targets, emission taxes have to be continuously adapted to changing economic framework conditions.

Emissions trading: In emissions trading, certificates are issued that represent the licence to emit a specified amount of greenhouse gases. Companies will purchase certificates on the emission market, provided that the costs for the certificate are lower than the achievable revenues anticipated. If it is cheaper for a company to reduce its own emissions instead of purchasing additional certificates on the emission market, it will reduce its emissions and can thus sell certificates. This interaction of demand and supply decisions leads to a uniform emission price. As opposed to the emission taxes approach, the amount of emissions available in emissions trading is limited in absolute terms from the very start.

across the EU (cf. Box 11). The introduction of the EU ETS marks the first emissions trading scheme established at an international level. Based on 2005 emission levels, the emissions budget for emissions trading will be reduced by 21 percent by 2020. The third trading period began in January 2013 and runs until December 2020. Several shortcomings of the first two trading periods (2005 to 2007 and 2008 to 2012) have been resolved or at least mitigated. Yet there is still need for further reform.

The following issues should be considered here:

– The EU ETS currently covers only about half of the EU's greenhouse gas emission sources.[158] All those emission sources that are not included in the EU ETS are subject to the supervision of the individual EU member states. In the sectors that are not covered by the scheme, member states have to achieve an average emission reduction rate of 10 percent[159] between 2005 and 2020 if the EU is to reach its overall climate target of 20 percent compared with 1990 levels (cf. Figure 1). In practice, a number of regulations is in place across all EU member states to reduce emissions beyond the EU ETS, e.g. in the transport sector and the household sector. These include efficiency

BOX 11

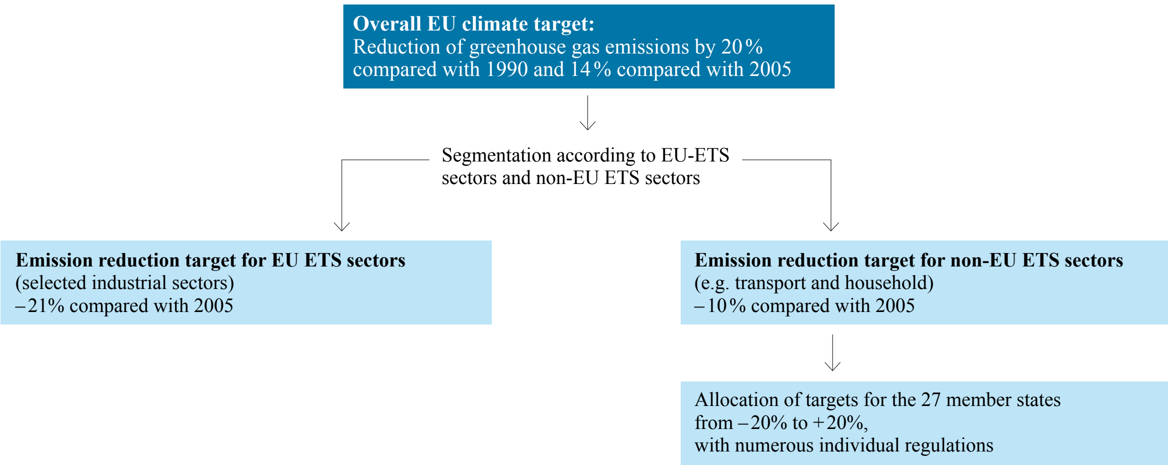
The European Emissions Trading System

In 2005, the EU launched its European Union Emissions Trading System (EU ETS), an emissions trading scheme for selected energy-intensive industries.[157] During the first two trading periods from 2005 to 2007 and from 2008 to 2012, only CO_2 emissions were included in the scheme. In the third trading period (2013 to 2020), other greenhouse gas emissions will also be subject to the emissions trading provisions. Since the start of the second period, the Clean Development Mechanism (CDM) and the Joint Implementation (JI) arrangements allow companies to purchase additional allowances through project-based emission reductions in third countries. The underlying aim is to tap low-cost emission reduction potentials outside the EU.

The first EU ETS trading period (2005 to 2007) was designed as a pilot phase. Due to the generous provisions of emission allowances, it was fairly non-restrictive, which led to a very low emission allowance price. In the early stages of the scheme, the EU ETS emissions budget was allocated freely to participants so as to reduce the cost burden caused by emissions trading for the respective industries, and to foster acceptance for the leading role of this European emissions trading scheme. In the third trading period, the majority of certificates will be auctioned on the stock exchange. Receipts will be allocated to the EU member states according to a fixed distribution key. Energy and trade intensive industries in particular shall continue to receive certificates gratuitously in order to protect them against major disadvantages in international competition – the rationale being that the EU is a limited economic area, while greenhouse effects are global in nature. This entails the risk that emissions are relocated counterproductively to countries that are lacking a relevant regulatory framework, an effect that is known as emission leakage.

Segmentation of the EU climate target

FIG 01



Source: own depiction following EU (2009).

standards for buildings, public funding for public transport, as well as energy consumption taxes and subsidies for renewable energy sources. Yet these measures are not directly linked with each other. As a result, the marginal abatement costs differ between EU ETS and non-EU ETS sectors and also between individual non-EU ETS sectors. This leads to efficiency losses, which means that climate protection at EU level is becoming more expensive than necessary.

– Prices for emission certificates in the EU ETS are well below the estimated level required to compensate for damage caused by each additional tonne of CO_2 emitted.[160] The negative externalities of greenhouse gas emissions are thus not fully internalised.
– The effectiveness of EU climate policy is further restricted by a number of energy-related subsidies that are not aligned with the overall objective of emission reduction. Subsidies for specific fossil fuels work against the objective of a cost-efficient energy mix deemed necessary according to climate protection considerations.
– The current design of the EU ETS does not provide for dynamic efficiency. In the event that emission prices fluctuate considerably and political reduction targets become uncertain over time, risk-averse players (cf. Box 12) within the EU ETS tend to rely on established prevention techniques such as the switching from coal to gas-fired power plants, while disregarding long-term desirable investments in innovative, climate-friendly technologies.

Empirical studies on the innovation effects of emissions trading suggest that the EU ETS has not had a major effect on corporate R&D decisions and the source-specific portfolio of energy suppliers – not least due to low and volatile emission prices.[161] Thus it could be shown that electricity producers primarily focussed on improving efficiency in their natural gas and coal power plants – while the EU ETS has

Risk aversion

BOX 12

Investments are always associated with risks.[162] These include e.g. sales risks, customer risks and price risks, but also political risks. While risk-neutral investors exclusively focus on the expected return, risk-averse investors are willing to accept a lower expected return in exchange for a higher level of security. This is based on the consideration that a potential loss is weighted more heavily than a potential return of the same amount and probability. Wherever risks are involved, the risk-averse behaviour of market participants will result in a shortage of socially desirable private investments. The higher the risk, the more pronounced is the problem of private underinvestment.

had a limited effect on the use of renewable energy, demand-side energy savings and investments in new technologies such as carbon capture and storage technologies. The emissions trading scheme is indeed a cost-efficient way of reaching short-term, less ambitious emission reduction targets within the EU ETS. However, if these measures are not aligned with ambitious emission reduction targets, the risk of path dependencies in favour of conventional (fossil) technologies will increase, creating high abatement costs in the long term.

3. Reform concepts

In view of the existing deficits in German and European climate policies, a number of reform concepts are currently being discussed.

The efficiency of climate policy could be enhanced by including all sectors in the emissions trading system.[163] The market price mechanism would provide the countries involved with incentives to use the most favourable abatement options across all greenhouse gas emission sources, and additional costs for segmented and uncoordinated policy measures would be eliminated. In political discourse it is sometimes argued that the expansion of emissions trading to all emitting market participants would incur high transaction costs. Yet this could be avoided if regulation were applied to the early links of the value chain: transaction costs would be incurred nationally by only a few importers and producers of fossil fuels. Appropriate controls should be in place to ensure that carbon markets with only a few key players are not exposed to distorted competition caused by market power.

The EU ETS' dynamic incentive effects could be enhanced by stabilising certificate prices within a target range based on reliable estimates of long-term climate damages caused by greenhouse gas emissions. Given the low EU ETS emission prices in the past, the proposed reforms are primarily aimed at providing price support. As an effective short-term measure, certificates could be withdrawn from the market as set-asides. As regards measures with a more sustainable effect, the introduction of a price floor is currently being discussed. In the event that the market price of certificates falls below the floor, the minimum price would have the same effect as a tax. Price stability could also be enhanced by establishing a central, independent authority, which would control the supply of emission allowances in a way that would ensure that certificate prices remain within a specific corridor even in times of economic distortions.[164]

Since incentives to invest in innovative emission reduction and prevention technologies may be considerably hindered due to risk-averse behaviour and insufficient planning security on the part of companies, the German Advisory Council on the Environment (SRU) recommends developing climate goals and associated legally binding provisions at least for the period until 2030.[165]

ENERGY POLICY

B 1–3

1. Rationale for energy policy: renewable energy and energy efficiency

If there were no further indications of market failure besides the externalities of greenhouse gas emissions, any renewable energy and energy efficiency objectives could be deemed superfluous or even counterproductive. The reduction target for greenhouse gas emissions could be achieved using a single market-conforming regulatory instrument – such as comprehensive emissions trading – in a statically and dynamically efficient way. The balancing of marginal abatement costs would automatically create a cost-effective mix of greenhouse gas reduction options. These would include not only a stronger use of renewable energy or improvements in energy efficiency, but also innovation in climate-friendly technologies. In such a scenario, explicit renewable energy and energy efficiency targets, as stipulated in the policies of the Federal Government and the EU, would be superfluous as targets would be reached through efficient climate policy anyway, or they would be costly due to additional efforts employed. Measured against the target for greenhouse gas reduction, the energy system would in fact over-cater for renewable energy or energy efficiency.

In addition to the externalities of greenhouse gas emissions, there are other forms of market failure that call into question the dynamic efficiency of emissions trading as the sole instrument of climate policy and would justify complementary regulatory measures. These forms include knowledge spillover and adoption externalities in particular (cf. Box 13). Besides this, existing price uncertainties may provide risk-averse market participants with investment incentives that are deemed sub-optimal from an overall economic perspective.[166] This is an issue that applies to the energy sector in particular, since the energy sector is characterised by uncertainties regarding binding long-term climate and energy policy objectives and their regulatory implementation. What is more, investment needs for R&D are relatively high in the energy sector and investment cycles for energy technologies are long.

Due to knowledge spillover, adoption externalities and price uncertainties, emissions trading that focusses solely on static efficiency is not a suitable means of overcoming what is known as the carbon lock-in. Today's energy sector is dominated by fossil fuel based technologies that benefit from sunk investment costs and economies of scale. Thus, established technologies not only benefit from compatible infrastructures, but also from accumulated knowledge assets as well as social and institutional habits and structures. All of these factors result in path dependencies. Moreover, cost-reducing economies of scale and learning curve effects for new technologies can only be expected in the medium to long term.

From an industrial policy perspective it is often argued that the promotion of renewable energy and energy efficiency can improve the competitiveness of domestic industries. Yet, beyond any regulatory concerns, it remains doubtful whether the promotion of the renewable energy sector will be suited to overcompensate costs incurred by regulation, tap additional innovation benefits and implement strategic competitive advantages.

Another argument in favour of public support for renewable energy and energy efficiency improvements is Germany's dependence on imported fossil fuels: Germany heavily depends on imports from various world regions, some of them politically unstable. Moreover, limited competition in international energy markets entails the risk of unreasonably high energy prices caused by the market power of individual suppliers. Regulatory intervention to reduce import dependency may be justified whenever countermeasures by private stakeholders – such as

BOX 13

Knowledge spillover and adoption externalities

Knowledge spillover: In the field of research and innovation, externalities occur in the form of knowledge spillover. By inspecting innovative products and processes, market participants can acquire knowledge without having to bear the full costs of knowledge creation. Conversely, this means that innovators cannot privatise the full social and societal returns of their product or process development. Form a social point of view, innovators invest too little in the production of knowledge due to the fact that the private innovation returns deviate from the social innovation returns. In energy technologies, there are additional factors that complicate the situation: here, patentability is restricted due to the complexity of plants and the diversity of stakeholders involved, which makes it even more difficult to privatise R&D returns.[167]

Adoption externalities: The costs of using a technology can depend on the number of market participants that have already adopted the respective technology. Users who adopt new technologies at an early stage can provide other stakeholders with valuable information on a new technology's existence, characteristics and success factors. Additional positive effects arise whenever (production) costs can be reduced as a result of the producer's increasing experience with the technology. If third parties benefit from these effects without making adequate compensation, this is referred to as adoption externalities. Thus it is often the case that developers, manufacturers and first-time adopters of a new technology cannot obtain the full return on the knowledge they generate.[168] Adoption externalities result from interaction between technology suppliers and technology users and the feedback loop between technology and market development, which are initiated by a stakeholder's investments and can be used by other market participants without compensation.

Regulatory measures for balancing these externalities include e.g. the strengthening or creation of property rights (e.g. through patenting), direct R&D subsidies, tax benefits for knowledge production, and sales promotion.

the diversification of supply sources or energy savings – do not suffice to meet the precautionary level deemed desirable from an overall economic perspective. In practice, however, it is often difficult to determine the scope of such deviations – which may e.g. result from different discount rates or different risk preferences[169] – and to develop targeted corrective measures on the basis of sovereign provisions.

In terms of energy efficiency, market failure can also be caused by information-related issues and institutional barriers. This means that energy efficiency measures deemed profitable from an overall economic perspective are not conducted. This is particularly the case in the energy-efficient renovation of buildings: home owners and landlords have to expend in order to obtain relevant information on potential savings and energy efficient products and technologies.[170] In the face of large investment amounts and long payoff periods, risk-averse owners will refrain if a potential investment's profitability is uncertain. What is more, home owners often anticipate financing constraints – especially in cases where diverse individual measures can only be properly implemented as part of a comprehensive renovation scheme. Coordination issues may also exist between tenants and landlords, known as the landlord-tenant dilemma: tenants have an interest in keeping their rental and property payments at the lowest possible level, but have insufficient knowledge about the energy efficiency of the building. Landlords have insufficient incentives for implementing energy efficiency measures, unless they directly profit from lower energy costs or pass investment expenditures on to their tenants – on the grounds of the market situation, on legal grounds, or due to the fact that tenants are underinformed.[171]

From a climate protection perspective, the systematic expansion of the renewable energy sector and improvements in energy efficiency are often justified on the grounds that the EU ETS only covers part of the overall economy's greenhouse gas emissions. Thus, for instance, greenhouse gas emissions produced in the generation of heating energy – with the exception of heating energy generated through electricity and district heating – are not regulated by emissions trading. Obviously, by expanding European emissions trading to all emission sources, this problem could be solved cost-effectively and according to the polluter-pays principle.

2. Renewable energy

2.1 The EEG: analysis of the current situation

The expansion of the renewable energy sector in Germany is regulated by the Act on Granting Priority to Renewable Energy Sources (Renewable Energy Sources Act – EEG) (cf. Box 14). The EEG is based on the 1991 Grid Feed-In Law *(StrEG)*. It entered into force in 2000 and has since been amended several times. The EEG's main pillars are the operator's obligation to connect to the grid, the priority of electricity generated from renewable energy sources as opposed to electricity from conventional sources, as well as feed-in tariffs and optional market premiums respectively. In terms of both static and dynamic efficiency, the EEG shows serious shortcomings.

Static efficiency would be achieved if the expansion of the renewable energy sector was ensued by balancing the marginal costs of production, i.e. by ensuring that the next unit of green electricity was supplied through the cheapest generation option. In practice, however, feed-in tariffs as stipulated in the EEG vary depending on the technology used, which is the reason why marginal costs do not balance. For instance, electricity generated from solar power will achieve a much higher price than electricity generated from wind power. As a result, too much solar power is being produced. Thus the expansion target for renewable energy is not implemented based on a minimum cost technology mix. Furthermore, an unrestricted take-or-pay clause for fixed and high feed-in tariffs leads to a much greater expansion than originally planned, which is associated with substantial additional costs.

When calculating future investments, operators of plants generating electricity from renewable sources can disregard the costs of potential additional investments in the electricity grid. The EEG does not provide any incentives for minimising the overall costs of constructing and operating plants and grids. Neither does the EEG provide sufficient incentives for operators to embark on demand-driven production and to invest in storage technologies and storage technology research. Although the EEG's market premium model serves the purpose of promoting the demand-driven generation of electricity from renewable sources, the premium is optional and plant

BOX 14

Germany's Renewable Energy Sources Act (EEG)

Connection requirement for grid operators: Under the EEG, grid operators are obliged to connect installations generating electricity from renewable energy sources to their grid system.[172] Grid operators are obliged to expand their networks if necessary to secure the purchase, transmission and distribution of electricity from renewable energy sources.[173]

Prioritising electricity feed-in from renewable energy sources over electricity from conventional energy sources: The total available electricity from renewable energy sources shall be purchased, transmitted and distributed by grid operators as a matter of priority.[174] Only in exceptional cases are grid operators permitted to engage in feed-in management, that is, to reduce the feed-in power of installations generating electricity from renewable sources. This only applies if network bottlenecks are anticipated, or the safety and reliability of the electricity supply system is at risk.[175] Whenever the supply of electricity from plants generating electricity from renewable sources is reduced, plant operators are to be compensated.[176]

Feed-in tariffs: Grid operators are obliged to pay tariffs to operators of installations generating electricity from renewable energy sources.[177] This obligation also applies in cases where electricity is temporarily stored prior to being fed into the grid system.[178] Applicable tariff rates are stipulated by the EEG and may differ depending on the energy source.[179] Tariff rates are subject to a degression formula, i.e. rates decrease per year for each newly commissioned plant,[180] while rates for energy produced by a plant remain constant for a period of 20 years.[181] Grid operators are obliged to supply electricity for which tariffs are paid to the relevant transmission system operator,[182] while the latter is obliged to compensate the grid operator accordingly.[183] Transmission system operators who have to purchase electricity from renewable energy sources in quantities greater than the average share are entitled to seek compensation from other transmission system operators.[184] All transmission system operators must sell the electricity purchased on the energy exchange's spot market[185] in accordance with the requirements of the Equalisation Scheme Ordinance *(Ausgl-MechV)*.[186] To cover the shortfall resulting from the difference between the sales-generated income on the exchange and expenditures incurred by the legally binding tariffs, transmission system operators may require electricity suppliers that supply electricity to end consumers to pay a fee (EEG surcharge) for each kilowatt-hour of electricity usage.[187]

Market premium: Plant operators may dispense with the statutory feed-in tariffs and directly market electricity from renewable energy sources. Since January 2012, plant operators are entitled to charge a market premium to the grid operator.[188] For each new calendar month, plant operators can decide anew whether to make use of the statutory feed-in tariffs, or whether to sell the produced electricity directly on the day-ahead market.[189] The market premium model aims to provide incentives for a demand-oriented production of electricity from renewable energy sources.[190]

operators are free to return to feed-in tariffs each month. It is therefore to be feared that deadweight effects will occur, which could further increase the costs of the EEG.[191] Moreover, it is doubtful whether the market premium model can initiate adjustments to the feed-in system according to market prices, since the supply of electricity from renewable sources is very inelastic to price movements (with the exception of biomass-generated electricity). The lack of demand orientation in the supply of electricity from renewable energy not only increases system integration costs, but also jeopardises the security of supply. Demand-oriented energy supply is a prerequisite for achieving enhanced self-sufficiency in power supply through the use of renewable energy.

Based on the criterion of dynamic efficiency, technology-specific feed-in tariffs can be generally justified on the grounds of varying degrees of adoption externalities. Yet the EEG's technology-specific feed-in tariffs do not address technology-specific adoption externalities but rather the respective electricity production costs, which results in distorted investment incentives.

The EEG has certainly created opportunities for incremental innovations, as operators demand technologies with the best possible ratio of production costs and feed-in tariff rate per unit of electricity produced. Yet incentives provided by the EEG for developing radical technological innovations are limited, because the remuneration guaranteed by the EEG is calculated based on the average cost of the respective technology. Thus, for a potential innovator, the revenue from an (ex-post) cost-effective new technology is the same as the revenue generated through pre-existing technologies. As a consequence, it does not pay to embark on risk-involving investments in technological innovations.[192]

By means of a graded feed-in tariff system, the legislator aims to facilitate the launch of technologies that are not yet saleable. But the EEG has also failed as an industrial policy instrument,[193] a fact that currently manifests itself in the economic problems of the German solar industry. Today, the EEG is largely used as a means of promoting the import of photovoltaic modules from foreign manufacturers – instead of providing German companies with a sustainable competitive edge.[194]

But the EEG is also costly and less targeted with regard to internalising knowledge spillover occurring in the early stages of the innovation process and in the development phase of entirely new technologies. Here, the EEG primarily acts as a production subsidy for electricity rather than an R&D funding measure. In the context of the massive expansion of the renewable energy sector, R&D activities have increased in absolute terms. Yet, in relative terms, R&D activities have decreased considerably: thus the R&D ratio of the German solar power industry decreased from nearly 4 percent in 2001 to a mere 1.6 percent in 2008. Especially companies with fairly mature technologies do not feel the need to invest in research. The excessive growth of the market has indirectly lead to market entry barriers for less mature technologies, while at the same time facilitating lock-in effects in favour of established renew-able energy technologies.

The explicit promotion of renewable energy can be partially regarded as a strategy for reducing greenhouse gases. Yet, when considering the CO_2 abatement costs associated with the EEG, this regulatory instrument is by no means a cost-effective way of reducing CO_2 emissions. The macroeconomic CO_2 abatement costs differ widely depending on the renewable technology used. Also in the medium term, the respective abatement costs tend to be well above the expected CO_2 prices in emissions trading or the estimated marginal costs of climate change. The highest abatement costs occur in the photovoltaic industry, and will remain high for the decades ahead (cf. Table 2), while the lowest costs are recorded in the onshore wind energy sector, and, from 2040, the offshore sector will follow suit.

It is sometimes also argued that subsidising the renewable energy sector has a positive effect on employment, as new jobs are being created in this industry.[195] Yet the EEG's macroeconomic employment effects are not quite clear. The EEG's promotional measures are financed through higher electricity prices for companies and private households, incurred via the EEG surcharge. This results in lower consumption levels, lower investments in other areas and, ultimately, negative employment effects. Furthermore, energy policy cannot serve as a substitute for labour market strategies to reduce unemployment.

Another problem inherent in the EEG are its regressive distributional effects. Since demand for electricity is very inelastic, low-income households are burdened to a relatively higher degree than high-

TAB 02 **Estimated macroeconomic CO_2 abatement costs in euro per tonne of CO_2**

	2010	2020	2030	2040	2050
Photovoltaics	387	161	163	169	177
Wind onshore	59	42	57	55	71
Wind offshore	107	88	64	49	56
Biomass	120	116	140	148	154

Source: own depiction, based on Ifo Institute and FfE (2012).

income households.[196] This distribution effect is reinforced by the fact that high energy consuming manufacturing companies have to pay only a reduced EEG surcharge so as to remain competitive.[197] This results in an even greater cost burden for all other electricity consumers. While low-income households are more affected by the EEG surcharge than high-income households, recipients of subsidies for rooftop photovoltaic installations are benefitting from payments resulting from the EEG's provisions. As property owners, these beneficiaries tend to belong to a more affluent segment of society.[198]

2.2 Reform concepts

With regard to the promotion of renewable energy sources, several reform concepts have been brought forward.

A reform concept that remains fairly close to the existing system, is to select plants eligible for funding through a tendering procedure, while feed-in tariffs stipulated by law would continue to be paid for a specified period of time. At any rate, a tendering model could be a suitable means of monitoring the capacity expansion of individual renewable technologies. The market-based auctioning of technology-specific generation capacity would create incentives for cost efficiency. Yet it will be difficult to precisely identify technology-specific expansion targets.

This would not be the case with green certificates, a measure recently recommended by the German Council of Economic Experts (SVR, cf. Box 15) and the German Monopolies Commission[199]. To reach the overall target, the respective contributions from renewable energy technologies shall be determined cost-efficiently on the basis of a market-based price mechanism. Individual US states, as well as a number of countries, have already introduced green certificates, among them EU member states such as Great Britain, Sweden, Poland, Belgium and Italy. The Netherlands are planning to introduce green certificates in 2015.

The trading of green certificates leads to a uniform price that provides orientation for all market participants. According to this model, revenues of producers of electricity from renewable energy flow from two different sources.[201] First, compensation is made through selling electricity at market prices. Second, revenues are generated from selling green certificates. The electricity price provides a direct incentive for demand-oriented supply and investments in storage technologies. Expanding trade in green certificates to other EU member states would lead to further efficiency improvements, since the locational advantages of the different European regions could be utilised here (e.g. solar energy in southern Europe and wind energy on the North Sea coast).

BOX 15

Green certificates as proposed by the German Council of Economic Experts[200]

Newly installed plants for producing electricity from renewable energy sources shall no longer be subject to the EEG. Yet the operators' obligation to connect to the grid and the priority feed-in continues to apply. Plant operators shall sell their electricity on the electricity exchange, where they compete with producers of electricity from conventional sources, or they arrange for long-term contracts with electricity consumers. For each electricity unit generated, operators of plants producing electricity from renewable sources shall receive green certificates from their transmission system operators. These certificates will be tradable. Energy suppliers shall be required to cover a minimum quota of electricity supplied to consumers from renewable sources. This quota will increase over time. For each accounting period, energy suppliers shall be obliged to produce a certain number of green certificates. The number shall be calculated based on the minimum quota and the total amount of electricity supplied to the end consumer.

Green certificates shall be traded on the exchange market. Producers of electricity generated from renewable sources shall sell their electricity to energy suppliers. The interplay between supply and demand will result in a uniform market price. A payment scheme graded according to technology shall not be in place.

Ultimately, the trading of green certificates shall be coordinated within Europe under a harmonised procedure.

The introduction of green certificates entails the risk of high price volatility at least in the early stages, which might discourage risk-averse investors.[202] In order to mitigate price volatility, market participants should be enabled to trade across periods and on futures markets. Other countermeasures include the introduction of price corridors, as well as a guaranteed term for investors regarding their plants' certificate validity.

According to the German Council of Economic Experts, green certificates should be flanked by additional innovation support measures so as to account for knowledge spillover and adoption externalities.[203] These include e.g. the expansion of university and non-university research and the creation of attractive framework conditions for private research.

The introduction of banding multipliers in the production of green electricity could be an alternative to a strict separation of technology promotion and quantity control through green certificates.[204] This measure is based on the idea that renewable technologies with higher generation costs would receive more Renewable Energy Certificates per kilowatt hour. Certificates would also be traded on a homogeneous certificates market. However, the introduction of banding multipliers would entail the government to make discretionary decisions – similar to those related to determining EEG feed-in tariffs – on the eligibility of alternative technologies in green power generation.

3. Energy efficiency

3.1 Analysis of the current situation

At German and European levels, a number of taxes and regulations are in place to increase energy efficiency. Besides introducing energy taxes, the legislator has enacted e.g. efficiency standards in the field of building and transport, eco-design guidelines for electrical devices, as well as bans on conventional light bulbs and night storage heaters. In the field of energy efficiency, specific instruments have been developed to manage information and financing issues and the landlord-tenant dilemma (as described above). These include e.g. financial incentives (such as KfW programmes), information and advisory services (including energy certification) funded by the public sector, as well as technical regulations (Energy Saving Ordinance) and amendments to tenancy law.

Notwithstanding the usefulness of explicit energy efficiency targets, energy policy should create incentives for implementing energy-saving measures where they are at the lowest overall economic cost. The current conglomeration of rule-based and discretionary measures does not meet this requirement. Current standards and bans disregard the fact that substantial welfare losses may be incurred by restricting producers' and consumers' choices. Moreover, standards do not provide incentives for increasing energy efficiency beyond the prescribed level, which results in the fact that continuous innovation activities are not fostered.

3.2 Reform concepts

A tradable quota system could provide a possible solution for achieving cost-efficient energy savings. A quota system would balance out the marginal costs of energy saving incurred by different energy saving measures.

Quota systems as an energy-saving measure are currently being discussed in the context of the new EU-wide Energy Efficiency Directive[205]. According to this directive, which is to be transposed into national law by the spring of 2014, energy consumption of end users in all member states shall be reduced by 1.5 percent annually based on the average annual sales volume of the years 2010 to 2012. Member states may achieve this goal either through an energy savings quota for energy distributors and retail supply companies, or through alternative measures.[206] In France, Great Britain, Italy, Denmark, and the region of Flanders, quota systems for energy saving are already in place. In all of these economies, energy companies are obliged to produce prescribed energy savings and to prove their savings. Moreover, companies also receive certificates for energy saving measures implemented for their consumers. These tradable certificates serve as proof that a particular saving has been accomplished.

B 1–4 INNOVATION POLICY

1. Rationale for innovation policy

A functioning innovation system with adequate incentives is the prerequisite for reaching climate and energy policy objectives efficiently.

Various types of market failure caused by knowledge spillover and adoption externalities may occur in innovation processes. These types of market failure are particularly relevant for the climate and energy market – not least because of the industry's particularly long investment horizons and the high degree of uncertainties regarding policy developments. These reasons justify not only the promotion of research and development, but also the promotion of new technologies in terms of market entry and diffusion.

Yet, when it comes to practical implementation, innovation policy is a highly complex task. It is close to impossible to analytically deduce an efficient mix of applicable innovation policy measures. It is therefore essential to critically assess the innovation system on a regular basis through monitoring and evaluation and to adjust policy measures as necessary.

Beyond market failure caused by knowledge spillover and adoption externalities, the objectives of supply security and strategic competitive advantages for Germany's economy provide the rationale for climate and energy-related innovation policies. Furthermore, it is often argued that, in the medium term, the development of innovative, climate-friendly technologies can lead to emission reductions in countries that are lacking a stringent climate policy. This can be achieved through technology transfer, which can lead to an increase in the (global) cost efficiency of unilateral climate policies.

BOX 16

Forward-looking projects in the Federal Government's requirement area "Climate and Energy"[208]

CO_2-neutral, energy-efficient and climate-adapted cities: With this project, the Federal Government promotes the ideal of the zero-emissions city. The project addresses the energy efficiency of buildings and production facilities, the future design of sustainable mobility and the development of intelligent energy networks. With the support of the Federal Government, selected cities will be transformed into low-carbon regions by 2020. Up to EUR 560 million are earmarked for the implementation of the forward-looking project "CO_2-neutral, energy-efficient and climate-adapted cities".

Renewable biomaterials as an alternative to oil: This project aims to explore the potential of renewable resources as an alternative to oil. The project's two main objectives are to increase the use of biomass without entering into competition with the food production industry, and to establish new processes for making full use of biomass. The budget of the forward-looking project "Renewable biomaterials as an alternative to oil" will amount to approximately EUR 570 million.

Intelligent restructuring of energy supply: The Federal Government considers progress in science and research as a prerequisite for reaching climate and energy-related policy objectives. Against this background, three inter-departmental research initiatives have been launched: "Energy Storage", "Grids" and "Solar Architecture / Energy-Efficient City". The budget of EUR 3.5 billion earmarked for the implementation of the Federal Government's 6th Energy Research Programme will largely be used for this forward-looking project.

2. Analysis of the current situation

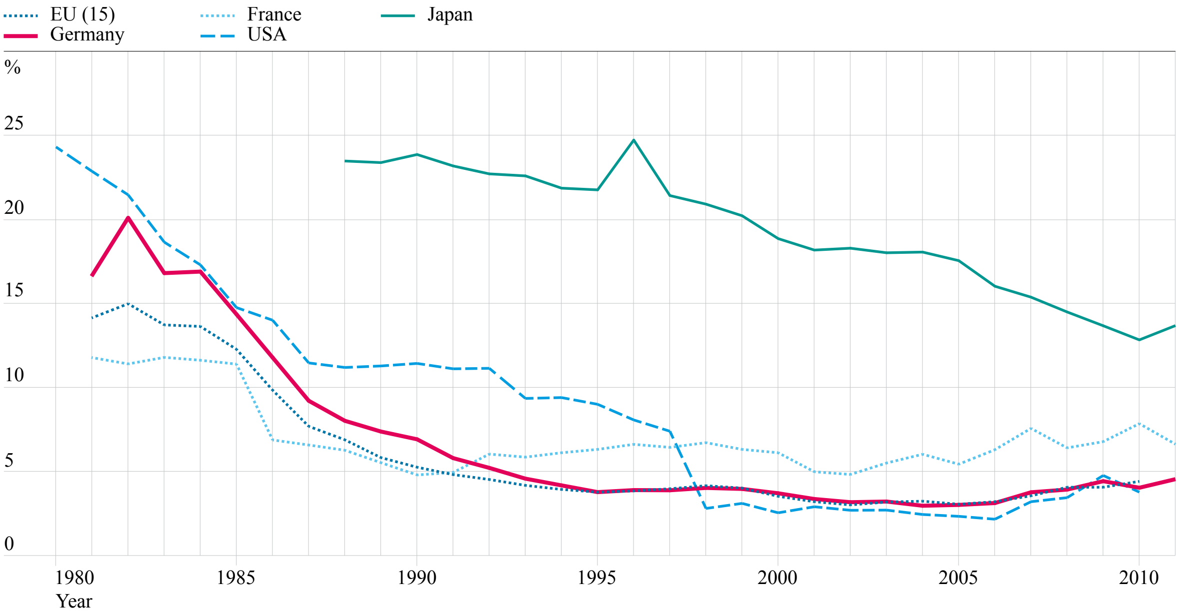
2.1 High-Tech Strategy 2020 and the 6th Energy Research Programme

The High-Tech Strategy 2020 is the Federal Government's key mechanism for coordinating the promotion of innovation across all government departments.[207] In addition to providing support measures, the High-Tech Strategy also focusses on improving framework conditions for innovation. The High-Tech strategy is based on a mission-oriented approach. It is divided into five requirement areas,[209] with "Climate and Energy" being one of these requirement areas.[210] The respective requirement area's key challenges are addressed via "forward-looking projects", and concrete objectives for scientific, technological and social developments are pursued over a period of ten to 15 years.[211] To date, three forward-looking projects have been designed for the requirement area of "Climate and Energy" (see Box 16).

With the 6th Energy Research Programme "Research for an environmentally sound, reliable and affordable energy supply", the Federal Government has established the guidelines and focal areas of its energy-related funding strategy.[212] It was adopted by the Federal Cabinet in August 2011. The programme was developed jointly by the Federal Ministry of Economics and Technology (BMWi), the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), the Federal Ministry of Education and Research (BMBF), the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV), and coordinated by the BMWi. Between 2011 and 2014, the Federal Government is allocating approximately EUR 3.5 billion to the implementation of the 6th Energy Research Programme, which largely focusses on three key objectives. First and most importantly, the Research Programme aims to contribute to reaching the Federal Government's energy policy targets. This includes the priority to promote energy efficiency and the development of the renewable energy sector in a way that is cost-efficient as well as environmentally and ecologically sound. The second objective is to strengthen the position of German companies in the area of advanced energy technologies. The Research Programme's third objective is to secure technological options and to expand and improve the flexibility of energy supply in Germany. Thus, the Federal Government also regards the ongoing promotion of nuclear technology as part of an energy policy approach that is open in principle.

When compared with earlier programmes, the 5th Energy Research Programme had already a much stronger focus on renewable energy and energy efficiency. The 6th Energy Research Programme puts an additional focus on the promotion of energy storage technology and grid technology, the integration of renewable energy into the energy supply, and energy technology interaction within the overall system. For the more complex issues of energy storage and grids, interdepartmental research initiatives have

FIG 02 **Public R&D expenditures for energy research of selected countries in relation to total expenditures on civil research**

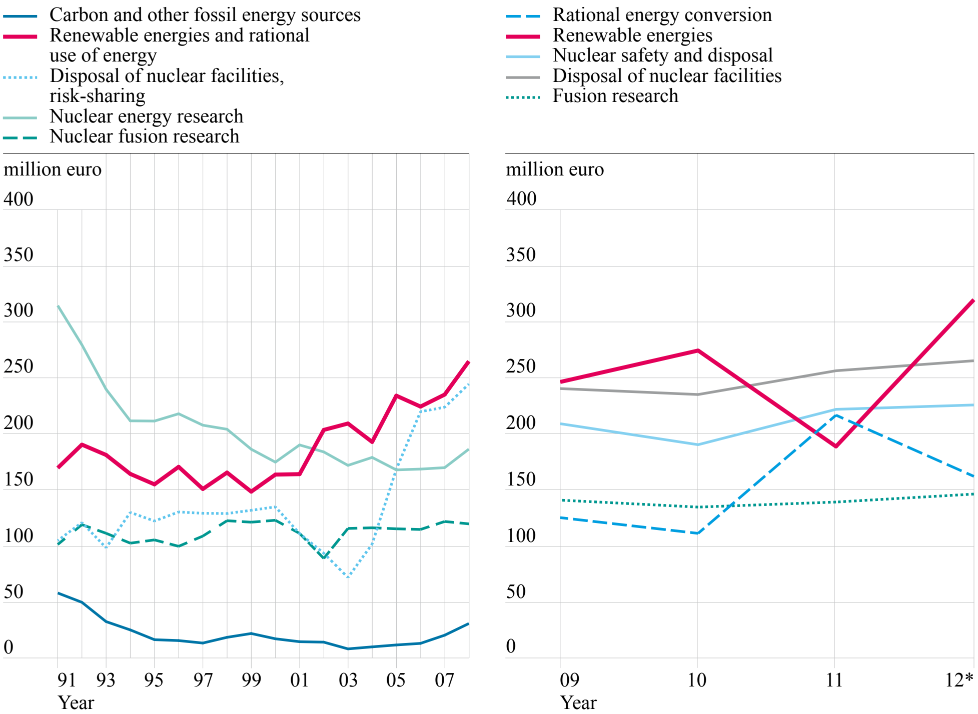


Source: own depiction based on calculations by the Ifo Institute; cf. Rave et al. (2013).

Note: R&D expenditures as GBAORD (Government budget appropriations or outlays on R&D) based on data from funding agents (including payments from foreign organisations); classification according to NABS 1992 (Nomenclature for the analysis and comparison of scientific programmes and budgets) and, for the period starting from 2007, NABS 2007; data for Japan only available from 1988.

The Federal Government's total expenditures on science, research and development in the funding priority areas of energy research and energy technologies, in million euro

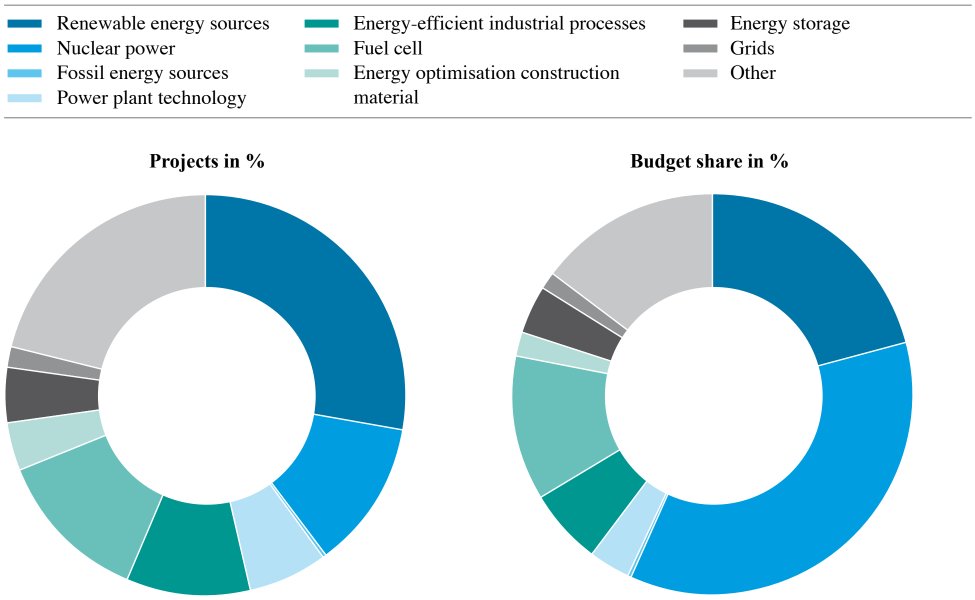
FIG 03



Until 2008: according to the Federal Government's 2005 R&D planning system. Division into support areas and funding priorities partially estimated. From 2009: according to the Federal Government's 2009 R&D planning system. 2009-2011: including investment and repayment funds without *Länder* allocations (Stimulus Package II); from 2011: including energy and climate fund. 2012: target values.
Source: own depiction based on the BMBF data portal; cf. Rave et al. (2013).

Allocation of energy-related project support by the Federal Government

FIG 04



Figures include all continuing projects as of February 2012.
Source: own depiction based on calculations by the Ifo Institute; data: *Förderdatenbank des Bundes,*[213] cf. Rave et al. (2013)

been launched. Compared with previous programmes, much lower priority has been given to fossil power plant technologies, such as technologies for carbon capture and storage. Around 18 percent of the programme's funds are being allocated to nuclear fusion research between 2011 and 2014.

In addition to the 6th Energy Research Programme, the Federal Government's High-Tech Strategy 2020 lists further lines of action, most of which have a global outlook.[214]

The Energy Research Programme does not cover research ventures in the fields of transport research, electromobility and aviation research, environmental research, housing and construction research, or research in the field of information and communication technologies – unless research addresses energy-related issues. These fields are partially covered by other requirement areas outlined in the High-Tech Strategy 2020.

2.2 Public research expenditure

In 2011, the share of public R&D spending on energy research amounted to slightly below 5 percent of the total civil research expenditure in Germany (cf. Figure 2). Yet, when compared on an international level, it should be noted that surveys on energy research are conducted differently according to country, i.e. a uniform standard does not exist. In the early 1980s, Germany was still spending up to 20 percent of civil research expenditure on energy research – which is quite remarkable, even when compared internationally. Until the early 2000s, this rate continuously dropped to approximately 3 percent, a low also in absolute terms. During this period, the Federal Government's R&D expenditure for nuclear energy research fell sharply.[215] A relative increase in research expenditure could be observed only in recent years. Energy research expenditure has also declined significantly in a number of other countries. This applies to the United States in particular, where the proportion share dropped significantly during the 1980s, and again from the mid-1990s on. In the 1980s, the share of public research expenditure of the EU-15 countries was about 2 to 3 percentage points lower than that of Germany, with figures converging over time. In Japan, where high priority is being attached to cost-intensive nuclear research, the share of energy research expenditure has been – and still is – much higher than in many other countries worldwide.

Figure 3 shows that the Federal Government's expenditure on science, research and development has increased significantly since the late 1990s, especially in the area of renewable energy. Since 2004, higher growth rates have also been recorded for research into the disposal of nuclear facilities.

An evaluation of the Federal Government's funding catalogue provides detailed information on the government's stance on funding energy-related projects. The catalogue lists the support measures provided by the Federal Ministry of Education and Research (BMBF), the Federal Ministry of Economics and Technology (BMWi), the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) and the Federal Ministry of Transport, Building and Urban Development (BMVBS) (cf. Figure 4). In the field of renewable energy, a total of 599 projects receive funds of EUR 457 million, making up 27.8 percent of energy-related projects and accounting for 20.9 percent of the total energy funding budget. Almost half of the resources will be allocated to solar energy projects, and approximately a quarter to wind energy projects. Energy storage and grids – areas that are currently widely discussed in political realms – make up only 6.3 percent of projects funded, while using only 5.3 percent of funding resources. Even though the percentage share for all energy-related projects is much lower (12 percent), a relatively large proportion (38.5 percent) of funds is allocated to nuclear research, which is owing to the large project volume in this field. Four-fifths of funds in this research area are used for research into disposal and waste management.

While expenditure on energy research has been declining for many years, which is largely attributable to diminishing research into nuclear energy, the late 1990s saw an increase in expenditure especially in the area of renewable energy.

3. Reform concepts

As regards renewable energy policies, is has often been suggested to reallocate funds from diffusion promotion to earlier phases of the innovation

Distribution of renewable energy research funding and market development funding in Germany, in million euro

TAB 03

	2008	2009	2010	2011 [f]
Total research funding [a]	222	357	375	~ 373
Research funding (federal only)	161	277	275	~ 273
Research funding (federal only, projects only)	131	220	219	~ 200
Total funding of market development	4,607	6,176	8,620	~ 12,920
Support through EEG (EEG differential cost) [b]	4,300	5,600	8,100	~ 12,400
Other support measures [c]	307	576	520	~ 520
Total research funding as a share of market development funding	4.8 %	5.8 %	4.4 %	~ 2.9 %
Federal Government's R&D project funding as a share of EEG differential cost	3.0 %	3.9 %	2.7 %	~ 1.6 %
Federal Government's R&D photovoltaics project funding as a share of EEG differential cost [d]			~ 1.5 %	~ 0.9 %
Federal Government's R&D wind energy project funding as a share of EEG differential cost for wind energy [e]			~ 1.9 %	~ 1.8 %

Source: own depiction, based on a compilation in Rave et al. (2013), in: Braun et al. (2011); BMU 2011; BMU 2012; BDWE (2012).

Notes:
[a] Project funding and institutional funding by federal and *Länder* governments; without project funding partially relating to R&D for renewable energy (2010: EUR 12 million from BMU, BMWi, BMBF each); *Länder* governments' research funding: EUR 61 million in 2008, estimated increase to EUR 80 million (2009) and EUR 100 million (2010, 2011).
[b] Differential cost: difference between the grid operator's revenue from the sale of renewable energy electricity and their expenditure in purchasing renewable energy electricity; 2011: estimates by BDEW (2012).
[c] Market incentive programme, "100,000 roofs" solar power programme (remaining expenditure), support of advice (estimated renewable energy share), export promotion, market launch of sustainable commodities (estimated renewable energy share), support programmes of the *Länder* in relation to the market development of renewable energy (approx. EUR 25 million annually); 2010: target values.
[d] EEG differential cost according to BDEW (2012): EUR 4,470 million (2010) and EUR 6,914 million (2011); R&D cash outflow according to BMU (2011, 2012) ca. EUR 65 million (2010) and EUR 60 million (2011). R&D support subject to underestimation due to attribution problems.
[e] EEG differential cost according to BDEW (2012): EUR 1,980 million (2010) and EUR 2,712 million (2011); R&D cash outflow according to BMU (2011, 2012) ca. EUR 50 million (2010) and EUR 37 million (2011). R&D support subject to underestimation due to attribution problems.
[f] Values are provisional or based on estimates respectively.

process, and to invest these funds in basic and applied research in particular.

The funding volume earmarked for market development in the area of renewable energy is 35 times greater than the total volume available for R&D funding (cf. Table 3). When comparing the funding volume of EEG-based support measures at national level with R&D project support from the Federal Government, a factor of 62 applies. Although a policy-induced market growth is also accompanied by an absolute increase in R&D activities,[216] the Expert Commission still sees a major imbalance between diffusion promotion measures and R&D support measures.

Additional basic and applied research is likely to generate considerable potential for cost reduction and innovation. Thus, according to the Fraunhofer Institute for Systems and Innovation Research (ISI), it would make sense to align research funding for photovoltaics with the entire value chain.[217] Moreover, public funding in the field of onshore wind energy should focus on concrete optimisation approaches, since this is a mature field of technology.[218] Yet in offshore wind energy research, which is still in its early development stages, specific segments should be considered to a much greater extent. These include the adaptation of wind energy plants, the development and improvement of load-bearing structures, as well as installation and maintenance concepts. As with photovoltaics, wind energy is generally characterised by a substantial need for research into smart solutions for integrating wind energy into the supply network. In addition to this, energy-related research should be coordinated more closely with research in other industries, e.g. aviation or micro-system technology.[219]

In order to assess, adjust and improve the innovation system, innovation policy has to be complemented by a continuous monitoring and evaluation process. EU countries with a highly advanced evaluation system include Denmark, Great Britain and Austria.[220] It would therefore make sense to multilaterally exchange previous findings and policy recommendations as well as methods for data collection and data analysis.

B 1–5 POLICY COORDINATION

1. Interplay between climate, energy and innovation policies

An economic evaluation of individual climate, energy and innovation policy instruments can be very complex and challenging. The task at hand is to develop theories and models for assessing if and how regulatory changes affect the behaviour of economic entities, and thus change the market outcome, as compared with a non-regulated reference situation. Where possible, the theoretical models used have to be validated on the basis of empirical work, i.e. by means of econometric or experimental studies. Although economic policy advice makes frequent use of theoretical insights, the task of analytically identifying cause-and-effect relationships is becoming more and more complex. This is aggravated by the frequent occurrence of opposite effects, which have to be evaluated based on quantitative (numerical or empirical) studies.

Economic evaluations of the isolated or combined use of climate, energy and innovation policy instruments can take the form of a descriptive study, or, as is the case in cost efficiency evaluations, a normative study. Prior to any assessment of policy interaction and policy coordination, the respective target system should be clearly established. If only one policy objective is to be pursued, such as the reduction of greenhouse gas emissions, one instrument (in this case emissions trading) usually suffices for achieving the objective efficiently. In these cases, the use of multiple instruments could be deemed either redundant or inefficient and would create the need for coordinative action, when in fact coordination is not needed in the first place. In the event that there is multiple evidence for market failure – such as greenhouse gas externalities, price uncertainties, knowledge spillover and adoption externalities – it is advisable to employ multiple instruments. Thus, emissions trading may be flanked with price corridors as a hedge against price uncertainties, and further complemented by innovation support measures for climate-friendly technologies – provided that significant knowledge spillover effects or adoption externalities are attributable to private R&D. In such a scenario, overlapping regulatory measures are inevitable, and an efficient mix of policy instruments has to take into account such economic interrelationships. Here, it is also important to closely coordinate the different policy measures across all stakeholders involved.

The EU ETS and the EEG, two key instruments of German climate and energy policy, may serve as an example for overlapping regulatory measures. As long as the objective of German climate and energy policy is confined to climate protection, the cost-effective implementation of a given emissions target can be achieved in static terms through the instrument of emissions trading. The additional promotion of renewable energy through feed-in tariffs merely leads to emissions being relocated within the EU ETS. As a result of this promotional measure, Germany's electricity industry – which, in terms of cost efficiency, has too strong a focus on the use of renewable energy – embarks on emission prevention, while "vacant" emissions are demanded elsewhere in the EU ETS. In this particular case, overlaps in regulation remain ecologically neutral but not cost-neutral. The higher proportion of renewable energy – as enforced by the EEG-based support – has the effect that the emission reduction target is achieved at unnecessarily high costs, and these costs are borne by electricity consumers.

But regulatory overlaps of the EU ETS and the EEG can also lead to other undesirable side effects. The EEG lowers the demand pressure on the supply of emission certificates, which results in price cuts for emission allowances. Plants that are most emission-intensive benefit from this, which means that, in terms of their energy mix, lignite-fired power stations for instance, are treated better than gas-fired power plants.[221] Within the framework of the EU ETS, regional carbon leakage occurs – largely to the benefit of countries that function as net importers of emission certificates and hence pay lower rates once emission prices drop, while net exporters lose out. Innovation incentives for climate-friendly production technologies derived from emissions trading are diminished by falling allowance prices. On a similar note, it is often argued that the promotion of renewable energy outside the EU ETS can contribute to emission reduction – e.g. in the area of heat generation. Yet, this hypothesis does not hold true: when analysing emission abatement costs, it turns out that the costs incurred by renewable energy, and photovoltaics in particular, are much higher than the prices of EU ETS certificates.

The same weaknesses can be observed with regard to climate protection targets that are complemented by additional energy efficiency provisions. Again, emissions within the EU ETS remain unaffected, while costs are increasing due to the fact that abatement costs are not balanced across different emission sources. As a result, climate protection becomes more expensive than necessary. Judged from this point of view, overlapping regulation for the sake of enhancing energy efficiency (such as the Eco-Design Directive for energy-using products) can be deemed counterproductive. While the emissions trading system creates incentives to compete for cost-efficient prevention measures, the Eco-Design Directive restricts the choice of products and forces manufacturers to modify their products, which leads to additional costs for producers and to welfare losses for consumers (cf. Box 17).

The Expert Commission is also sceptical concerning the introduction of energy or emission taxes as a climate protection measure to flank comprehensive emissions trading. From an ecological perspective, additional emission taxes within the EU ETS would simply evaporate – or at least this will be the case as long as allowance prices continue to be positive as a result of the EU ETS provisions. In the case of a sole emission tax, allowance prices would simply be reduced in line with the applicable tax rate. If tax rates differ between EU countries, or if national taxes do not refer to emission levels alone, this will result in multiple regulation requirements, which will incur additional costs.[222]

BOX 17

Counterproductive overlapping of emissions trading and energy efficiency measures

Example 1: The ban on conventional light bulbs
The ban on conventional incandescent light bulbs has led to a decline in the demand for electricity. As a result, the amount of CO_2 emissions caused by electricity generation is reduced. Yet the emission levels of the EU ETS sectors are not reduced. The electricity generating companies' lower demand for certificates leads to lower prices and thus to an increased demand for emission allowances from other EU ETS sectors. This means that CO_2 emissions are merely relocated. At the same time, the ban has limited the freedom of households to choose their type of lamps according to their own preferences.

Example 2: The ban on night storage heaters
The ban on night storage heaters has led to a decrease in full-load hours e.g. for base load plants operating on brown coal. This means that the respective plants produce less CO_2 emissions. On the part of base load plant operators, the demand for certificates decreases. As a result, certificates are becoming cheaper, and demand from other EU ETS sectors is increasing. CO_2 amounts emitted by the EU ETS remain stable. Outside the EU ETS, additional emissions are caused, as night storage heaters are replaced by oil and gas heaters. Moreover, home owners are restricted in their freedom to choose heaters according to their preferences.

If further objectives such as the advancement of renewable energy or energy efficiency improvements are to be justified, the stakeholders involved need to broaden their one-dimensional perspective on climate protection. The "extra costs" generated by overlapping regulatory policies could then, under the command of a reasonable mix of instruments, be overcompensated with the benefits from the pursuit of additional objectives.

As regards climate protection strategies, an emissions trading scheme with a price corridor will create incentives for innovation that are largely dynamically efficient. In the field of innovation policy, measures to internalise knowledge spillover should continue to focus on basic and applied research, while diffusion promotion should be applied where adoption externalities occur. From a theoretical point of view, there are indeed reasons to question the EEG's suitability as an innovation policy instrument.

Only very few empirical studies exist on the interaction effects between targeted innovation, climate and energy policy instruments. This also applies to the EEG. This research gap should be closed by means of systematic evaluation research activities.

2. Institutional aspects

Over the last 20 years, Germany has been exposed to increasing overlaps in environmental and energy policy issues and legislative initiatives at its institutional level. This poses a potential for conflict between the Environment and the Economics Department in particular. The latter is in charge of Germany's energy policy.

Already in the 1970s, a period that marked the beginning of an independent environmental policy in Germany, a rivalry developed between environmental concerns and the interests of energy and environmentally intensive industries affected by regulation. Existing conflicts of interest were aggravated with the increasing pressure to adopt a more stringent climate policy, and the call to promote renewable energy and energy efficiency not only as a complementary source, but also as development goals in the transformation of the energy system. The implementation of far-reaching energy policies, among them the EU ETS and the EEG, were pushed forward by the Environment Department and monitored very critically by the Economics Department.[223] Due to the scope and complexity of the issues concerned, an increasing number of other federal ministries had to be integrated into the coordination process.

Currently, ministerial responsibilities for climate and energy policies are scattered across several departments.[224] The area of power supply systems for instance is coordinated not only by the Federal Ministry of Economics and Technology (BMWi), but also by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and the Federal Ministry of Education and Research (BMBF).[225]

In the context of implementing the 6th Energy Research Programme, the BMWi is responsible for application-oriented project funding of R&D in the field of non-nuclear energy research (excluding renewables) and nuclear safety and repository research. In the field of renewable energy (excluding bioenergy), the BMU is in charge of application-oriented project support, while the BMELV is responsible for application-oriented project funding of R&D in the field of bioenergy. With but a few exceptions, institutional funding in the energy sector – which includes funding of the Helmholtz Association in particular – falls into the remit of the BMBF. The BMBF also supports project-oriented research on fundamental issues in the areas of energy efficiency, renewable energy, nuclear safety, waste management, radiation, fusion and precautionary research, as well as the training of experts and young scientists. Finally, the BMVBS is in charge of traffic research projects that are not included in the 6th Energy Research Programme, as well as research in construction and housing.

When analysing Germany's current institutional framework conditions, a range of issues can be instantly highlighted. Judged from an outside perspective, the federal ministries' public image and communication is inconsistent. Collaboration between the Federal Government and the *Länder* governments, each of which have their own approach to energy policy, is insufficient. The expansion of high-voltage lines, which has become necessary due to the increase in electricity from renewable energy, may serve as an example for the complexity of the coordination process involved.

Existing coordinative problems could be solved based on procedural or structural approaches. Procedural approaches address administrative coordination within the participatory process, while structural approaches primarily address the departmental layout. Thus, for instance, various stakeholders have called for establishing an Energy Ministry in Germany.[226] Denmark and Britain are among those countries that have already established such a ministry.[227] Advocates believe that a central ministry would enhance the visibility of issues arising in the context of mastering the complex challenges of the Energy Transition. Critics point to potential interdepartmental coordination problems, which would arise e.g. from conflicting objectives between nature conservation and the promotion of renewable energy.[228]

B 1–6 RECOMMENDATIONS FOR ACTION

Climate policy

The cost efficiency of EU climate policy should be increased by expanding European emissions trading to all emission sources. To improve innovation incentives created by the EU ETS, the Expert Commission recommends enhancing planning security for all companies involved. This should be implemented by means of binding emission reduction targets until at least 2030. In addition to this, minimum prices for emission allowances should be introduced.

Energy policy

In addition to the target of reducing greenhouse gas emissions, there are further energy-related policy objectives. These include the development of renewable energy and an increase in energy efficiency. These objectives can be justified by such factors as competitive advantages, the creation of "green" jobs and energy security. From a welfare economic perspective, these factors should be critically reviewed. Provided that explicit goals for developing the renewable energy sector and for increasing energy efficiency can be justified in terms of welfare policy, objectives should be implemented in the most efficient way. With regard to the renewable energy sector, the Expert Commission agrees with the recommendations of the German Council of Economic Experts and the German Monopolies Commission to introduce green certificates. An increase in energy efficiency should be implemented by introducing an energy saving quota. Especially in the building sector, which is characterised by major obstacles such as information asymmetries and the landlord-tenant dilemma, the quota system should be flanked by further measures. These include e.g. standardisation, saving regulations and financial incentives for energy-saving redevelopment. In addition to this, property, contract, planning, approval and tenancy law should be amended, and building regulations should be adapted.

Innovation policy

The issue of knowledge spillover effects in the field of R&D makes it necessary to support basic and applied research, e.g. by means of direct subsidies and R&D tax credits. Energy-related applied research should focus on key technological challenges associated with the Energy Transition, such as the development of new or improved renewable energy products and processes, storage and transmission technologies, as well as energy efficiency technologies in construction and transport.

Carbon capture and storage as a technological approach to climate protection should be researched and carefully assessed with regard to the opportunities and risks associated. In this context, demonstration projects should be implemented, with the purpose of developing and testing new technologies. A premature verdict for or against a specific technology should be avoided.

In the view of the Expert Commission, renewable energy policy is characterised by a drastic imbalance between diffusion promotion and the promotion of R&D. The Expert Commission recommends correcting this imbalance in favour of R&D funding.

While energy and climate policy measures can have a considerable impact on innovation incentives, only little empirical evidence has been provided to date. As a consequence, policy measures have to be evaluated on a regular basis and according to the latest scientific methods. Regular evaluations would enable the stakeholders involved to reliably assess overlaps in the regulatory fields of climate, energy and innovation policy.

Coordination

The fragmentation of responsibilities for energy research in Germany is quite bizarre, and responsibilities relating to the implementation of the Energy Transition are scattered widely. The Expert Commission reiterates[229] the need to coordinate and consolidate energy-related policies more closely. The pooling of competencies through the creation of an Energy Ministry is a much debated approach that has been adopted by a number of countries. Yet, in the view of the Expert Commission, this measure is not necessarily best suited for solving existing coordination issues. Even under the umbrella of one government department, contradictory assessments may persist and frictions may continue to occur and, conversely, constructive ways of collaborating may also be established across departmental boundaries. The launch of a national platform could be a viable alternative to one integrated Energy Ministry with full responsibility for the Energy Transition. Such a platform would comprise not only the relevant federal ministries, but also representatives of the *Länder* governments and key companies. Again, stringent management by the Federal Chancellery would be the prerequisite for successfully coordinating climate, energy and innovation policies.

Unnecessary coordinative efforts in the realms of climate, energy and innovation policies can only be prevented if solely those objectives are pursued that can be justified on the grounds of market failure. In the event that several objectives exist, these objectives have to be prioritised, which will facilitate clear recommendations for action. As regards regulation overlapping, ex-ante studies should be conducted to identify potential synergies and counterproductive effects. In order to prevent policy failure, policy initiatives of the EU, the Federal Government, several ministries and the *Länder* have to be coordinated more closely.

B 2 INTERNATIONAL R&D LOCATIONS

B 2–1 TRENDS IN R&D GLOBALISATION

The internationalisation of research and development (R&D) is continuously progressing and will become increasingly relevant also in the years to come. R&D globalisation leads to a relocation of R&D sites and a new balance of power in the world economy. This will have a major impact on Germany's policy options in the field of research and innovation.

One of the main reasons behind the ongoing internationalisation of R&D are the development strategies of numerous countries that are strengthening their efforts in the field of R&D and innovation. Major challenges, particularly those addressed by the priority areas of the Federal Government's High-Tech Strategy, are yet another reason for pursuing targeted and cooperative efforts across national boundaries. In addition to this, there is an emerging trend towards open, globally distributed innovation systems (open innovation). Finally, new information and communication technologies are reinforcing the trend towards open, globally distributed innovation processes.

The key players here are large R&D intensive multinational corporations that are spurring the development and worldwide distribution of products. High fixed costs for R&D and accelerated product cycles lead to the fact that amortisation in highly dynamic product segments can only be achieved through global operations. As a result, more and more companies are forced to position themselves on the global market – especially by means of R&D and production sites in several international locations.

The internationalisation of R&D activities is spurred on primarily by industries that are R&D-intensive and that are characterised by short development cycles, which is particularly the case in cutting-edge technology. The pharmaceutical industries and the electronics, telecommunications, information technology and software industries display a particularly high proportion of R&D expenditure abroad. But also in export industries such as the automotive, mechanical engineering and chemical industries – all of which play an important role for Germany's economy – foreign R&D activities are becoming increasingly important.

There are several key motives for conducting R&D abroad:
- market-seeking motives
- resource-seeking motives (R&D-related and technological motives)
- production and engineering driven motives (related to the production and value creation system)
- reactions to political and legislative conditions that make it necessary to conduct R&D simultaneously at several locations.

As regards market-seeking motives, surveys frequently mention the size and the growth of certain target markets as decisive factors, as well as the important role of individual lead markets. The capacity of a national market to absorb innovative products and the innovation orientation of local clients provides strong incentives for being in close proximity to customers, also in terms of R&D activities.

Resource-seeking motives refer to the availability of research resources and research findings, access to talent, and the opportunity to conduct R&D at reasonable costs. R&D centres are established primarily at locations that feature particularly high numbers of STEM subject graduates.

Another reason for the globalisation of R&D centres is the ongoing development of global production and value chains.[230] In many sectors, innovation success depends on close geographical proximity, manufacturing know-how, and simultaneous product and process development. Once multinational enterprises (MNEs) have established production plants in foreign locations, it will not be long until they also establish local development and engineering centres.

The internationalisation of R&D is also increasingly influenced by political and legal framework conditions. Differing regulations and standards make it necessary to develop and adapt products in several countries.[231] In addition, more and more countries are demanding a stronger local presence and higher domestic value-added shares, also known as local content requirements, with the aim of developing high-value production structures and securing technology transfer. Thus many countries demand that foreign MNEs strengthen their commitment to conducting R&D locally.[232] Especially in cases where public procurement plays a key role in the evolution of demand, companies that are present with local R&D sites will be treated more favourably.[233]

To quite a large extent, the internationalisation of R&D is also the result of acquisitions. Companies with existing research structures are often acquired, particularly in highly developed countries. Thus periods of extensive mergers and acquisitions activities are accompanied by an increased internationalisation of R&D. Yet this does not necessarily imply that new R&D capacities have been expanded – a fact that should also be taken into account when interpreting statistics on the internationalisation of R&D, if valid assessments and policy recommendations are to be derived.

However, it is important to differentiate long-term, stable structures from short-term changes. In the field of R&D, investor structures are relatively stable. The majority of investors come from highly developed countries that are well endowed with domestic multinational corporations, which also take on the role of major donors for foreign direct investment. By far the largest proportion of investors is made up of MNEs from the United States, followed by enterprises from Switzerland, Germany, Sweden and Japan.[234] In 2008, MNEs from the US invested a total of EUR 25 billion in foreign R&D activities.[235] Between 1998 and 2008, the foreign share of R&D expenditure of these companies increased from 13 percent to 16 percent.[236] In some smaller countries that have strong domestic MNEs, the proportion of foreign R&D is above 50 percent.

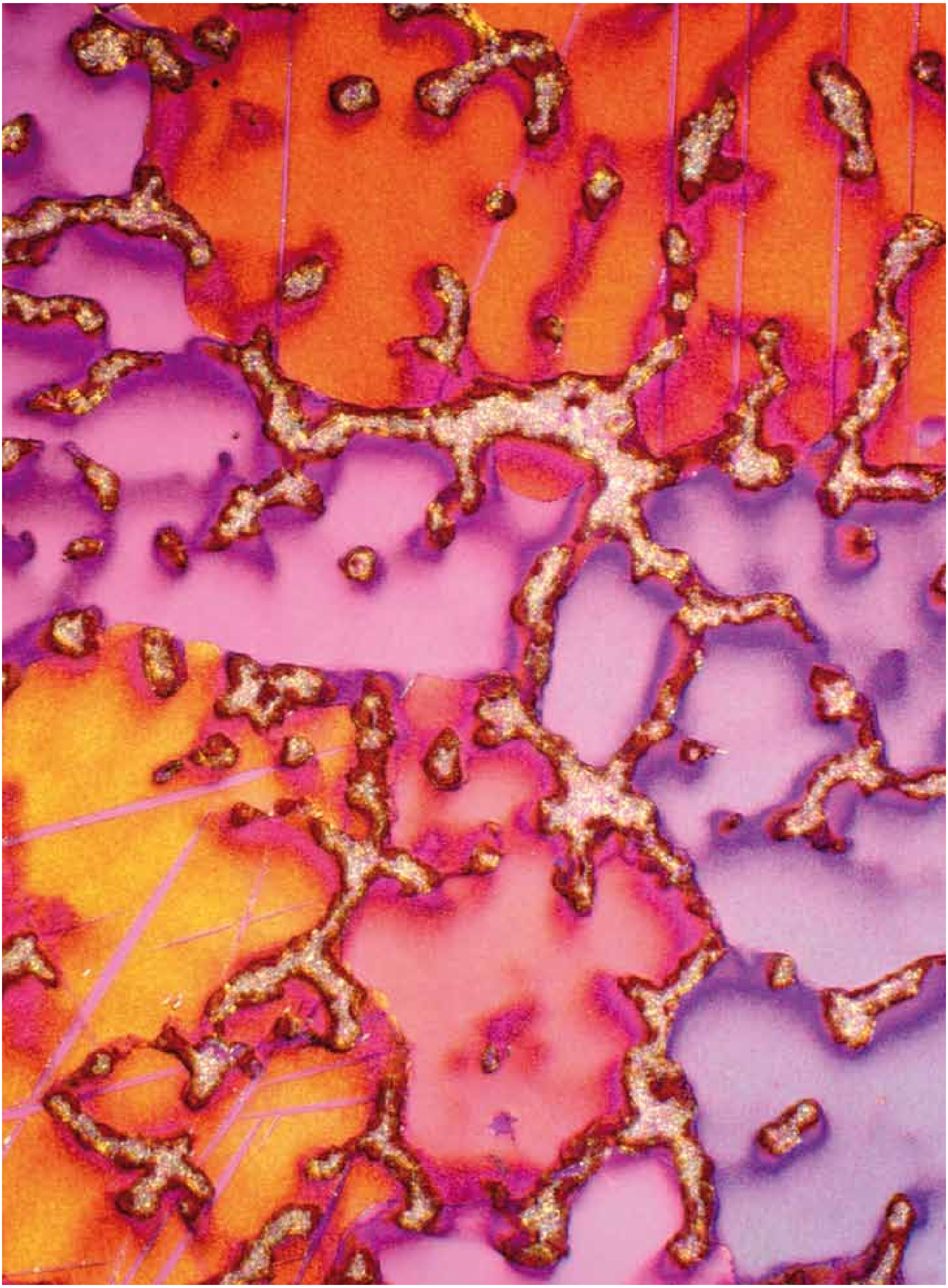
A considerable increase in foreign R&D investment could be observed between Europe and the United States and between Asia and the United States. Investment flows with Asian countries and developing countries are also becoming increasingly important. The 1990s and the beginning of the new millennium were dominated by foreign R&D activities of companies within the Triad countries. Here, US companies in Western Europe and Western European companies in the United States accounted for the largest share of investments. Only in recent years, a shift towards new target countries outside the Triad countries has been taking place.

With regard to the structure of the target countries for R&D investments, emerging changes are more pronounced than changes in the investor countries. Yet this does by no means imply that "classical" locations are swiftly replaced by new locations. As a location for foreign R&D investment, the United States continue to dominate the scene, with foreign MNEs investing a total of EUR 35 billion in R&D in 2009. The proportion of industrial R&D investment in the United States attributable to subsidiaries of foreign MNEs increased from 13 percent in 2000 to 15 percent in 2009. As a location for foreign R&D investments, Germany fills the important second position, followed by the UK and France.[237]

Table 4 displays the ranking of target countries for MNEs' R&D investments (as measured by R&D expenditure in billion euro in 2009) for selected OECD countries.

The share of R&D expenditures of foreign affiliates as a percentage of R&D expenditures of the business sector is not only a sound indicator of a country's attractiveness, but also for its dependency on foreign investors (cf. the right column of Table 4). A high value (e.g. above 50 percent) indicates a high dependency on foreign companies' management decisions, while a low value (e.g. less than 10 percent) indicates that foreign investors find impeding conditions for conducting R&D (e.g. Japan), or assess the target country's technological competencies as being limited. Some smaller countries, such as Israel, Ireland and the Czech Republic, have 60 to 70 percent shares of foreign investors. These countries make themselves dependent on foreign companies' investment deci-sions, since MNEs may relocate their R&D investments at any time.[238]

The BRIC countries and, especially, the emerging economies in Asia are playing an increasingly important role as locations for R&D investments by foreign companies. Yet these countries are not fully accounted for in official statistics. Only the most recent EU study[239] on the internationalisation of R&D addresses the interdependencies between the EU and key Asian countries. Figure 5 displays the worldwide interdependencies of R&D investments between the EU, Switzerland, China, Japan and the USA for the year 2007.



Magensium alloy.

View inside a low-pressure plasma reactor at the Fraunhofer IFAM's PLATO section.

TAB 04 **Ranking of target countries for foreign R&D expenditures of multinational companies (selected OECD member countries)**

	R&D expenditures of subsidiaries of foreign MNEs in 2009 (in billion euro)	Share of foreign MNEs' R&D expenditures as a percentage of business R&D expenditures in 2009
USA	34.8	15.4
Germany	*12.2*	*27.3*
Great Britain	8.8	46.7
France	4.8	19.6
Japan	4.9[2]	5.1[2]
Israel	3.8[2]	61.8[2]
Canada	3.3	32.6
Australia	3.0	32.1
Italy	2.6	24.5
Austria	2.5	52.3
Belgium	2.3	53.8
Sweden	2.1	29.6
Netherlands	1.6[1]	32.6[1]
Spain	1.5[2]	34.3[2]
Ireland	1.2	69.9
Czech Republic	1.0	58.0
Finland	0.7[1]	16.0[1]
Poland	0.5	50.5
Norway	0.5[2]	30.5[2]
Hungary	0.4	52.6

[1] 2008 figures, [2] 2007 figures.
Source: own depiction based on OECD, Main Science and Technology Indicators, Volume 2012/1.

In the medium term, major structural shifts away from the "traditional" target countries for R&D investments are likely to occur. It can be observed that Asia's R&D system is growing much faster than that of the highly developed Triad countries. Between 1996 and 2007, China's national R&D expenditure increased by 22 percent annually. Korea's annual growth rate was 12 percent, with Taiwan at 10.5 percent and Singapore at 9.5 percent. In the same period, national R&D expenditure in the United States, the EU and Japan increased by only 5.4 to 5.8 percent. MNEs are thus provided with further incentives for establishing locations in some of the world's most dynamic R&D regions.

Against this background, there has been an increasing shift of R&D investments towards aspiring emerging economies – a trend that is certainly going to progress in the future. Investment flows are primarily focussed on BRIC countries, and a particularly strong increase can be observed in China. Other important new R&D locations for MNEs include Singapore, India and Israel, as well as selected Eastern European countries.

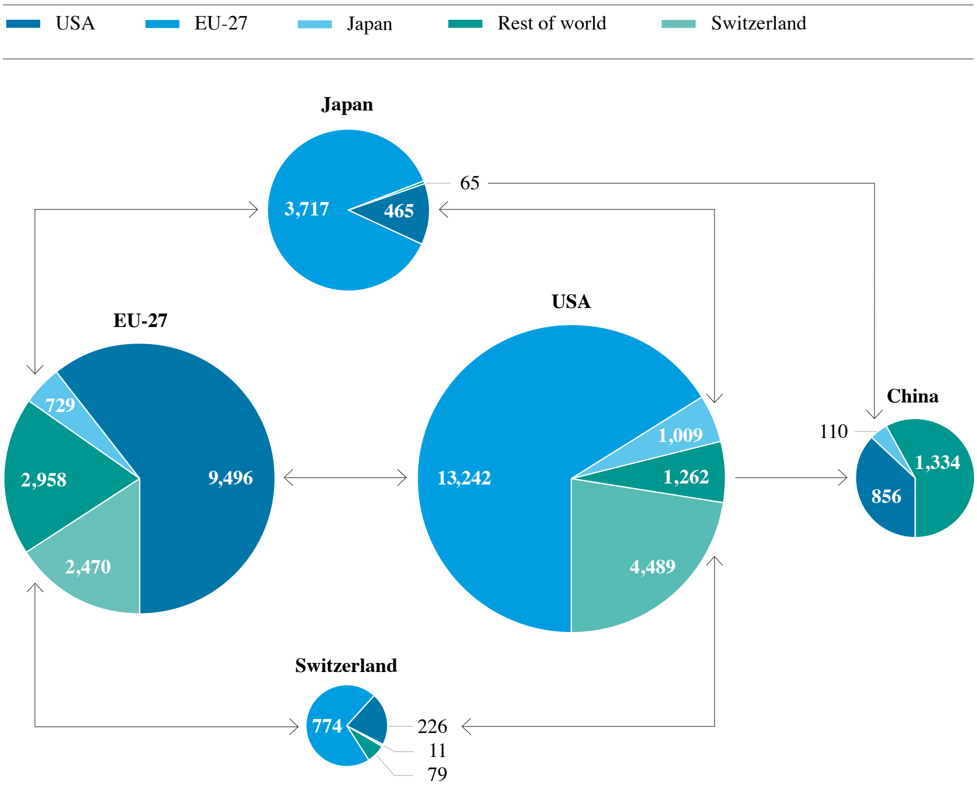
Over a period of ten years (between 1998 and 2007), Asia's share of foreign R&D expenditure by US-based MNEs increased from 11 percent to 20 percent. Within the same period, Europe's and Canada's shares decreased from 83 to 74 percent. Similar structural shifts can be observed in terms of R&D investments by foreign MNEs from Western Europe and Japan. In future, the structure of the global R&D system will be much more multipolar. This ongoing trend entails serious consequences for national research and innovation policies.

FOREIGN R&D INVESTMENTS BY GERMAN COMPANIES B 2–2

German companies are represented at many locations across the globe – not only with sales offices and production facilities. To an increasing extent, German companies have to secure key markets through research and product development on site. In 2009, German companies spent a total of EUR 11.3 billion on foreign R&D. German companies highly prioritise their foreign R&D activities. Foreign and domestic R&D activities are often characterised by a division of labour and tend to reinforce each other in a complementary manner. In this respect, an increase in foreign R&D investments could be assessed positively as such investments will also augment Germany's position as an innovation hub. Yet this can also lead to temporary adverse effects, which is e.g. the case when foreign R&D is increased at the expense of domestic capacities, or when promising research areas are no longer pursued at the home base.[240]

In the 1990s, foreign R&D investments experienced a sharp upward trend. Between 1995 and 2001, R&D investments of foreign affiliates of German MNEs increased from EUR 5 billion to EUR 12 billion (cf. Table 5). During this period, the foreign R&D share increased from 23 percent to nearly 35 percent. German companies followed the overall globalisation trend of R&D and proved to be very active in the United States and in a number of European and Asian countries.

FIG 05 **Inward BERD relations between the EU-27, the USA and selected other locations in 2007**



Comment: companies from the EU-27 invested EUR 774 million in R&D in Switzerland in 2007;
Swiss companies invested EUR 2,470 million in R&D in the EU-27 in 2007.
Figures for Switzerland include the services sector; figures for China estimated based on national data and data on foreign R&D by the United States and Japan.
Source: *Europäische Kommission* (2012b: 29).

TAB 05 **Structure of R&D expenditures of German MNEs 1995 to 2009**

	1995	2001	2007	2009
Foreign R&D expenditures of German companies (billion euro)	5.1	11.9	9.4	11.3
Domestic R&D expenditures of German companies (billion euro)	17.0	22.5	29.2	30.1
Total R&D expenditures of German companies (billion euro)	22.1	34.4	38.6	41.4
Share of foreign R&D expenditures as a percentage of total R&D expenditures	**23.1**	**34.6**	**24.4**	**27. 3**

Source: Own depiction based on IWH et al. (2013).

Foreign R&D expenditures of German companies by industry 2001 to 2009 TAB 06

Industry	2001	2005	2007	2009
	R&D expenditures of German companies abroad (billion euro)			
Manufacturing	11.6	11.3	8.8	10.7
Chemical industry	3.6[a]	1.2	1.6	0.7
Pharmaceutical industry		2.1	2.1	3.7
Mechanical engineering	0.4	0.7	0.8	0.5
Computer, electrical engineering, optics	2.8	2.3	1.2	1.8
Automotive engineering	4.6[b]	4.8	3.0	3.6
Remaining sectors	0.4	0.2	0.6	0.6
Enterprise sector in total	11.6	11.4	9.4	11.3
	Proportion of German companies' foreign R&D expenditures in percent			
Manufacturing	36.4	30.7	24.2	27.4
Chemical industry	48.0[a]	29.7	29.9	25.4
Pharmaceutical industry		51.8	69.2	54.0
Mechanical engineering	39.5	27.2	29.4	19.5
Computer, electrical engineering, optics	37.4	31.6	20.2	33.2
Automotive engineering	30.1[b]	26.5	15.6	18.3
Remaining sectors	13.7	10.1	27.3	25.7
Enterprise sector in total	34.7	29.9	24.4	27.3

[a] The values for the chemical and pharmaceutical industries are not separately identifiable for the year 2001.
[b] Vehicle construction
Source: Own depiction based on IWH et al. (2013).

The years 2002 to 2007 saw a temporary return to investments in domestic R&D. In the preceding years, the number of foreign R&D sites had increased considerably, which resulted in coordination issues in transnational project collaboration.[241] By 2007, foreign R&D expenditure of German companies had temporarily decreased from EUR 11.9 billion to EUR 9.4 billion. In the period 2002 to 2007, domestic R&D expenditure increased from EUR 22.5 billion to EUR 29.2 billion (cf. Table 5). A new surge in the globalisation of German R&D could be observed since 2008. Since then, foreign R&D expenditure has been growing much faster than domestic R&D expenditure. The increase of foreign exports and foreign investments following the financial crisis was partially driven by an increase in foreign R&D activities, especially in the emerging economies.

The manufacturing industries are a major driving force behind the internationalisation of R&D.[242] Strong export activities will lead to the creation of local production sites and an increase in direct investments, albeit with a certain delay. This will attract further R&D investments from abroad. As a result, foreign R&D investments of German companies are concentrated on a limited number of export sectors. Thus, automotive engineering alone accounts for 38 percent of foreign investment by Germany's private sector, with a total R&D expenditure of EUR 3.6 billion. Another EUR 3 billion (27 percent) are attributable to mechanical engineering, electrical engineering and the chemical industries. Germany's pharmaceutical industry is also very active as an investor in foreign R&D. Thus, between 2003 and 2009, the pharmaceutical industry's foreign R&D expenditure more than doubled (with EUR 3.7 billion in 2009). In the pharmaceutical industry, the share of foreign R&D amounts to more than 50 percent, while other sectors invest between 20 and 33 percent of total R&D expenditure abroad (cf. Table 6).

The United States continue to be the most important foreign R&D location for German companies, which is largely owing to high R&D investments in the pharmaceutical and electrical engineering industries. In 2009, one third of the German enterprise sector's foreign R&D investment was allocated to locations in the United States (a total of EUR 3.8 billion). Other important target countries include Austria (EUR 1.3 billion), France (EUR 0.8 billion), the UK (EUR 0.4 billion) and Switzerland (EUR 0.4 billion)[243]. Following in sixth position is Japan with a total of EUR 0.3 billion foreign R&D. Figures are based on estimates by the German Institute for Economic Research *(DIW Berlin)*. Figures on the enterprise sector's foreign R&D expenditure are currently not fully recorded by the *SV Wissenschaftsstatistik.*[244] Especially R&D investments by German companies in important emerging economies (China, India, Brazil, and Russia) have been documented only partially to date.

Besides the *SV Wissenschaftsstatistik,* the *Deutsche Bundesbank* also publishes data on cross-border R&D expenditures of German companies with foreign affiliates (cf. Table 7). While these figures only cover a fraction of all foreign R&D spending by German companies, they still allow for conclusions regarding the relevance of key target countries. The data provided by the *Deutsche Bundesbank* primarily relate to payments of German-based corporate research units to subordinate research units abroad. This does not include foreign R&D expenditures in application-oriented research funded by foreign business units. These application-oriented R&D expenditures tend to be several times larger than corporate R&D expenditures.

Despite the fact that available data on R&D expenditure are limited, foreign R&D activities of German companies can still be analysed by examining recent patent statistics. These statistics itemise the inventors' place of residence and the location of the patent-filing enterprise. Thus, when analysing patent applications of German companies that involve inventors domiciled abroad, conclusions can be drawn regarding the presence of German companies in certain target countries. From the inventor's place of residence it can be indirectly concluded that the respective research was also conducted in the country concerned.[245] Furthermore, the patent class, also itemised in the patent statistics, provides indications on the technological fields in which individual companies are active in specific countries.[246]

Cross-border foreign R&D expenditures of German companies (mainly corporate headquarters' expenditures) TAB 07

	R&D expenditure in 2011 (billion euro)	Target country's share in recorded foreign R&D expenditures (in %)
1. USA	0.78	18.0
2. Austria	0.53	12.1
3. France	0.50	11.7
4. Switzerland	0.34	7.9
5. Great Britain	0.34	7.8
6. Japan	0.26	6.1
7. Italy	0.19	4.4
8. India	0.15	3.4
9. China	0.12	2.7
10. Netherlands	0.10	2.3
Rest of world	1.02	23.5

Source: own depiction based on IWH et al. (2013).

The relevance of foreign inventors within German companies, as measured by the German Applications of Foreign Inventions (GAFI) indicator, has steadily increased over time. The GAFI indicator refers to patent applications with at least one inventor residing outside of Germany and one applicant based in Germany. To determine the GAFI ratio, the GAFI value is calculated in relation to the total number of patents filed by German applicants. In 1991, the GAFI ratio was 8 percent; it rose to 13 percent by 2000 and reached a value of almost 16 percent in 2009. The GAFI indicator is used to detect long-term trends, even though it can only be used as a proxy variable for foreign R&D activity.[247]

What is striking is the relatively high number of inventions filed by researchers residing in the Netherlands and Switzerland. These values tend to be significantly higher than the R&D expenditure in the respective countries, as indicated in the previous section. The GAFI ratios of different countries have displayed considerable structural changes over time. Thus, for instance, the relevance of foreign inventors in the United States has decreased from 26.5 percent between 1991 and 1994 to 19.4 percent between 2006 and 2009. Within the same period, the relevance of foreign inventors in the UK and Japan has declined from 10.4 percent to 7.0 percent and from 4.9 percent to 3.0 percent respectively. A considerable increase could be observed regarding inventors residing in the Netherlands, a country that has doubled its GAFI ratio since 2000.[248]

Patent figures are also suited to record emerging countries as R&D locations. A growing proportion of patents filed at the European Patent Office refer to inventions involving researchers residing in China. The GAFI ratio for China rose from 0.3 to 3.7 percent (cf. Table 8). An increase in the GAFI ratio has also been recorded for other countries, among them India, Hungary, the Czech Republic and Brazil.[249] Meanwhile, the relevance of the Russian Federation as a R&D location for German enterprises has declined over time. With a GAFI ratio of 1.9 percent between 1991 and 1994, Russia still ranked in first place within the BRIC countries. However, between 2006 and 2009, this share fell to 0.8 percent and Russia was overtaken not only by China, but also by India, Brazil, Hungary and the Czech Republic.

An analysis based on the GAFI indicator also provides information regarding the industries and fields of technology that German companies with inventions in foreign R&D locations are active in. In the United States, German companies are strongly active in the following areas in which foreign inventors have been recorded: computer technology, pharmaceuticals, biotechnology, organic fine chemistry and basic materials chemistry. German companies, by contrast, tend to be less active with R&D in the United States in the areas of transport technologies, thermal processes and apparatus, motors, pumps and turbines, medical instruments, measurement, digital communication technology, as well as electrical machinery and apparatus.

German companies thus tend to employ large numbers of foreign inventors in the United States in research areas in which the United States are technological leaders (e.g. computer technology, pharmaceuticals and biotechnology). At the same time, German companies in the United States conduct relatively little research in areas where the relevant technological expertise is to be found in Germany or in other countries (e.g. in the fields of transport, engine and turbine construction and measurement).

It is also worthwhile comparing the foreign inventive activities of German companies with the respective foreign inventive activities of US companies.[250]

TAB 08

Ranking of important foreign invention locations for German companies

Foreign inventor locations	GAFI ratio 2006–09 (%)	GAFI ratio 1991–94 (%)
Major existing foreign inventor locations		
1. USA	19.4	26.5
2. Netherlands	12.1	5.5
3. France	9.6	9.2
4. Switzerland	9.0	5.7
5. Austria	8.5	9.8
6. Great Britain	7.0	10.4
7. Italy	4.3	3.4
8. Belgium	3.4	4.9
9. Spain	3.3	2.7
10. Japan	3.0	4.9
New foreign inventor locations		
China	3.7	0.3
India	1.0	0.4
Czech Republic	0.9	0.3
Hungary	0.9	0.5
Brazil	0.9	0.4
Russia	0.8	1.9
Australia	0.8	0.7
Poland	0.6	0.3
Korea	0.5	0.1
Slovenia	0.5	0.2

The GAFI indicator refers to patent applications with at least one inventor residing outside of Germany and one applicant based in Germany. To determine the GAFI ratio, the GAFI value is calculated in relation to the total number of patents filed by at least one applicant based in Germany.
Source: own depiction based on IWH et al. (2013).

Thus, for instance, it can be observed that in the pharmaceutical, biotechnology, semiconductor and computer technology industries, Germany is far more dependent on foreign inventions than the US. At the same time, when compared with Germany, the United States are much more dependent on foreign inventions in the fields of transport technologies, machine tools, optics and civil engineering.[251]

Conclusions on the international division of labour can also be drawn by examining the distribution of competencies between Germany and other target countries. For instance, German companies with foreign inventors operate in China in the following areas: basic materials chemistry, macromolecular chemistry, polymers, organic fine chemistry, and electrical and energy engineering. At the same time, German companies with foreign inventors in China record relatively low numbers of inventions in the following areas: transport, thermal processes and apparatus, motors, pumps and turbines, machine tools, food chemistry, pharmaceuticals, medical instruments and optics.[252]

US companies with R&D activities in China are focussing on quite different areas. Thus, in the fields of computer technology and communication technology, US companies display a relatively high number of foreign inventors who are domiciled in China. As China has been developing these areas in particular, it is now closely linked with US enterprises through transnational value chains.

B 2–3 GERMANY AS AN R&D LOCATION FOR FOREIGN COMPANIES

Germany is a core location within a dense network of R&D related to foreign direct investment. While the United States are the most important hub within this network, Germany is occupying an important second position. Germany's strongest links are with the United States and several European countries. Germany plays a major role as a location for R&D subsidiaries of foreign MNEs and has been able to continuously advance its position over the last two decades.[253] In 2009, foreign MNEs invested EUR 12.3 billion in R&D in Germany, while employing a staff of 85,000 R&D fulltime equivalents, which amounts to approximately one quarter of the German economy's total R&D personnel.[254]

The relevance of foreign companies as R&D investors within the German innovation system has increased steadily since the early 1990s. While their shares in the R&D expenditure of Germany's business sector had amounted to 16 percent in 1993, this figure went up to 25 percent in 2001 and reached 27 percent by 2009. Table 9 shows a comparison of the R&D expenditure of foreign MNEs in Germany and the domestic R&D expenditure of German companies. While German companies increased their R&D expenditure between 1995 and 2009 by approximately 50 percent in nominal terms, foreign companies almost tripled their R&D expenditure in Germany during the same period. A significant part of this increase is attributable to business acquisitions.

Foreign enterprises are making a lasting contribution to technological development in Germany and are major employers of highly skilled workers. Between 1997 and 2009, R&D staff levels in subsidiaries of MNEs were increased by 37,500 jobs in total. A substantial part of this increase is the result of acquisitions of German companies by foreign MNEs. During the same period, the number of R&D personnel in German companies remained almost stable.[255]

Table 10 shows the importance of key industries in which foreign companies play a major role in implementing R&D and securing employment in Germany. The manufacturing industries remain at the forefront here; especially the electrical, vehicle construction, chemical and pharmaceutical industries, as well as mechanical engineering. The main areas in which foreign companies provide employment in R&D are largely identical with those fields that German companies also excel in. The proportion of foreign R&D employers in Germany is particularly high in other transport equipment – especially in the aerospace industry (81 percent) – and in the pharmaceutical industry (44 percent). In electrical engineering (including computer technology) the proportion of foreign companies amounts to 29 percent. Yet, in contrast to other industries, an increase in foreign R&D employment has not been recorded in recent years. Throughout the last decade, a considerable decline has been recorded in the field of computer technology, where a significant shift towards the Asian markets could be observed. In addition to manufacturing, the services sector is playing an increasingly important role for foreign R&D employment. Particularly in the areas of business services and information and communication services, the number of R&D personnel employed by MNEs increased from 2,200 to 9,300 over the past decade.

Foreign companies focus their R&D activities on industries and technology fields in which Germany has proven technological expertise and in which the research priorities of domestic enterprises are reflected. Existing strengths are thus further reinforced. It is only rarely the case that foreign investors develop new fields of competence in Germany. Acquisitions of existing businesses and the creation of R&D sites in the vicinity of existing R&D centres of German companies are strong driving forces here. Both factors

Structure of business R&D expenditures in Germany between 1995 and 2009 TAB 09

	1995	2001	2007	2009
R&D expenditures of foreign MNEs in Germany (billion euro)	4.3	8.9	11.2	12.3
Domestic R&D expenditures of German companies (billion euro)	22.4	27.1	31.6	32.7
Total business R&D expenditures in Germany (billion euro)	26.7	36.0	42.8	45.0
R&D expenditures of foreign affiliates as a percentage of total business R&D expenditures in Germany	16.1	24.8	26.3	27.3

Source: own depiction based on IWH et al. (2013)

R&D personnel of companies in Germany between 1997 and 2009, according to industries TAB 10

	1997	2001	2007	2009
R&D personnel employed in German subsidiaries of foreign MNEs (full-time equivalents)	47,500	73,200	81,136	84,975
R&D personnel employed in German companies in Germany (full-time equivalents)	238,770	234,057	240,717	247,516
Share of foreign companies' personnel as a percentage of private R&D personnel in Germany	16.6	23.8	25.2	25.6
R&D personnel in foreign MNEs according to industries (full-time equivalents)				
Chemicals / pharmaceuticals	6,900	11,250	14,372	12,129
Mechanical engineering	5,900	7,500	7,741	7,878
Electrical engineering / computer	17,900	20,300	20,763	18,247
Vehicle construction	11,200	21,700	24,840	25,865
Business services	–	4,177	4,253	4,288
Information and communication	–	–	–	4,986
Foreign MNEs' personnel as a percentage of industry-specific R&D personnel				
Chemicals / pharmaceuticals	14.6	26.7	34.7	29.9
Mechanical engineering	15.0	20.1	18.4	20.8
Electrical engineering / computer	24.9	25.4	29.2	28.9
Vehicle construction	13.7	24.6	25.6	26.1
Business services	–	20.1	12.6	19.6
Information and communication	–	–	–	226

Source: own depiction based on IWH et al. (2013)

tend to have a preserving effect, rather than stimulating the creation of new areas of competence in Germany. As this is an obvious deficit, Germany will have to develop new strenghts also in the area of cutting-edge technology – precisely the area in which foreign MNEs are the main investors.

In order to analyse R&D and invention activities of foreign companies, indicators from patent statistics are used to complement available data. The increasing activity of foreign patent applicants involving German inventors is measured by the FAGI indicator (Foreign Applicants of German Inventions). The FAGI value serves as an indicator of research and invention activities of foreign companies located in Germany, since the presence of inventors in Germany suggests that the corresponding R&D work was also conducted in Germany.[256] The FAGI ratios in the periods from 1991 to 1994 and from 2006 to 2009 increased continuously. The importance of patent applications by foreign MNEs involving German inventors increases over time. Over the last 15 years, however, significant structural shifts have occurred regarding the home base of the applicants. These are summarised in Table 11. Especially businesses from the US, Switzerland, the Netherlands and France are dominating the scene. Between 2006 and 2009, the overall relevance of patent-filing enterprises based in France, Finland, Japan and Sweden has increased. This is complemented by growing numbers of MNEs from emerging economies – especially companies from China and Korea as well as Central and Eastern Europe, all of which also employ inventors residing in Germany.

TAB 11

Share of foreign applicants with inventors residing in Germany (FAGI ratio)

Applicants‘ country of residence	FAGI ratio 2006–09 (%)	FAGI ratio 1991–94 (%)
Existing important countries of residence		
1. USA	28.7	29.9
2. Switzerland	23.1	22.8
3. France	11.1	8.9
4. Netherlands	5.6	14.4
5. Finland	4.7	0.4
6. Japan	4.6	2.3
7. Sweden	4.4	2.3
8. Austria	4.0	4.3
9. Belgium	2.7	2.8
10. Great Britain	2.1	5.4
New countries of residence		
China	0.5	0.0
Korea	0.4	0.0
Australia	0.3	0.3
Israel	0.2	0.4
India	0.1	0.0
Russia	0.1	0.2
Poland	0.1	0.0
Czech Republic	0.1	0.0
Hungary	0.1	0.0
Turkey	0.1	0.0

The FAGI indicator refers to patent applications with at least one inventor residing in Germany (German inventor) and one applicant residing outside of Germany (foreign applicant). To determine the FAGI ratio, the FAGI value is calculated in relation to the total number of patent applications with at least one German inventor.
Source: own depiction based on IWH et al. (2013)

An analysis of the FAGI ratios also allows for an assessment regarding the competencies that companies from specific countries are seeking in their R&D activities in Germany. Companies from the United States continue to make up the largest group. These focus their research in Germany on the areas of transportation (8 percent of patents filed by US companies), medical instruments (8 percent), and electrical machinery and apparatus (7 percent). Yet in other fields of technology, US companies are not very active in Germany. US companies tend to prefer international locations other than Germany when it comes to R&D in the field of pharmaceuticals, biotechnology, and semiconductor and communication technology.

The research and invention activities of Western European companies are partially focussed on the same fields. Yet it has also become apparent that applicants from specific home countries have specific technology profiles. Particularly striking is the strong focus on medical instruments (15 percent) by Swiss companies in Germany, as well as the strong focus on digital communication by businesses from France, the UK and the Netherlands.[257]

Germany’s technological fields of competence can also be assessed through a comparative analysis with the foreign R&D portfolio of US-based corporations. Germany continues to be not only the most important foreign R&D location for US companies, but also the second-most important location for inventors after the United States. That said, a number of emerging economies are increasingly competing with Germany as a location for R&D, among them China, India and Israel. When analysing the profile of foreign inventions by applicants from the United States, and specifically the profile of inventions in Germany, it turns out that the commitment of US companies continues to be high in technology areas in which Germany has been traditionally strong. This applies to the following areas in particular: motors, pumps and turbines, medical instruments, as well as electrical machinery and apparatus. At the same time it also becomes apparent in which fields US companies have ceased to conduct research in Germany and have instead relocated to other, more renowned R&D locations. In the field of computer technology for instance, US companies are much more present in the UK and in China, while India serves US companies as a location for R&D in data processing and IT services. US companies increasingly choose emerging economies as locations for their R&D, especially in the area of cutting-edge technologies. A detailed analysis of foreign patenting profiles of MNEs from different nations could serve as a useful diagnostic tool to assess Germany's technological performance.

B 2–4 FOREIGN R&D ACTIVITIES IN EUROPE

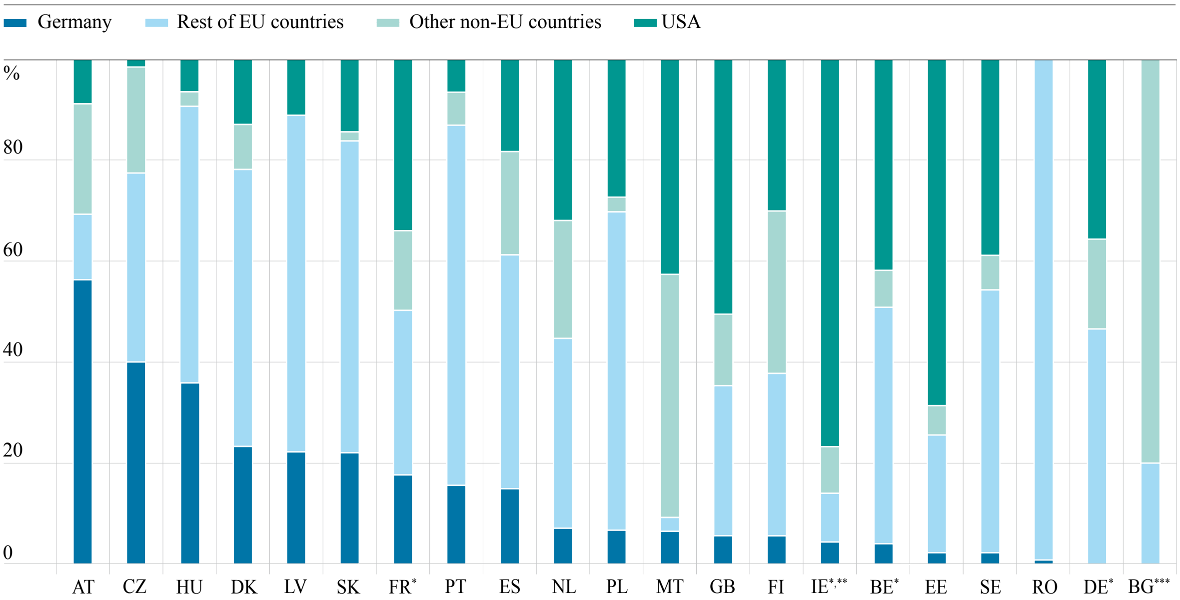
In the EU 27, the distribution of domestic patents with at least one domestic inventor and at least one foreign applicant – which serves as an indicator of R&D internationalisation – is very heterogeneous. Most of these patents can be attributed to Germany (27.3 percent), the UK (18 percent) and France (14.3 percent), i.e. these countries attract the largest part of foreign R&D activities. Between 2001 and 2009, Germany managed to increase its share of such patents within the EU-27 by approximately 1.7 percentage points, whereas the UK and France lost percentage points (2.9 and 1.3 percentage points respectively). However, when examining the number of patent applications per 1 million inhabitants (as opposed to absolute numbers), an entirely different picture emerges: here, small countries such as the Netherlands, Belgium, Luxembourg and Sweden tend to score best in the patent application statistics.

Figure 6 shows the share of R&D activities of German and US companies in Europe as compared with other European and non-European companies. German enterprises are represented in numerous EU countries and make up a large part of foreign R&D activities in the respective countries. The share of German companies in foreign R&D expenditure is above 50 percent in Austria, above 30 percent in the Czech Republic and Hungary, and above 20 percent in Latvia, Slovakia and Denmark. It is also noteworthy that US companies are primarily represented in EU countries where German companies have made only minor R&D investments – and vice versa.

It can be generally observed that foreign direct investment will also result in R&D activities at a later stage. Hence a country's market size and revenue plays a key role in attracting foreign R&D.[258] In earlier studies, several factors have been identified that may be relevant to MNEs when choosing their R&D locations. To begin with, a country's industry structure and existing R&D activities play an important role: companies seek the proximity of other companies from the same industry and from other industries, which will enable intra-industry and inter-industry spillover effects. Thus existing private R&D investments in a potential new location are an important decisive factor for MNEs when choosing a location.[259] Another important factor is the quality of the local research system. When companies choose their R&D locations, academic research, collaborations with local universities and the supply of human capital are taken into account.[260] The protection of intellectual property rights is another important criterion for businesses in deciding for or against a location.[261] There is only weak evidence to confirm that lower labour costs facilitate the establishing of foreign R&D capacities,[262] whereas geographical proximity does indeed have a positive effect.[263]

A recent study examines the determinants of foreign R&D activity in the EU-27 countries on the basis of cross-border patents.[264] The study largely confirms findings from earlier studies. Thus it could be shown that a high proportion of a region's labour force working in scientific and technical careers encourages foreign R&D activities. This suggests that human capital is indeed an important factor for attracting foreign R&D. The study further confirms that private R&D expenditure and foreign R&D expenditure are positively linked, which suggests the existence of

FIG 06 **Important groups of investors in the EU target countries in 2007**



*Manufacturing only; **values for the year 2005. ***Germany included in rest of EU countries, United States included in other non-EU countries.
Source: *Europäische Kommission* (2012b).

knowledge spillover effects.[265] R&D tax benefits also have a positive effect on foreign R&D activities. If one examines the changes in tax rates over a longer period, there is evidence that higher statutory corporate tax rates are negatively linked with foreign R&D activities, which means that R&D activities decline as a consequence of an increase in tax rates.[266]

In terms of private R&D expenditure, Germany is relatively well-positioned when compared on a European level. Yet, when it comes to human capital, Germany displays deficits particularly with regard to its shortage of students in STEM subjects and engineering.[267] This is an area that requires further efforts if Germany is to strengthen its position in the international competition for R&D locations.

But also within a particular country, regions differ in terms of their attractiveness as R&D locations. In Germany, foreign R&D activities focus on the south and southwest of the country (cf. Figure 7), and this also applies to German patent applications.[268] The analysis of the determinants of foreign R&D activities in Germany[269] shows, again, that the existing industrial structure plays an important role. Thus, intra-industry and inter-industry spillover effects are important for a company's locational decision at regional level – just as they are at national level. The key role of the research system has also been confirmed in the regional analysis. Furthermore, a region's public education and science structure and sector-specific human capital have been identified as important decisive factors.

KNOWLEDGE FLOWS IN INTERNATIONAL R&D NETWORKS B 2–5

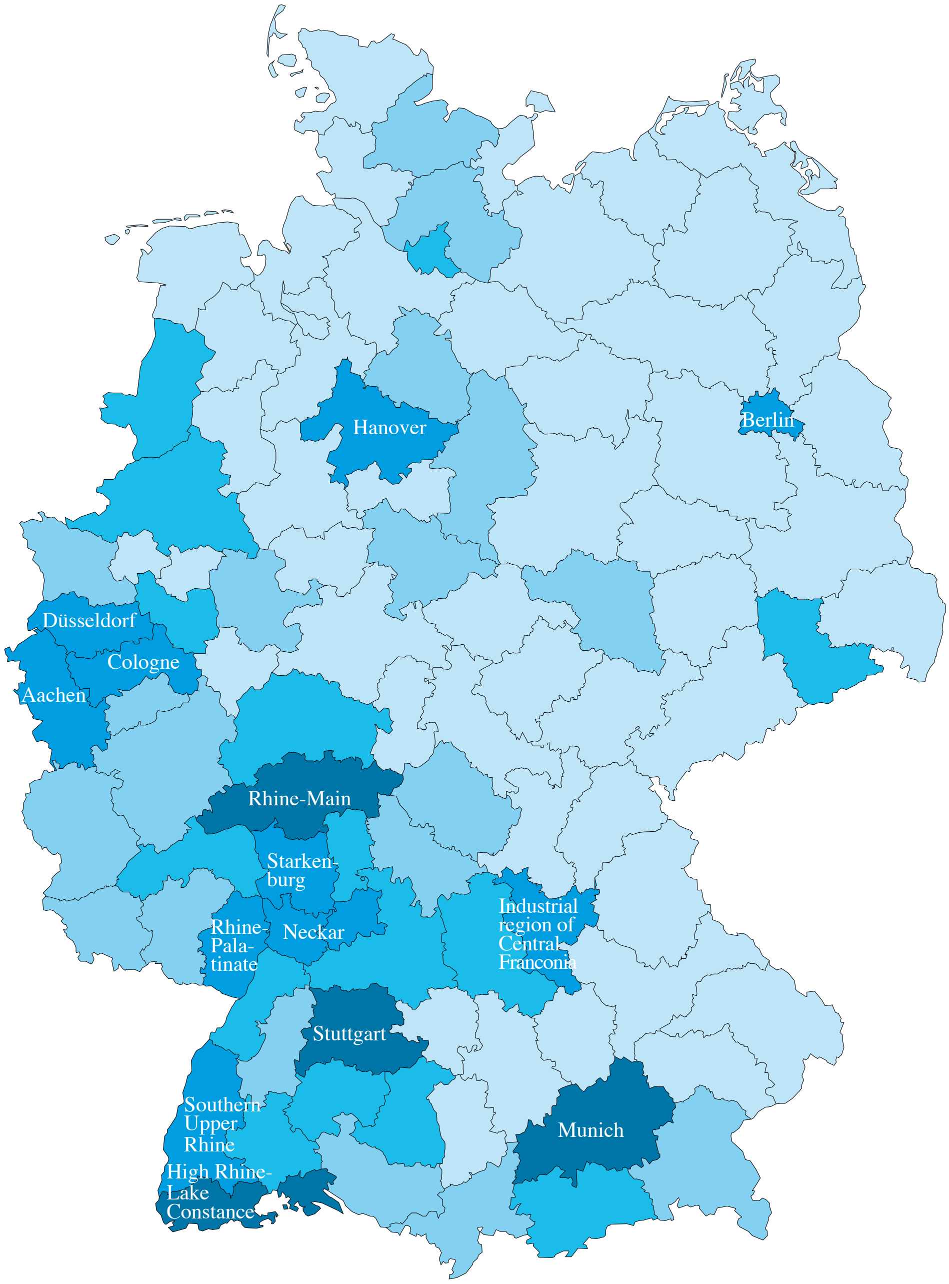
The increasing importance of technological motives in the choice of international R&D sites demonstrates that MNEs can gain access to new knowledge by developing international R&D locations. A number of empirical studies have addressed the impact of foreign R&D investments on productivity and innovation activity of domestic companies that can result from technology transfer within an MNE or knowledge spillovers in the domestic economy.

Studies on German and British enterprises[270] have shown that companies with relatively strong R&D ties with the United States – as measured by the share of patents with inventors residing in the US – benefit disproportionately from R&D growth in the United States, when compared with less well-

Share of patent applications of foreign manufacturing enterprises in spatial planning regions, as measured by the total number of foreign patent applications in Germany in 2008

FIG 07

above 5% | 2%–5% | 1%–2% | 0.5%–1% | below 5%



Source: own depiction based on IWH et al. (2013).

connected competitors. For UK-based companies, knowledge spillovers from foreign R&D investment to domestic corporations result in a productivity increase of 5 percent on average, while German companies benefit from a 15 percent productivity increase.[271] Moreover, it can be assumed that only some of the potential knowledge spillover effects can be documented by patent statistics. In addition, the statistics clearly indicate for German companies that close cooperation with US enterprises resulting in joint patent applications has a further positive effect on domestic productivity.

But a reverse transfer of technological know-how stemming from foreign R&D activities can also affect the local economy beyond corporate boundaries, provided that local companies are subjected to knowledge spillovers (an effect that is also known as inter-firm reverse technology transfer). Initial empirical studies have confirmed that the domestic economy can benefit from knowledge spillovers of MNEs with foreign R&D activities.[272] Based on patent citations, a study on European MNEs[273] has identified knowledge flows in the chemical and pharmaceutical industries between multinational corporations' foreign R&D activities in the US to domestic companies in Europe. Thus it could be shown that an MNE's integration in the home country – i.e. a close relationship with suppliers, clients, competitors and local universities – can foster investment in basic R&D. It could also been shown that such spillover effects increase in line with the differences in technological development between the home country and the United States.

Empirical evidence from individual country studies suggests that, under certain circumstances and in certain industries, the international relocation of R&D activities can be beneficial to MNEs in their home country as well as to domestic businesses in the form of knowledge spillovers. Foreign R&D activities provide options for letting domestic corporations and local companies benefit from knowledge created abroad. As a general rule, it can be assumed that potential spillover effects are strongest when stemming from foreign R&D knowledge transfer of technologically advanced countries such as the United States.

NEW CHALLENGES FOR THE RESEARCH AND INNOVATION POLICY IN GERMANY

B 2–6

The globalisation of research and innovation urges us to reconsider the scope of national and European innovation policies. The analysis of the development of international R&D locations has shown that there is an ever increasing international division of labour. Companies are highly mobile in their choice of R&D locations and consciously choose sites that enable them to benefit from local know-how. German enterprises that have considerably increased their foreign R&D expenditure primarily belong to the pharmaceutical, automotive and chemical industries, as well as computing, electronics and optics. Foreign enterprises that are present in Germany with their own R&D capacities primarily belong to the automotive, chemical and pharmaceutical industries, as well as mechanical and electrical engineering and computer manufacturing.

For Germany as a research and innovation location, this entails opportunities and threats, which will have to be adequately addressed by national research, innovation and education policies. R&D activities of foreign companies in Germany strengthen Germany's position as a centre of innovation in the areas mentioned above, while also creating attractive employment opportunities for researchers in Germany. Furthermore, the increasing shift of R&D in key areas of cutting-edge technology to locations abroad poses a particular challenge for Germany as an R&D location.

In view of the high specialisation of German companies in certain fields of technology, and in view of the streamlined concentration of foreign MNEs' R&D activities in Germany, the Expert Commission strongly recommends designing educational and basic research policies on a broad-based approach so as to prepare for future technological developments. At the same time, the foundations for the future use of newly created knowledge will have to be laid by means of efficient technology transfer.

To ensure that R&D in cutting-edge technology is conducted in Germany, it is essential to retain strong application-oriented public research institutions in Germany and to attract foreign MNEs that will expand their R&D capacities, while also closely collaborating with domestic research organisations.

Restraint should be exercised in the funding of applied research activities by German public research organisations abroad. Obstacles for foreign enterprises participating in support measures, such as cluster programmes and the Research Campus, should be removed. An effective promotion of applied research in Germany can contribute to making Germany a more attractive partner for companies from abroad.

Germany will be able to achieve the high level of R&D intensity targeted only if cutting-edge technologies and knowledge-intensive services are expanded. To accomplish this, it will be increasingly necessary to attract further investment from foreign MNEs in Germany. Reliable financial and fiscal framework conditions play a crucial role for the investment decisions of MNEs. Germany is one of the few countries that still does not offer R&D tax credits. If Germany is not to fall behind in international competition, this tax-related locational disadvantage will have to be corrected by means of implementing R&D tax credits. It is imperative that these measures be introduced at the beginning of the next legislative term.

In addition, decision-makers from politics and science should engage in a regular, systematic exchange with research-intensive companies from abroad. The foreign R&D activities of German companies are also the topic of the federal government's dialogue with decision-makers from industry and academia. The Federal Chancellor's Innovation Dialogue, held in late 2012, was titled "Innovation Strategy Asia". In the coming years, the Innovation Dialogue should discuss strategic locations and the innovation strategies of selected countries and their implications for Germany. Moreover, Germany's large companies with R&D facilities abroad are also members of the high-level Research Union. The Research Union could provide a platform for addressing the issue of balancing foreign and domestic R&D. The Federal Government engages in regular intergovernmental consultations with several countries (e.g. the US and China) in the context of which innovation and education policies are also discussed. For instance, bilateral innovation policy platforms have been established with China and the United States, which also serve to address the balancing of bidirectional foreign R&D investment.[274] The Federal Government and the federal ministries have implemented dedicated internationalisation strategies. These measures could initiate projects and developments that are mutually beneficial.

In view of the increasing importance of R&D internationalisation, it is paramount to improve the available data and academic research on transnational R&D processes. Especially the database relating to R&D expenditure and key activities of German companies abroad is very patchy and stems from multiple institutions. The *Deutsche Bundesbank,* the *SV Wissenschaftsstatistik* and other existing research institutions should link their databases based on the example of the annual publications of the Bureau of Economic Analysis (BEA) in the United States. Such an approach would greatly benefit innovation policy in Germany.

B 3 INNOVATION-ORIENTED PUBLIC PROCUREMENT

Introduction

Over the last decades, demand-oriented innovation policy has become increasingly important in many countries. Demand-oriented innovation policy measures include regulation (e.g. the specification of minimum technical standards for products), the promotion of private demand for innovative goods (e.g. buyer's premiums), as well as the public procurement of innovative goods and services. This group of measures is herein referred to as innovation-oriented procurement. Both in the European Union and in Germany, proposals for designing innovation-oriented procurement as an innovation-promoting policy instrument have recently been discussed. In the following section, the Expert Commission aims to review and assess these proposals.[275]

There are two different forms of innovation-oriented procurement:

- the procurement of innovations available on the market: innovative products and services that already exist on the market or have been newly introduced on the market;
- the procurement of innovations not available on the market: products and services that have not entered the market yet and that have yet to be developed for a specific purpose, as well as products and services that have already been developed but are not yet ready for series production.[276]

Examples of innovation-oriented procurement are presented in Box 18.

High quantitative significance of public sector demand

The interest in the effects of innovation-oriented procurement largely arises from the considerable volume of public sector demand. A significant share of Germany's gross domestic product is attributable to procurement by public institutions. Each year, federal agencies and state and municipal institutions purchase goods and services. In 2008, these amounted to a total value of 13 percent of GDP according to OECD figures. This equals a volume of approximately EUR 320 billion.[277] If only a small proportion of the annual procurement budget were allocated to innovative products and services, an important incentive for innovation activities could follow from this.[278]

In spite of the large procurement volume, there is still a lack of reliable information on the extent to which resources are used for the procurement of innovative goods – which is also owing to the fact that the creation of procurement statistics proves to be extremely difficult in practice. The division of competences in federal and Länder procurement law alone makes it difficult to collect data on a national scale.[279] This is further complicated by the fact that there is no uniform standard for defining whether or not a product or a service can be classified as innovative, and by the fact that a uniform standard for recording such goods is also lacking.

Objectives of innovation-oriented procurement

The advantages and disadvantages of innovation-oriented procurement are subject to controversial debate. Advocates of an increased use of innovation-oriented procurement argue that the public sector's high demand potential could be used to strengthen a region's or a country's innovation dynamics. However, sceptics doubt that governments are actually able to achieve this effect with such policy measures. In the following section, the Expert Commission presents potential objectives of innovation-oriented procurement and evaluates the suitability of measures for achieving these objectives on the basis of theoretical and empirical research findings.

Procurement of innovations as an element of public service

The public sector provides citizens with direct or indirect services in the fields of civil security, defense, health, education and infrastructure. Stakeholders from the public sector must ensure that their services meet sufficient quality levels and are delivered efficiently. To meet these requirements, the public sector has to make use of sufficiently innovative primary products and services as part of their service delivery process. Thus, innovation-oriented procurement can be regarded as an essential element of governance. While the public sector can make use of materials and services that are available

BOX 18

Examples of innovation-oriented public procurement

Linux in Munich's municipal authorities
In 2004, Munich City Council in its role as municipal service provider decided to migrate its complex IT structure from an operating system based on Microsoft products to a system that can be freely configured. This decision emerged from the need to avoid medium to long-term costs incurred by licence fees and hardware upgrades necessary for the smooth operation of the Microsoft software. In addition to this, the aim was to establish a consolidated IT architecture with automated and standardised documents that would lead to increased efficiency through reduced coordinative and administrative efforts.

Following a public tender, Munich City Council finally opted for the Linux-based LiMux Client – an open source software solution tailored to their needs. The first work stations were migrated in 2005. By the end of 2013, 80 percent of work stations will operate on the LiMux Client. In the course of the gradual migration, existing Microsoft Office products have been replaced by the open source alternative OpenOffice. In January 2013, as many as 13,000 out of 15,000 work stations were using the new software.[280]

The LiMux project has been assessed positively so far. For Munich City Council, LiMux represents a successful example of innovative procurement launched on the grounds of improved user benefits and an expanded range of software functions available. Enhanced reliability, easier maintenance and higher safety levels are important success factors of Munich City Council's LiMux project. The new IT solution will facilitate efficiency and productivity on the part of the employees. In addition, running costs can be reduced as a result of vendor independence (licence fees and hardware upgrades do not apply), which leads to a sustainable increase in the City Council's economic efficiency.[281]

Sensor-based landing aid (SeLa) for *Bundeswehr* helicopters
Pilots of the German Federal Armed Forces *(Bundeswehr)* are often faced with low visibility during their operations. Particularly in landing maneuvers, loss of orientation due to snow or accumulated dust may occur, which can result in aircraft accidents. After a helicopter nearly crashed in Afghanistan in 2005, the *Bundeswehr* decided to equip their helicopters with an electronic landing aid to support the pilot when landing under difficult visual flight conditions.

Thus, the Federal Office for Arms Technology and Procurement commissioned the company ESG Elektroniksystem- und Logistik-GmbH with the development of a new sensor-based landing aid, which was not available on the market at that time. In collaboration with the European Aeronautic Defence and Space Company N.V. (EADS) and the Fraunhofer-Gesellschaft, the ESG developed the SeLa system, which is capable of precisely determining an aircraft's position. All data are processed by a computer system and are immediately made available via the pilot's display.

The SeLa system went through several development and test stages. It is designed in a way that also allows for application to other types of Bundeswehr helicopters. In 2011, the first *Bundeswehr* helicopters were equipped with the new system; the process is due to be completed within the next four years. Hence, it is yet too early for assessing the ultimate success of procuring the SeLa system.[282]

on the market, it also has to initiate innovation processes whenever the required products and services are not available on the market and have yet to be developed.[283]

In practice, however, it has been demonstrated that the public sector makes only limited use of innovative products and services.[284] Factors that hinder the systematic use of innovations by the public sector shall be discussed in more detail below. The limited use of innovative products and services by public agents threatens the quality and efficiency of governance, while private innovation providers are losing an important client. As a result, the market for innovative products and services is shrinking, which decreases the economy's overall innovation activities.

The issues described here do not necessarily require to be solved by means of R&I policy. Rather, economic policy-makers should make it a priority for government agencies to make sufficient use of innovative services and solutions, with the objective of delivering high-quality services in an efficient manner.

Innovation-oriented procurement as a means of correcting market failure

In a market economy, innovation processes are exposed to various forms of market failure. Innovation-oriented procurement can be a means of correcting market failure and strengthening incentives for innovation. The following effects of innovation-oriented procurement are frequently mentioned in this context:

1. In the case of suboptimal (private) investment in R&D and innovation processes, innovation-oriented public procurement can contribute to the systematic support of R&D activities. Promotional measures may be targeted at specific technologies that have been neglected by the private sector.
2. Innovation-oriented procurement can be used as a means of gathering information about new technologies and their uses, while also making this information available to third parties. Thus, it is argued that the public authorities' practical experience will make it easier for private users to assess and use innovative products and services. Public procurement can thus facilitate the tapping of new consumption patterns and new consumer groups for innovative products such as electric vehicles.
3. Innovation-oriented procurement is an instrument that can, at least partially, rectify undesirable developments resulting from lock-in effects and network externalities. Thus, public procurement can be used as a means of replacing outdated technologies by new technologies, and as a means of reaching a critical mass necessary for launching new technologies. This is especially important in such cases where a new technology requires a specific infrastructure in order to disseminate (e.g. charging stations for electric vehicles, tracks for high-speed trains, etc.).
4. Public procurement can also be used as a tool for achieving economies of scale on national and international markets to overcome classic forms of market failure, e.g. market failures that occur in the defense sector in the context of the development of weapon systems and aircrafts.

In most of these cases, a market failure correction could also be accomplished through alternative measures such as subsidies or R&D tax credits. Thus, policy-makers are confronted with a selection problem. This raises the question whether certain policy instruments possess comparative advantages that would justify their preferred use. Generally speaking, a parallel use of several instruments aimed at correcting one and the same market failure can be deemed counterproductive.

Innovation-oriented procurement as an instrument of strategic R&I policy

Innovation-oriented procurement may also serve other strategic purposes. Thus, some observers suggest that procurement policy can support the evolution of domestic lead suppliers and lead markets and the enforcement of technological standards. Supporters of an active industrial policy approach consider it an important task of government institutions to promote the competitiveness of their home country through strategic policy measures.

Thus, strategic objectives such as the use of renewable energy, energy independence, or competitive advantages in specific technologies or industries (biotechnology, smart grids, etc.) could be pursued through government action. These objectives go far beyond the correction of the market failures discussed above. As a part of strategic, innovation-oriented procurement, the government could, for instance, create particularly favourable development opportunities for infant industries, while subjecting domestic businesses to preferential treatment. Albeit such preferential treatment in particular is met with ordoliberal criticism, it can hardly be denied that there are countries that actively pursue such a policy.

Assessment

The three arguments presented above are all subject to controversial debate.[285] In some cases, strategic, innovation-oriented procurement could indeed create macroeconomic benefits.[286] Yet, the Expert

Commission is sceptical as to whether this argument suffices to justify the systematic and broad use of such an instrument.

When assessing the second argument – innovation-oriented procurement to correct market failure in research and innovation processes – it should be taken into account that demand-oriented instruments often function as substitutes for supply-oriented measures, and if an instrument proves more effective than another, then the respective instrument will be deemed particularly suitable. That said, there is only scarce empirical evidence to confirm the assumption that demand-oriented instruments lead to particularly favourable effects.[287] Besides this, demand-oriented interventions usually require pronounced sector-specific and technology-specific competences, while also intervening in market mechanisms to a much greater extent than supply-based innovation-supporting measures. Again, in the view of the Expert Commission, this does not provide the rationale for a systematic, broadly based use of innovation-oriented procurement.[288]

The Expert Commission believes that the first argument is the most important: it is indeed too often the case that public procurement makes use of established solutions or solutions with minor innovative potential, and hence the quality of public service is less than ideal. What is more, the limited demand for innovative intermediate products inhibits or disadvantages the development and dissemination of innovative products and services. The Expert Commission has developed its recommendations based on this very argument.

B 3–1 INNOVATION-ORIENTED PROCUREMENT IN INTERNATIONAL COMPARISON

In the following section, the scope of public procurement in Germany will be compared with public procurement in other industrialised countries. This comparison makes use of figures published by the OECD, which provides procurement data on a large number of industrialised countries calculated on a uniform basis.[289]

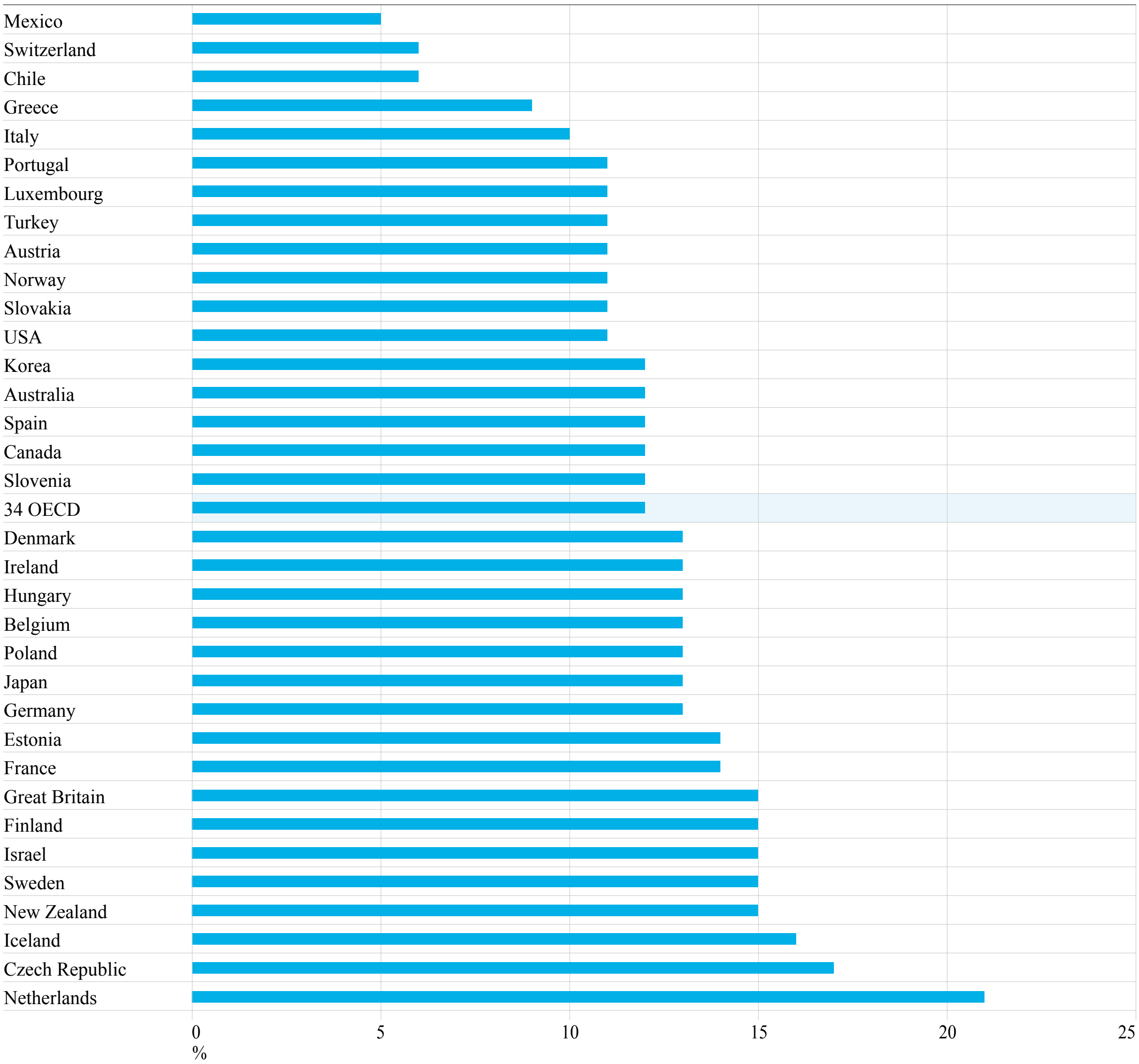
Figure 8 shows that there are considerable differences between OECD countries in terms of their procurement volume. In 2008, public procurement contracts in the Netherlands totalled 21 percent of GDP, while Switzerland's relative procurement volume accounted for only 6 percent of GDP. In Germany, the share of public procurement was 13 percent of GDP – slightly above the OECD average of 12 percent, while still remaining below the values of the two other large European industrialised countries, France (14 percent) and Britain (15 percent).

There are data available on the full scope of public procurement in OECD member states, with figures that have been collected on a uniform basis and allow for international comparison. Yet, when it comes to quantifying innovation-oriented procurement, the task at hand proves much more difficult, since uniform procurement statistics do not exist; neither in Germany, nor at an international level. Also, there are no uniform standards by which the share of procurement of innovative goods and services can be measured against the total procurement volume. For instance, there are no available data on whether or not innovative services were obtained as a result of a public tender. Hence, it is urgently needed to collect such data in compliance with internationally uniform standards and make them available to researchers.

To get an idea of the scope of innovation-oriented procurement in Germany – irrespective of the unfavourable data situation – the procurement process shall be examined in order to identify characteristics that will enable us to roughly estimate the volume of innovation-oriented procurement. Appropriate indicators are the awarding procedure selected for the procurement and the classification of procured products. For R&D services, cutting-edge technology goods, and environmental goods an above-average level of innovation can be expected. In addition, public awarding in the military sector can also be used as a basis for estimating the volume of innovative procurement, since this sector is characterised by a relatively high demand for innovative products and services.[290]

The statistical offices of the OECD and the EU do not keep procurement statistics that would allow for conclusions on procedural features or the nature of the procured product. Thus, the following analysis is derived from Tenders Electronic Daily (TED), the European Union's public online service for publishing public procurement notices.[291] The TED database is

FIG 08 **Size of government public procurement as a percentage of GDP 2008**



Source: OECD (2011b).

managed by the Publications Office of the European Union. It provides information on all public procurement (including tendering procedure and contract type) that has a volume above the EU threshold and thus has to be tendered on a Europe-wide basis.[292]

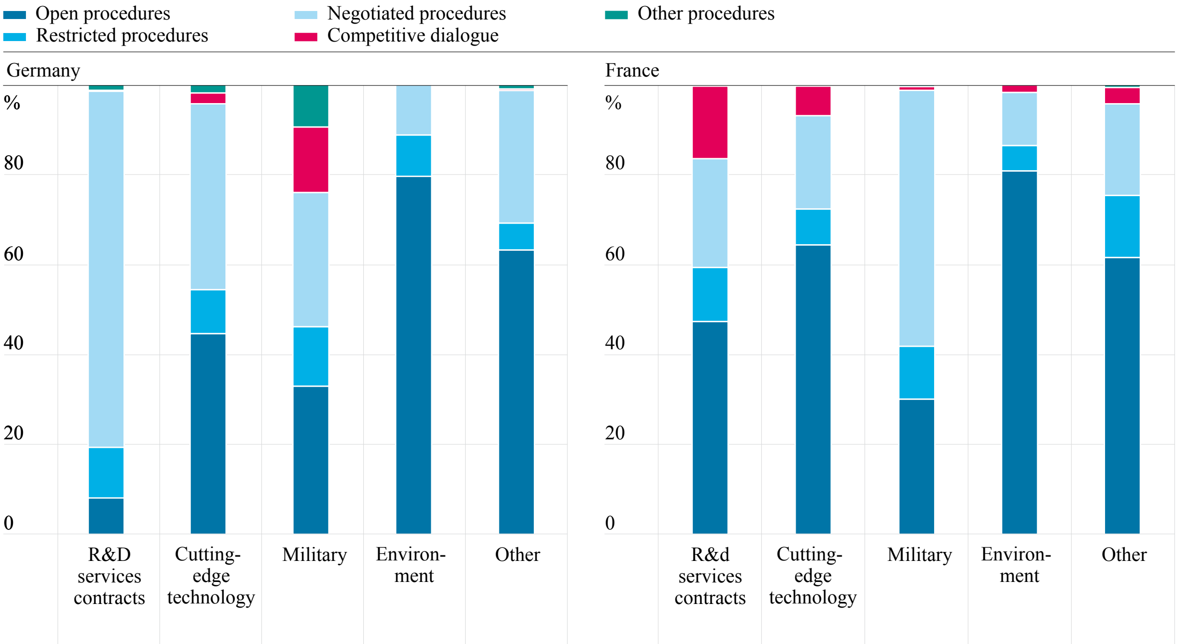
To facilitate the evaluation of results, data for Germany and France have been collected and compared.

Innovative procurement in Germany and France

The procurement procedure chosen by the tendering party serves as a first indicator to determine whether innovative products and services were or shall be procured. Procurement procedures employed by the public sector differ considerably with regard to their degree of formality and the steps involved.[293] The "competitive dialogue" procedure is a negotiation procedure that is characterised by a high degree of flexibility and is therefore particularly suitable for the procurement of innovative goods.

European tendered contracts as a proportion of total procurement according to procurement process and product type (2006–2010 aggregated)

FIG 09



Source: Tenders Electronic Daily. Own depiction.

In the competitive dialogue procedure, the object of procurement is not defined in the tender documents and is only specified in the course of one or more dialogue sessions with selected bidders. This procedure provides the public contracting party with a much greater choice of opportunities to identify appropriate and innovative solutions than would be the case in the context of the traditional open or restricted tendering procedures.[294]

The comparison of procurement procedures used in France and in Germany (Figure 9) shows that to date, competitive dialogue has hardly played any role in Germany's procurement practice: contracts awarded on the basis of this procedure account for less than 1 percent of Germany's total procurement volume. In France, however, competitive dialogue is used more frequently, making up approximately 4 percent of the total procurement volume.[295] Germany's procur-ers are resorting more frequently to this procedure in the procurement of military goods: in this sector, around 10 percent of all contracts are awarded through the competitive dialogue procedure (cf. Figure 9).

A comparison of product types procured in Germany and France classified according to goods and services – R&D services, cutting-edge technology, environmental goods, and goods and services in the military sector – between 2006 and 2010 has lead to the following findings:

R&D service contracts do not play an important role in public procurement in Germany or in France. During the examined period, R&D service contracts accounted for only 0.5 percent of the total procurement volume in Germany. In France, the respective figure is even much lower than this (0.1 percent).[296] In both countries, military procurement with Europe-wide tendering procedures account for only a small fraction of the overall procurement volume, with an average of 2.4 percent in Germany and 2 percent in France.[297] Environmental goods and services account for a much bigger share of the overall procurement volume in the relevant period, with 4.2 percent in Germany and 6.1 percent in France. It is striking that in both countries the demand for environmental goods experienced a decline between 2006 and 2010. In Germany, the decline observed was much more significant than that observed in France. The largest share of the total procurement volume is taken up by cutting-edge technology procurement. With an average of 13.5 percent, the share of cutting-edge technology procurement in France is almost twice as high as that of Germany (7.3 percent). In both countries, the peak intensity of cutting-edge technology procurement increased slightly in the examined period and continues to be several times greater than the share of R&D services.[298]

To sum up, the scope of public procurement in both France and Germany is considerable, and so is the potential for improving government services and for stimulating innovation activities. The indicators examined suggest that in the practice of procurement, however, the procurement of innovative goods and services plays only a minor role. Beyond these general statements, the findings of the analysis do not allow for conclusions regarding the qualitative and quantitative dimensions of innovation orientation in German procurement. A more detailed analysis of the German procurement practice can only be conducted once the federal, *Länder* and local governments have introduced uniform, reliable procurement statistics.

Innovation-oriented procurement in the United States and China

According to OECD figures, the total volume of procurement in the United States amounted to 11 percent of GDP in 2009, corresponding to approximately EUR 1,160 billion. Due to national differences in the collection of data, it is not possible to precisely identify the percentage share of innovation-oriented procurement in the US as compared with Germany and France.

Yet, a comparison of the three countries in terms of their procurement expenditure in cutting-edge technology and R&D goods as well as procurement in the military sector does suggest a certain trend: while the procurement volume of Germany and France in relation to the overall economic power (GDP) is larger than that of the United States, the US' share of innovative goods as a proportion of total procurement is well above that of Germany and France.[299]

The example of the United States demonstrates that government needs serviced through public procurement can be important drivers for innovation and may have great potential for private markets. The energy saving scheme FEMP for reducing power consumption in the stand-by mode, the development of computer and internet technology, or the development of the Global Positioning System (GPS) are examples of products originating in public procurement initiatives that have entered the private market.[300]

When compared on an international level, the United States can also provide the largest and most detailed public procurement database, as all of the federal agencies are required to report public procurement contracts that exceed the threshold of USD 2,500.

The United States' relatively high share of innovation-oriented procurement as a proportion of the total procurement volume might well be the result of individual public sector initiatives. Already three decades ago, the US Administration started promoting the public procurement of innovative goods. Thus, the Small Business Innovation Research Program (SBIR) was designed not only to strengthen small and medium-sized enterprises (SMEs); it was also designed to support innovation-oriented public procurement. The SBIR requires all federal agencies with an R&D budget of at least USD 100 million to allocate a certain percentage of their budget to SMEs. For these ends, federal agencies are expected to identify societal needs e.g. in the areas of health, safety, environment and energy. SMEs can then submit proposals for the financing of innovation projects in these fields of need. These projects may take the form of a feasibility study or the creation of a prototype.

Yet, the market launch of products developed in the context of the SBIR will be conducted outside the programme. Only a small number of US federal agencies, among them the Department of Defense, use the SBIR programme as a tool for public procurement of innovative products that have emerged from subsidised R&D activities.

In China, the volume of public procurement increased rapidly between 1998 and 2009. In 2009, the total of goods and services procured by the public sector amounted to EUR 67.4 billion – in real terms, this equals two hundred times the volume recorded in 1998. China's procurement spending is thus growing even faster than the country's drastically increasing GDP. While procurement accounted for only 0.04 percent of GDP in 1998, this share continuously increased during the following years to almost 2.2 percent. It can be assumed that a considerable part of the procurement volume still remained unreported: according to estimates of the European Chamber of Commerce, China's total procurement volume in 2009 amounted to approximately EUR 790 billion – a multiple of the officially reported volume.[301]

Due to the absence of reliable data it is not possible to assess the extent to which China's public sector has been requesting and tendering innovative goods and services. It is known, however, that it is the stated goal of the Chinese government to make consistent use of public procurement as a tool for promoting and disseminating domestic innovation.[302]

Innovation-oriented procurement in China is focussed on marketable innovations produced by domestic enterprises.[303] For these purposes, product catalogues with a classification of domestic goods are submitted to the provincial governments as a preselection of potentially suitable products. Contracting authorities are encouraged to purchase the goods listed in the catalogues, provided that they do not exceed the price of alternative goods. Domestic innovative products enjoy a price preference of up to 18 percent. If the price of the domestic product is still too high, suppliers are permitted to rewrite their offers.[304]

US policy supports domestic businesses in quite a similar manner. Thus, the US Buy American Act grants a price preference of 6 to 25 percent for domestic products.[305] The Buy American Act explicitly excludes itself from the scope of the Government Procurement Agreement (GPA) adopted by the World Trade Organization (WTO). The GPA has established competition, non-discrimination and procedural transparency as the three guiding principles for public procurement (cf. B 3–2). China's regulations for the promotion of domestic innovation also contravene the provisions of the GPA,[306] but indeed China is not a signatory of the agreement but is merely in negotiations with the WTO.[307]

The analysis of procurement in China shows that the government influences technological development by pursuing a targeted innovation-oriented procurement policy – much more than Germany and France. China's procurement policy seeks to promote not only the goal of facilitating the market entry of socially desirable technologies, but also serves as a means of shielding the Chinese market from international competitors. Due to the exertion of pressure from Europe and the United States, China abandoned its plan to introduce a product catalogue at a national level. Yet, at a provincial level, the number of product catalogues to promote domestic innovation has increased continuously. Moreover, there are also indications of a hidden preference towards Chinese companies.[308]

INNOVATION-ORIENTED PROCUREMENT IN GERMANY: LEGAL FRAMEWORK AND PRACTICE

B 3–2

Public procurement is an area that is very much governed by legal provisions. The complex structure of procurement law primarily serves the purpose of guaranteeing non-discriminatory access to transparent procedures that are open to the public. The guiding principles of public procurement – competition, non-discrimination and procedural transparency – are stipulated in the World Trade Organization's Government Procurement Agreement and are thus authoritative for all GPA member countries, including Germany.[309]

The easiest way of achieving the objective of a transparent, non-discriminatory procurement process is a price competition on competitive markets. Hence, until the beginning of the last decade, the EU procurement rules, which form the basis of national procurement law, had a strong focus on price competition. It was not until 2004 that social, sustainable factors were added to the set of rules; factors that had previously been deemed "extraneous aspects".[310]

With the law on the modernisation of public procurement law, the Federal Government transposed the European public procurement Directive 2004/18/EC in April 2009. Besides integrating the social and environmental award criteria laid down in the Directive, the Federal Government also added additional innovative criteria.[311] Germany's legal framework thus generally provides options for innovation-oriented procurement, and yet these options have been used only little to date. The following section aims to examine the reasons why public procurement in Germany focusses only to such a limited extent on innovative products and services. At the same time it should also be borne in mind that innovation orientation is only one of several aspects of public procurement. Irrespective of the procurement law reform, the central concern of public procurement is to meet the economic demand of public institutions. This is also the reason why public procurers largely base their decisions on the economic efficiency of services and goods to be purchased, and on the budget available.[312]

Innovative products are frequently disregarded even if they are clearly more cost-efficient than competing conventional products. The reason for this is that procurers tend to avoid the risks associated with the launch of a new technology or the collaboration with new enterprises that are still lacking economic stability. General concerns about innovations, insufficient knowledge of new products and technologies, and existing procurement regulations contribute to the fact that innovative products are disregarded. Another reason for disregarding innovative products is that procurers often fail to fully consider a product's life cycle costs.[313] Limited budgets and lacking intertemporal optimisation options often force procurers to purchase the cheapest product – instead of the most economic product.

The reform of the German public procurement law in 2009 has created leeway for integrating innovative aspects into the awarding of contracts. Yet, there are few incentives for procurers to make actual use of these options.[314] In fact, a 2009 survey among procurers at federal, state and municipal levels reveals that in the practice of procurement the degree of innovation of a product or service to be purchased is often deemed irrelevant or plays only a minor role. One of the main reasons for the lack of innovative aspects in the German procurement practice probably lies in the fact that up until the 2009 reform, the innovation criterion was classified as an "extraneous aspect" and was thus considered inadmissible.[315] Procurers are familiar with established patterns of behaviour and have not yet adopted the new regulations.

The acceptance of new patterns of behaviour is further complicated by the fact that the German procurement system is highly fragmented. Overall, there are an estimated 30,000 contracting authorities at the federal, state and local levels. All of the procurers involved have to be made aware of the benefits of innovative products and services and be equipped with relevant information on how to tap this new potential.[316] Thus, it will be one of the key challenges for the Federal Government to convince such a broad range of different institutions of the advantages of innovation-oriented procurement. Besides the fragmentation issue, there are also issues at individual levels that hinder a consistent focus on innovation in public procurement: procurers have the sole responsibility for the risks associated with their decisions, such as higher purchaser prices, late delivery or project failure.[317]

What is more, the selection of additional award criteria and the monitoring of requirements imposed are associated with increased workloads and administrative efforts for procurers. But the OECD Public Procurement Survey also shows that procurers' insufficient knowledge regarding the calculation of e.g. life cycle costs often hinders the consideration of economic aspects of sustainability and innovation. Besides this, it can be difficult to quantify the degree of innovation of a requested service or product. As a result, procurers are reluctant or simply unable to define innovation-oriented award criteria. Moreover, public procurers also feel that there is high legal uncertainty as to whether a chosen award criterion actually complies with the provisions of procurement law.[318] The integration of sustainable, innovation-oriented aspects into contract awarding is supported through information policies and initiatives. However, given the increasing complexity of the regulatory framework, these initiatives (cf. B 3–3) do not suffice to remove the procurers' fears of procedural mistakes and subsequent review procedures.[319] Another impediment for innovation-oriented procurement is, according to the Federal Ministry of Economics and Technology (BMWi), the fact that awarding documents are often over-specific in describing the required service, i.e. the leeway for offering new and innovative products is narrowed down further.[320]

CURRENT POLICY INITIATIVES TO PROMOTE INNOVATION-ORIENTED PROCUREMENT B 3–3

European Union

With its new framework programme for research and innovation, Horizon 2020,[321] and with its competitiveness programme, the EU is currently putting a strong emphasis on the use of public procurement as a means of fostering innovation.[322] Thus, the European Commission also encourages national contracting authorities to exchange good practice examples in the field of innovation-oriented procurement.

Especially through its framework programme, the EU Commission also increasingly focusses on the use of Pre-Commercial Procurement (PCP) particularly in the promotion of information and communication technology.[323]

The use of Pre-Commercial Procurement requires a public need for which the market does not provide a suitable solution. As part of an R&D project, governments can commission several companies with the development of new or alternative solutions. The development of solutions is divided into three phases. In phase 1, the participating companies present their design to the contracting authority. An evaluation committee subsequently selects those companies that will be permitted to enter phase 2, during which participants are required to produce a prototype. At least two of these companies progress to phase 3, which entails the original development of a limited volume of first products or services. This is followed by the commercialisation phase, i.e. the public institution now procures a solution, which is, in legal terms, a separate procedure. However, the procurer is not obliged to commission one of the PCP participants – it may also choose a company that was not involved in the PCP procedure.[324] The advantage of the PCP procedure is that the public contracting authority is not committed to offers that, in hindsight, prove to be technically immature or too expensive.

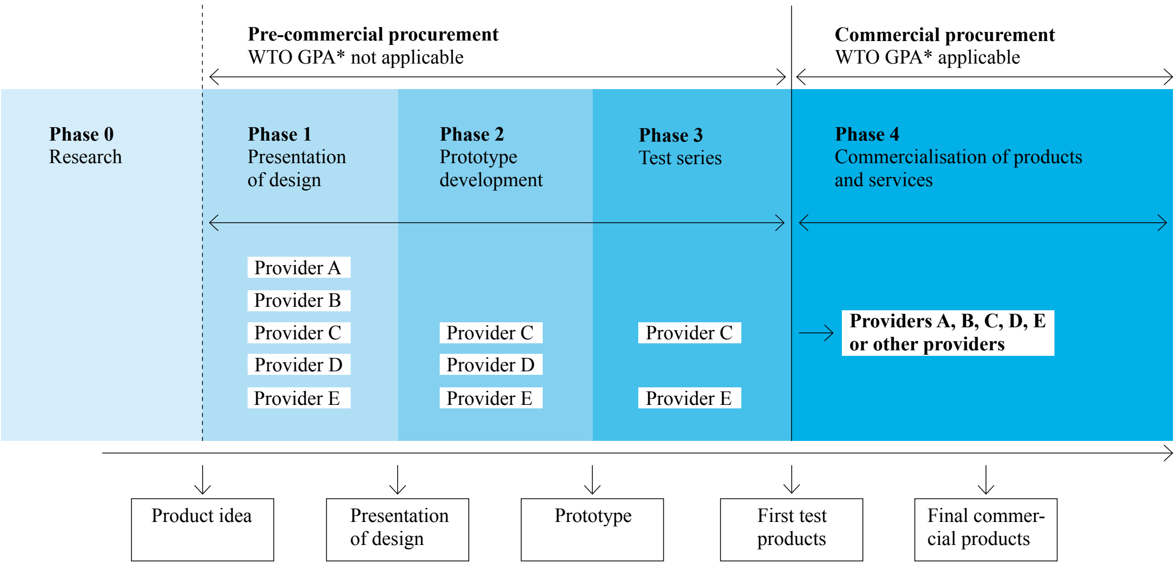
Besides the iterative selection process, the PCP procedure differs from a regular R&D contracting procedure in that it provides the opportunity to make use of the knowledge generated in the development process. PCP is therefore employed in cases where the knowledge generated is not solely for use by the contracting authorities, i.e. cases that entail a planned knowledge spillover to the private market. As a result, the guiding principles of procurement law – competition, non-discrimination and transparency – do not have to be adhered to.[325]

In the practice of procurement, it has not been clarified in detail how intellectual property rights emerging from a PCP procedure shall be assigned. The EU Commission has ruled that the beneficial interest in intellectual property rights held by PCP participants must be transferred to third parties at market prices if requested by the contracting authority. Yet, the assignation of rights differs considerably in the EU member countries and is sometimes not even subject to regulation. Germany is one of the countries that have not formulated rules and regulations for this policy area.[326] Among German policy-makers it is currently being discussed to let the respective companies, i.e. the contractors, retain the property rights, with the aim of enhancing the public appeal of PCP procedures and as a means of stimulating competition. The regulations that are in place in France, however, specify that property rights can be fully transferred to the government in its role as commissioning party. These provisions reflect the notion that rights should be transferred to the contracting party that can best utilise it.[327]

Alongside the launch of the PCP procedure as part of the Horizon 2020 programme, the European Commission has also been preparing the renewal of the Directive on European procurement law, which is due to be adopted in 2013. With regard to innovation-oriented procurement, two planned regulatory changes are of particular interest here: first, the EC aims to establish negotiated procedures with a prior call for competition as the standard procedure for public procurement. This means that, in future, procurers would not have to give explicit reasons for choosing this procurement procedure.

Second, the EC plans to introduce “innovation partnerships” as a new awarding procedure for innovative services. Innovation partnerships link the awarding of a development contract with the actual procurement of the product, thereby establishing a long-term partnership between the company and the contracting public authority.[328] This model differs from PCP insofar as only one company will be involved in the design and procurement process. Innovation partnerships shall make it easier for procurers to requisition innovative solutions. Since these innovative solutions solely meet the public sector’s requirements, the principles of procurement law have to be fully taken into account in such innovation partnerships.[329] The EU Lead Market Initiative represents yet another measure to promote innovation-oriented procurement at a European level.[330] Furthermore, in the context of the Innovation Union strategy,[331] the EU

FIG 10 **Schematic representation of pre-commercial procurement**[332]



*GPA = Governmental Procurement Agreement
Source: Commission of the European Communities. Own depiction.

has commissioned a study to explore the design options for a programme to promote innovation-oriented procurement. The study is based on the United States' Small Business Innovation Research Program (SBIR) (cf. B 3–1) and other respective programmes in Great Britain, the Netherlands and the region of Flanders, all of which are also modeled around the SBIR.[333]

Germany

In the spring of 2011, the Federal Ministry of Economics and Technology (BMWi) presented its innovation policy strategy to complement the High-Tech Strategy. The innovation policy strategy includes initiatives to stimulate innovation-oriented procurement at the federal level. Yet, for the year 2013, only EUR 3.8 million are earmarked for these purposes. One of the key projects includes the launch of a competence centre to advise procurers at federal, *Länder* and municipal levels, to enable networking and to provide good practice examples. At the federal level, the additional administrative efforts anticipated in the context of innovation-oriented procurement processes shall be, at least partially, offset by the planned competence centre. Furthermore, the BMWi plans to test the EU Commission's PCP procedure at national level on the basis of a pilot project. The project shall be conducted in close consultation with EU member states that have already gained experience in implementing PCP procedures.

With these initiatives, the BMWi aims not only to improve the practice of innovation-oriented procurement practices at the federal level, but also to provide incentives for the *Länder* governments and municipalities to introduce similar procedures.[334] For several years now, the BMWi has also been awarding a prize for innovative procurement, which serves as a further incentive for innovation orientation. The BMWi thus awards contracting authorities for their achievements in the procurement of innovation and the design of innovative procurement processes. The title of the award is *Innovation schafft Vorsprung* ("Innovation creates a competitive edge") and has been awarded since 2006 in collaboration with the Association Materials Management, Purchasing and Logistics (BME).[335]

In 2010, the Federal Government established the Alliance for Sustainable Procurement *(Allianz für eine nachhaltige Beschaffung)* as a primary step to improve the data situation in the area of public procurement. The Alliance comprises procurers from the federal and *Länder* governments and from municipal associations. Its declared goal is to strengthen cooperation between federal, *Länder* and local governments in all aspects of sustainable public procurement and to "significantly increase the proportion of sustainable products and services in public procurement".[336] To accomplish this, expert groups on standardisation, statistics and monitoring have been established, who will evaluate available data and fill existing data gaps.

So far, the Alliance primarily focusses on the overall objective of prioritising environmental and social criteria rather than innovative aspects of procurement – although innovative aspects are classified as valid award criteria since the procurement law reform of 2009. Yet, innovative procurement is only indirectly considered, e.g. by preparing proposals for the procurement of innovative environmentally friendly products such as electric or hybrid vehicles. Hence, the Alliance's recommendations for enhancing the data situation will contribute only to a limited extent to improving the public sector's innovation orientation.[337]

B 3–4 RECOMMENDATIONS FOR THE DESIGN OF INNOVATION-ORIENTED PROCUREMENT IN GERMANY

The Expert Commission believes that the potential of innovation-oriented procurement in Germany is not being sufficiently realised. The Federal Government should actively work on overcoming structural barriers and continuously explore new forms of procurement procedures. Experience gained in other countries can serve as a model in this regard. Thus, the Expert Commission recommends the following:

- The Federal Government should support EU initiatives promoting innovation-oriented procurement, such as the measures launched in the context of Horizon 2020, the Lead Market Initiative and the Innovation Union strategy. The EU Commission's initiatives on Pre-Commercial Procurement (PCP) and the renewal of the Directive on European procurement law particularly deserve the support of the Federal Government. The Expert Commission therefore welcomes the BMWi initiative on the adoption of pre-commercial procurement procedures. It is hoped that numerous procurement offices can be persuaded to follow suit. The BMWi should continue to take the lead by providing good practice examples to promote the adoption of PCP procedures by public institutions. At the same time, the Federal Government will have to ensure that the instrument of pre-commercial procurement does not lead to permanent restriction of competition; a concern that also applies at European level.
- The reform of the Directive on European procurement law will have an even greater impact on the practice of procurement than the introduction of PCP procedures, as it introduces negotiated procedures with a prior call for competition as the new standard procedure. In the view of the Expert Commission, this is indeed a suitable measure for promoting innovation. Yet, in the implementation of this reform, the Federal Government must also ensure that a permanent competition restriction is avoided.
- For R&D activities in the context of pre-commercial procurement, it may make sense for the contractor to register intellectual property rights. In such an event, it has to be clarified whether the contracting authority or the contractor is entitled to hold the respective rights. The Expert Commission prefers that the contractor retains the respective intellectual property rights. If property rights are transferred, this would generally have a lowering effect on the price of the R&D service. In some cases it may also be appropriate to request the contractor to make licences available to third parties by a licence of right declaration according to §23 of the German Patent Act *(PatG)*. An active management of intellectual property rights by public authorities is not a desirable objective.
- Already in the preparation phase of the procurement process, purchasing entities should be supported with expert advice and (financial) resources necessary for reducing information deficits on the part of procurers. This support would diminish the procurers' reluctance towards innovation at an early stage.
- Public procurement in Germany is highly fragmented and should be coordinated more closely. Furthermore, it is important to raise awareness among procurers about the opportunities of innovation-oriented procurement. The Expert Commission therefore welcomes the creation of a competence centre that offers advice and assistance to public procurers in the field of procurement.

- In order to make practical use of the opportunities created by the 2009 public procurement law reform, the Alliance for Sustainable Procurement must widen its focus beyond social and environmental criteria and consider the criterion of innovation orientation to a greater extent.
- In spite of the considerable volume of public procurement, there are still no uniform procurement statistics and no reliable data on innovation orientation in German procurement. It is essential to collect and publish relevant data in order to monitor the effectiveness of measures promoting innovation-oriented public procurement and to take corrective action if necessary. The Alliance for Sustainable Procurement, initiated by the Federal Government, should therefore develop explicit recommendations for an improved statistical collection of data relating to innovation-oriented procurement.
- The Federal Government's planned projects for the promotion of innovation-oriented procurement should be monitored and evaluated from the start.

B 4 TAKING MORE ADVANTAGE OF THE POTENTIAL OF WOMEN IN THE RESEARCH AND INNOVATION SYSTEM

In the coming decades, demographic change is going to systematically and sustainably alter the size and composition of Germany's labour force. A shortage of skilled workers, particularly in the STEM professions (science, technology, engineering and mathematics) is increasingly creating a bottleneck for the innovative power and competitiveness of domestic companies and of Germany as a business and investment location.[338] It is therefore becoming more and more important to utilise skill and innovation potentials that have been previously underused – especially the potential of women, and especially in the STEM subjects.[339] Against this background, Germany's educational expansion of recent decades is a great success: today, more women than men are obtaining an academic degree. Yet, too much of women's potential is still underutilised for innovation. The following three factors are most important here: first, female students systematically choose other study fields than male students and are underrepresented in engineering courses – a field of study that is highly relevant in terms of its innovation potential. Second, the success of women in the education system does not result in similar subsequent success in the labour market. Instead, Germany loses the potential of the ever-growing number of highly qualified women in the transition to the labour market and in the career progression. Third, women are still significantly underrepresented in higher-ranking positions; in fact: the higher the career level, the more pronounced the shortage of women – despite the fact that today, female pupils and students in the German education system outperform their male counterparts when measured by grades, study duration and graduation rates.[340] The success of women in the education system in Germany does not continue in the labour market, despite their high education level – a phenomenon that does not apply to other European or non-European countries. Thus, it is hardly surprising that the proportion of female scientists employed in R&D is much lower in Germany compared to other European countries.[341] Germany does not tap the potential of cost-intensive, valuable investments in human capital, although these potentials are urgently required – especially in view of the current demographic development, global challenges and the internationalisation of innovation competition.

The status quo

Against this background, the Expert Commission has further analysed the participation of women in education and training and the participation of women in STEM subjects in particular. Here it could be observed that the number of women with a higher education entrance qualification has increased significantly over the last three decades. Between 1980 and 2010, this number more than doubled, and the proportion of women eligible for tertiary education was significantly higher than that of men. While in 1980 only 45 percent of all higher education entrance qualifications were held by women, the percentage rate steadily increased in the following years. Since 1995, the proportion of eligible females has exceeded that of males, with a proportion of 53 percent in 2010.

Irrespective of the educational expansion described, female students in Germany continue to systematically choose different subjects than male students and are underrepresented in engineering courses – a field of study that is particularly relevant to innovation. Female students still focus on a limited number of subjects, especially those from cultural and social sciences, and there has been little or no progress with regard to most of the STEM subjects and particularly to those STEM subjects with high innovation potential. An international comparison shows that Germany's proportion of female graduates is well below the EU 27 average – especially in the field of engineering sciences (22 percent as opposed to 28 percent), and far from the EU's leading group (Iceland and Greece with 40 percent). With an average of 30 percent, Eastern European countries have a very high proportion of female engineering graduates. Other countries such as Spain (34 percent), Italy (33 percent) and Sweden (30 percent) also seem to succeed – much more than Germany – in convincing young women to enroll in engineering courses. The situation is even more alarming due to the fact that, over the last few years, Germany's increase in female first-year students in engineering has been more moderate than that of its neighboring countries.[342]

At school level

So what are the reasons for this distortion in the choice of fields of study at Germany's higher education institutions in an international comparison? In fact, explanations can be found at all levels of Germany's education and employment systems.

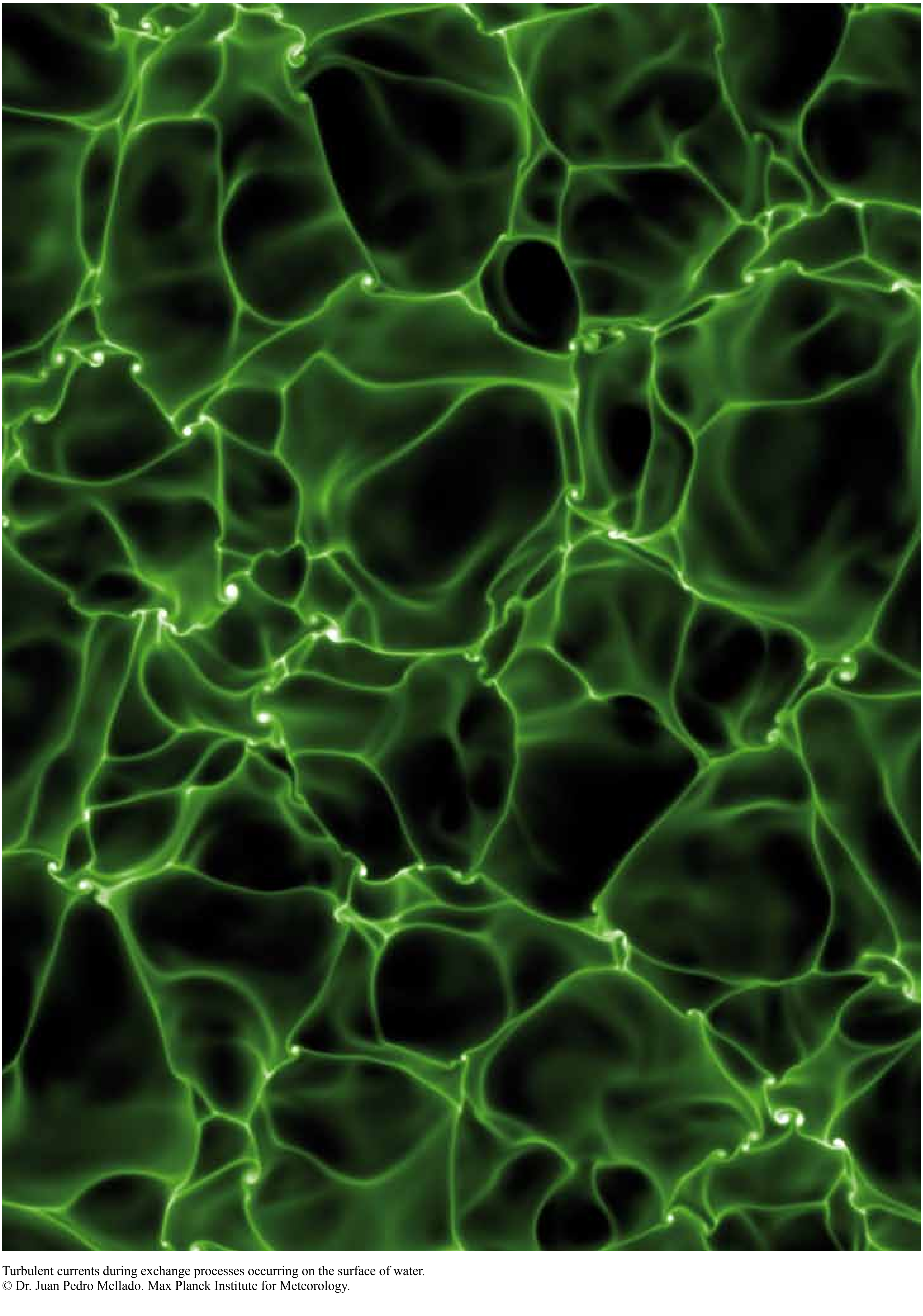
Already during primary and secondary schooling, one can detect differing interests and life concepts of girls and boys. Especially in Germany, the subjective perception of girls that they do not have a comparative advantage in technical skills is already being established at this early stage. Girls tend to see their strengths in the fields of (foreign) languages, communication, literature and music/arts, while boys tend to see their strengths in the domains of science and engineering.[343] While other countries also display a considerable gender gap in terms of pupils' self-perceived mathematical abilities, Germany is among the countries with the largest gaps; schools in Norway, Sweden and Russia seem to be more successful in counteracting this trend. In terms of self-perceived skills in natural sciences, the gender gap is substantially lower in other countries. Germany is one of the few countries where a statistically significant difference also prevails in the field of natural sciences.[344]

This leads to gender-specific differences in the prioritisation of subjects in secondary schools. The different scope of knowledge acquired in school is paving the way for gender-specific differences in deciding for or against a STEM field of study. The gender-specific prioritisation of subject groups at secondary schools leads to the fact that female students are less prepared for STEM degree courses, which further leads to the fact that female students less frequently enroll in a STEM course than male students.[345]

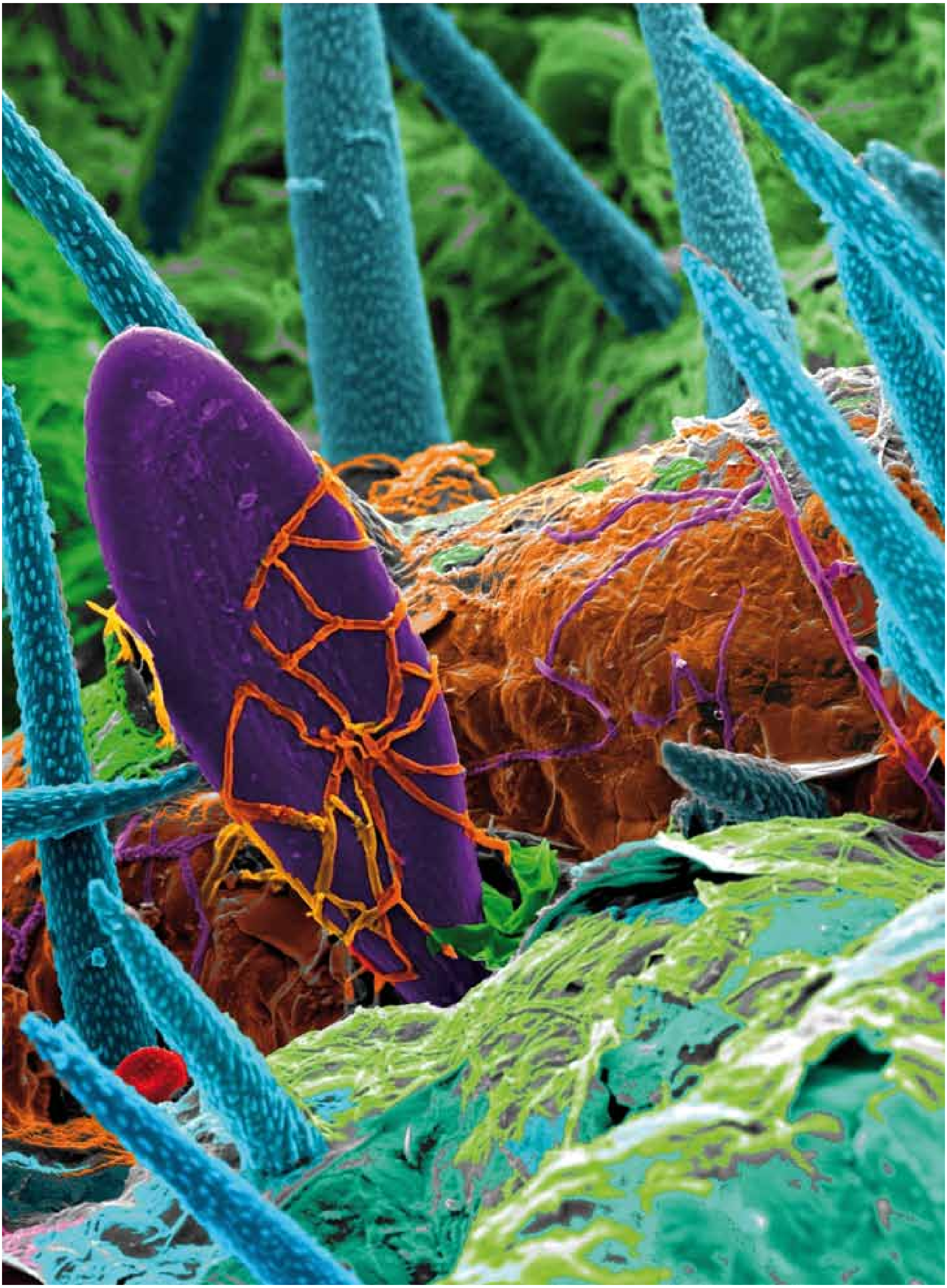
Yet, when it comes to introducing children to technical topics, it is not only the school, but also the parental home that plays an important role. Results from the 2006 PISA study on fifteen-year-olds indicate that in Germany both female and male pupils with parents working in a STEM profession have more advanced natural scientific competences than children from other backgrounds. Thus, it could be shown that children's natural scientific literacy is positively affected by natural scientific activities at home, parental career expectations and a personal appreciation of natural sciences.[346] Furthermore, children whose parents work in natural sciences or engineering professions have a higher probability of enrolling in a similar study course themselves than children without such a family background.[347] Parents, particularly those in science and engineering professions, should therefore take on the task of motivating their children, and especially their daughters, for STEM topics and stirring their interest in these topics.[348]

It is also quite striking that women's long-term career and life planning is more heavily influenced by intrinsic motives, while men are more likely to focus on career opportunities.[349] While women's decisions for STEM degree courses seldom stem from intrinsic motives, particularly in light of their detachment towards technical and mathematical subjects, as described above, men tend to perceive STEM degree courses as a particularly attractive career opportunity. Overall, it is hardly surprising that already at the age of 15 only 4 percent of girls in Germany can imagine themselves enrolling in an engineering or computer sciences degree course.[350]

However, the results for this age group are still largely similar in many other countries besides Germany. Yet, when examining the fields of study that are actually chosen at the later stage, other countries seem to be more successful than Germany in counteracting this phenomenon. In 2006, in none of the OECD countries the percentage of girls aged 15 who were planning to take up an engineering degree course amounted to more than 10 percent, while the OECD average for boys was 18 percent. However, differences in other OECD countries often turn out to be smaller when looking at the actual number of graduates from engineering degree courses. In some countries the proportion of female graduates from engineering degree courses amounts to as much as 40 percent[351], i.e. in the course of their educational career women nearly catch up with men. In Germany, however, the proportion of female engineering graduates amounts to only 22 percent – less than a quarter.



Turbulent currents during exchange processes occurring on the surface of water.



Coloured scanning electron microscope picture of an orange peel.

At university level

Although in Germany the proportion of women pursuing a STEM degree course is higher than the results of the survey among secondary school students would suggest, the proportion is still significantly lower than in other fields of study.[352] While more than 50 percent of newly enrolled male students pursue a STEM degree course, the proportion of female students in STEM subjects has been stagnating at about 23.5 percent for years. The proportion was particularly low in 2011 due to the suspension of mandatory military services, which lead to the enrollment of large numbers of male first-year students.[353] The most striking gap can be observed in the engineering sciences (with 20.6 percent of women enrolled in 2011), and in particular in electrical engineering (10.3 percent) as well as in mechanical, process and traffic engineering (17.2 percent). The gender gap is least pronounced in mathematics and natural sciences, where the proportion of women averages 36.0 percent. Female students are well represented in the fields of chemistry (42.3 percent), mathematics (50.5 percent) and biology (60.8 percent). The high proportion of women in mathematics and natural sciences is also attributable to the fact that female students often pursue a professional teaching degree with mathematics and biology being the chosen subjects of their curriculum.[354] The pronounced differences in female and male participation in individual STEM subjects suggest that the choice of a subject is not necessarily driven by a female aversion to skills and subjects perceived as masculine. As will be demonstrated below, there seem to be additional factors that emerge during study, and, especially, professional life. In fact, women seem to be generally very open towards fields of study other than cultural and social sciences, and yet in Germany this openness is currently not being utilised for the benefit of engineering or informatics. When comparing the different engineering courses, the low proportion of women is particularly striking in areas that display a particularly high number of patent applications, e.g. electrical and mechanical engineering – a fact that should also be given due attention.[355]

On a more positive note, it can be observed that women who have opted for an engineering degree do drop out of university less frequently than their male counterparts,[356] i.e. those few women who enroll in engineering degree courses are at least more likely to complete their studies successfully.

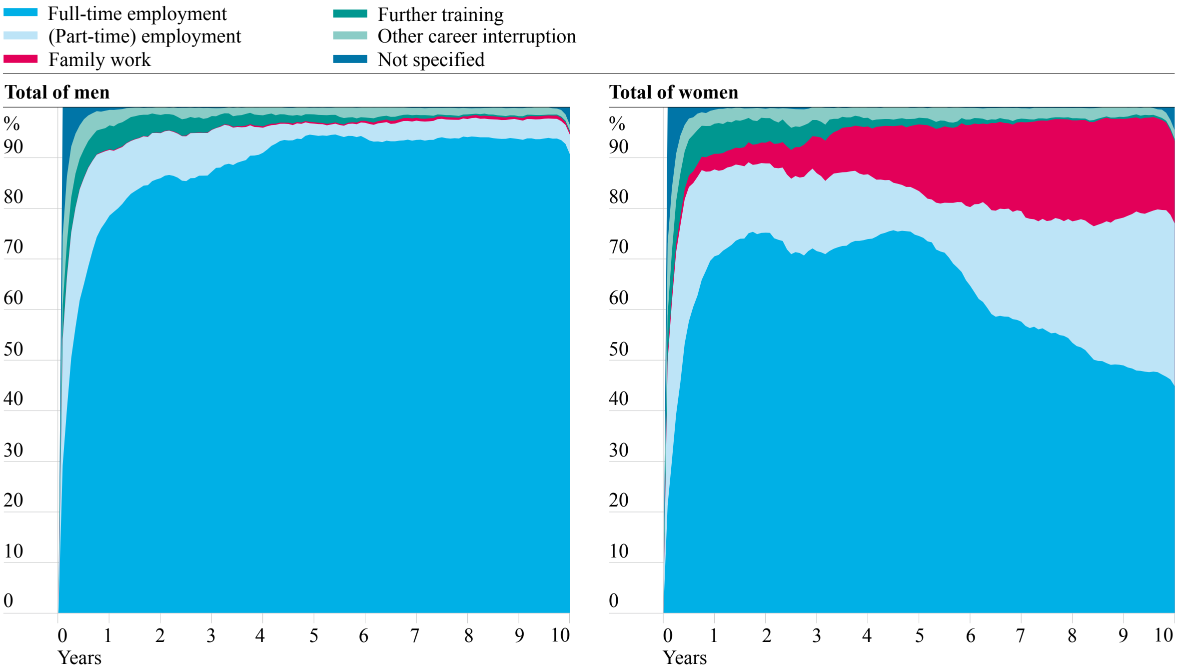
Labour force participation

The perceived benefits and development opportunities of a STEM degree play a key role when women decide for or against a STEM degree course. Surveys among individuals with a higher education entrance qualification show that women assess their expected labour market outcomes from graduating from a STEM subject lower than their male counterparts.[357] Thus, for women the perceived cost benefit trade-off of participating in a STEM course is unfavourable[358], i.e. women rarely decide in favour of STEM subjects. Also the labour force participation patterns of female engineers indicate that working conditions in engineering professions are not very attractive for female employees. As a result, Germany's labour market loses a large proportion of highly qualified female graduates; particularly those with an engineering degree.

Depending on the chosen field of study, considerable differences can be observed between the fields with regard to labour market entry and career paths. The family phase is especially characterised by a significant distortion in the participation of female graduates, and of female engineering graduates in particular. Figure 11 illustrates the labour force participation of an exemplary cohort of graduates from 1997 in the first ten years following their graduation.

The first of the surveyed years shows that – for both men and women – the transition from university to labour market does not tend to be seamless as many of the graduates enter the labour market only after an initial gap. For both full-time and part-time employment, this transitional process is usually completed within the course of a year. Already at this early stage, it can be observed that a significantly greater proportion of female graduates initially takes up part-time positions and also remains in such positions. Furthermore, there is an obvious trend among women to leave the labour market soon after their entry in order to pursue full-time family work.[359] This leads to the fact that ten years later only half of the female graduates are employed on a full-time basis, while the other half is at the most working part-time – often with a low number

FIG 11 **Employment in the first ten years following graduation in 1997, according to gender** (in percent)[360]



Source: Leszczensky et al. (2013).

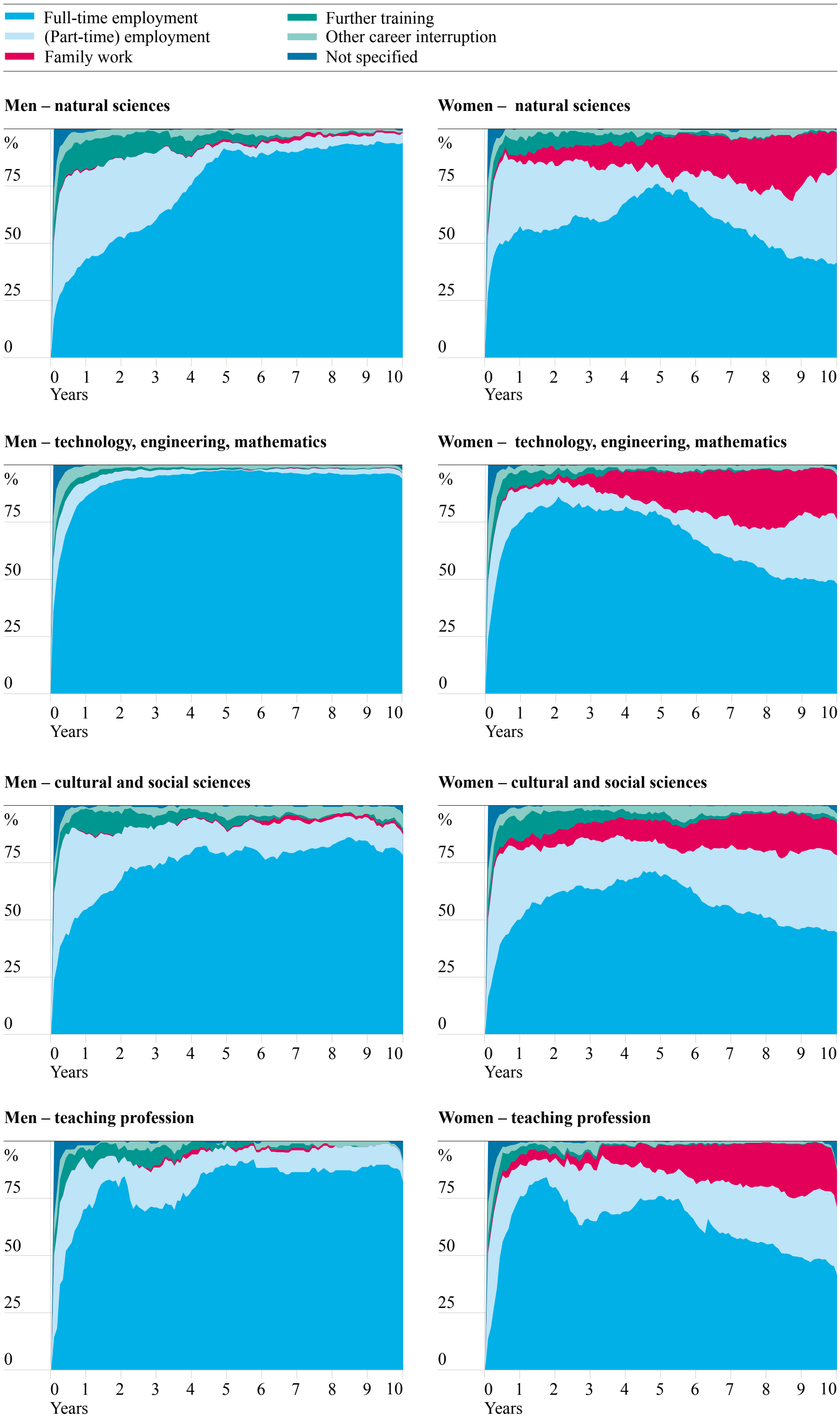
of hours – or refraining from the labour market altogether.[361] Measured in full-time equivalents and across all subjects, about one third of the labour force potential of highly skilled women is lost, compared to only about 5 percent of the male labour force potential. This is indeed an alarming finding, since empirical studies have repeatedly shown that such initial employment interruptions lead to lasting and often lifelong disadvantages in terms of labour force participation, unemployment risks and income levels.[362] When exclusively looking at employment rates among female university graduates in a European comparison, figures suggest that Germany is relatively well positioned with a rate of 84 percent in 2011 – nearly the same rate as that of the northern European countries, and even higher than that of France (78 percent) and Britain (79 percent).[363] However, a closer look reveals that among employed women with a higher education degree, the part-time rate is significantly higher than the EU average: in Germany almost 36 percent of women with a university degree are working part-time compared to the EU average of 25 percent.[364] Thus, measuring in full-time equivalents and taking into account long-term career prospects, Germany does not perform well in a European comparison. Moreover, the greater participation of women in other countries is not necessarily associated with a lower birth rate, as shown by France, Great Britain and the Scandinavian countries. With an average of 1.9 to 2.0 children per woman, these countries have a substantially higher birth rate than Germany (with an average of 1.4 children), and yet labour force participation levels of females are fairly similar.[365]

A closer look at female labour force participation in Germany according to fields of study indicates that there are significant field-specific differences (cf. Figure 12). Immediately after graduation, participation of women who had decided to take a degree in technology, engineering or mathematics (TEM) differs only little from that of male graduates. However, with the beginning of the family phase, female labour market participation literally collapses.

After ten years, the labour force participation of women in TEM professions is about as low as it is in other subjects (although the latter started with much lower labour force participation levels from the beginning). These figures clearly illustrate the specific problems of the employment situation of women in TEM professions. Although women who

Employment in the first ten years following graduation in 1997, according to fields of study and gender (in percent)[366]

FIG 12



Source: Leszczensky et al. (2013).

opt for TEM subjects prove with this choice that they have a high interest in labour force participation and indeed enter into employment just like men, they do not continue employment throughout the family phase. It can thus be assumed that working conditions in the TEM professions in Germany are particularly difficult to combine with family life, and that altering these conditions is a crucial starting point to improve the utilisation of the labour potential of women who have already completed a valuable TEM degree course.

When examining labour force participation in natural sciences professions, both women and men display certain structural patterns that differ significantly from other labour market segments. In the first six years of their working life, men display a strikingly high part-time rate (which is probably explained by part-time jobs during a PhD phase). This is usually followed by a typically male employment pattern, with more than 80 percent of men employed on a full-time basis. In terms of female labour market participation, it can be observed that an unusually high proportion of women initially participates: after one year, more than 90 percent are employed on a full-time or part-time basis. This high level of participation lasts for a relatively long period of time; the first five years are more frequently associated with full-time employment than would be the case in other professions, where the family phase would have already begun. However, the proportion of female full-time employees decreases significantly after five to six years and is only partially substituted by part-time employment.

A similar trend, albeit less pronounced, can be observed in the cultural and social sciences sector, an area that is particularly characterised by generally low participation rates for both women and men. When compared with other subject groups, male employment in cultural and social sciences is characterised by the lowest full-time rate, the highest part-time rate, and the highest share of other employment interruptions. Although in this domain female employment is characterised by a lower proportion of full-time employment and a relatively high and steady proportion of part-time employment, women only seldom withdraw completely from the labour market for the reason of family work. This suggests that the percentage of highly qualified women whose potential is completely lost is the lowest in the cultural and social sciences sector due to the part-time options available in this field. It can be assumed that this is attributable to the fact that many of these women are employed in the public services sector (especially schools and public authorities); institutions that provide clear-cut regulations for part-time employment.[367]

To sum up, it can be stated that women primarily choose fields of study (cultural and social sciences) that correspond with their educational interests and promise the best opportunities for combining working and family life. In this domain, large proportions of women contribute their skills to the labour force – even if only through part-time employment.

BOX 19

Corporate childcare projects of SMEs

While large companies usually have enough staff to maintain in-house childcare facilities, SMEs are often lacking the critical size for operating their own daycare facilities. Yet, also in the realms of SMEs, successful models have been implemented to facilitate the reconciliation of working and family life through collaborative projects. Successful models comprise e.g. exclusive contracts with child minders,[368] the provision of places in existing facilities, and the establishment of facilities in cooperation with other SMEs. Examples of such facilities include the projects *Adventure Kids* and *Till Eulenspiegel*. The *Adventure Kids* project in Gütersloh[369] is a collaboration of seven SMEs that have established a joint group for their employees' children at the *Adventure Kids* daycare centre. The central location, the opening hours (12 hours a day from 7a.m. to 7p.m.) and the flexible care hours help the companies' employees to combine work and family. The corporate crèche *Till Eulenspiegel* in Braunschweig[370] was founded by two local companies. Again, opening hours are designed in a way to assist parents in balancing family and working life in the best possible way. Thus the crèche opens at 7a.m. to suit the employees' starting time. The crèche is situated in the immediate neighbourhood of the company, making it easier for employees to organise their daily routine.

Both projects were supported by the European Social Fund through the "Company-sponsored childcare" programme which expired in December 2012.

At the same time, in Germany, only a small proportion of women choose subjects that appear to be less suited for combining work and family (especially mathematics, engineering and technology, as opposed to natural sciences).

Against this background, corporate as well as family and education policy measures to combine work and family could positively affect women's study choices in favour of technology, engineering, and mathematics – e.g. via part-time options, flexible work schedules, corporate or community-based childcare facilities and day schools. This line of argument is supported by findings from neighbouring European countries. In the Scandinavian countries, which occupy a leading position with regard to family-friendly working conditions, women and men are provided with the most favourable opportunities for combining work and family. Denmark, Sweden and Norway are among the countries with the highest public expenditure on childcare and early childhood education.[371] Especially in Sweden, men also participate in childcare to a much higher extent. In fact, more than 80 percent of Swedish men make use of the parental leave option, taking more than 20 percent of paid parental leave days. Accordingly, the labour force participation of women having children under the age of one is comparatively high with more than 67 percent and steadily increases as the children grow older.[372] Within the OECD countries, Finland, Denmark and Sweden have the highest rate of companies offering flexible working time models, such as flexitime. Scandinavian companies take a leading role when it comes to models for adjusting working hours, i.e. reducing or increasing the weekly number of working hours.[373] As expected, the family-friendly design of work places in the Scandinavian countries corresponds with an above-average employment rate among women – including those with children.[374] In Sweden and Finland, the employment rate of women with three or more children is also high.[375] Whenever a solid childcare infrastructure and family-friendly working time models are in place, it seems that more women are willing to enroll in degree courses in the fields of informatics, engineering, manufacturing or civil engineering and to work in the respective professions at later stages. Although there are several successful projects in Germany that aim to facilitate the reconciliation of work and family (cf. Box 19), these and other measures have to be implemented to a much greater extent. The Federal Ministry of Family Affairs, Senior Citizens, Women and Youth (BMFSFJ) financially supports participating companies in establishing corporate daycare facilities via a corporate childcare support programme.[376] However, it is up to the companies to develop and implement intelligent and feasible solutions that suit their company-specific needs.

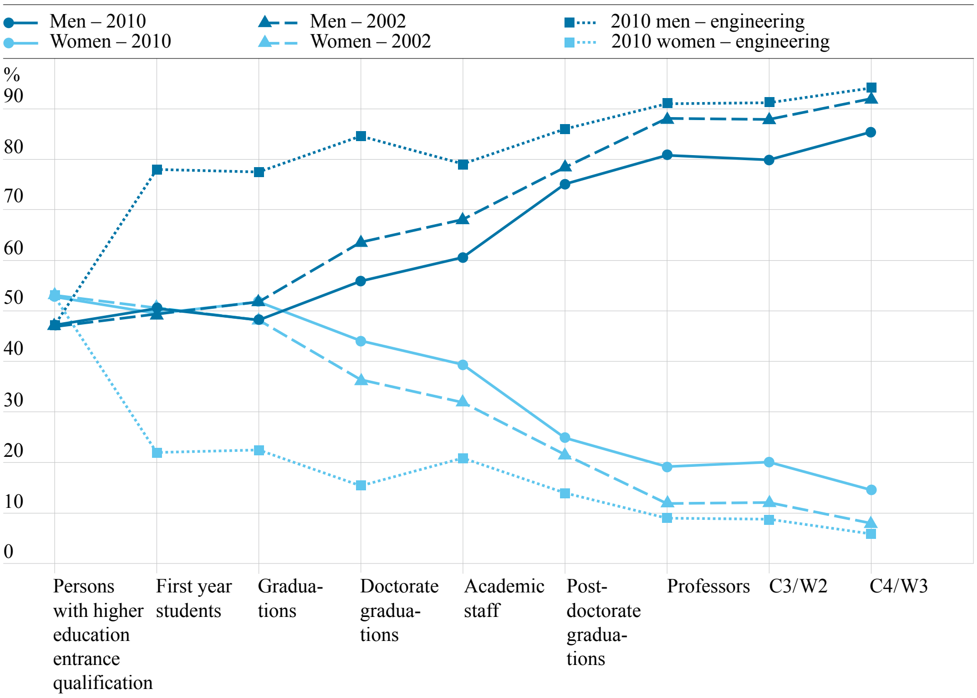
Career patterns and the "leaky pipeline"

The career patterns of men and women in Germany display further systematic differences in the first years following their entry into the labour market. Thus, the proportion of women decreases further at every ascending step of the educational and employment system – a phenomenon that is often referred to as the "leaky pipeline".

This phenomenon is particularly evident in the field of science, which is highly relevant in terms of its innovative potential (cf. Figure 13). In the context of Germany's educational expansion, the proportion of female secondary school graduates and first-year students has increased steadily and today even exceeds the male proportion. And yet this pipeline of talent leaks and becomes smaller with each additional level of education. This phenomenon is particularly evident in scientists' transition to the labour market and their progression within the labour market. Despite the above-average representation of women among individuals with a higher education entrance qualification (53 percent) and the gender balance among first-year students and graduates, women account for only 40 percent of PhD students and academic staff. The proportion even drops to 10 to 15 percent at the highest academic career level (C4/W3 professorships).

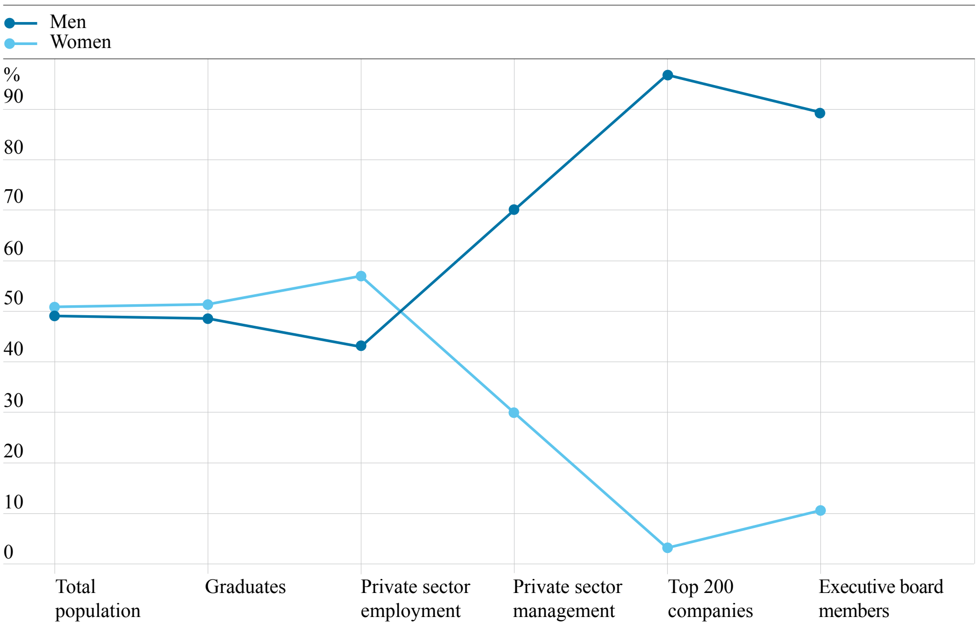
In the field of engineering (cf. Figure 13), the situation is also unsatisfactory, albeit for different reasons. With a proportion of newly enrolled female students of approximately 20 percent, the gender gap already occurs at the university entry level, but this gap does not widen much further, as it is the case in other fields of study. At each additional level of education, the proportion of women decreases slightly, and only 10 percent of women can be found to hold a C4/W3 professorship. When compared with other fields of study, the proportion of

FIG 13 **Share of women at different stages of a career in academia**



Source: Leszczensky et al. (2013).

FIG 14 **Share of men and women at different stages of a career in the private sector in 2010**



Source: own graph; data from Leszczensky et al. (2013), *Statistisches Jahrbuch 2012, DIW Führungskräfte - Monitor 2012.*

women is low but at least relatively stable throughout the entire academic career path. Thus, in engineering, the main bottleneck is the low number of women who can be convinced to enter an engineering degree course in the first place.

When interpreting the results shown in Figure 13, one certainly has to take into account that the educational and career paths leading to a professorship are relatively long. Consequently, a higher proportion of female students translates into a higher share of female professors only after more than a decade. And yet the long preparation period alone does not suffice to explain the low proportion of women among PhD students and academic staff, since these phases follow immediately after graduation. Hence, it is not very likely that the problem will just disappear over time. Although certain changes in trends can be observed when comparing results from 2002 and 2010, only little change is recorded at the advanced career levels when measured by the scope of inequality, i.e. the gender gap will not automatically close any time soon.

An international comparison reveals that a low proportion of women in senior scientist positions is not inevitable. When it comes to women's representation in management and decision-making positions in research (comparable to a professorship in Germany), Germany ranks with a share of 12 percent well below the EU 27 average of 19 percent and far behind the leading countries of Romania (32 percent) and Latvia (29 percent). Germany is also outperformed by Britain (17 percent), France (19 percent) and Finland (23 percent).[377]

In the United States, potential causes of the "leaky pipeline" phenomenon have been examined in the fields of biology and physics. Using an application process experiment, it could be shown that job applicants with female first names were assessed as being less competent by male and female professors than applicants with male first names – although the contents of the application documents were fully identical. The experiment further revealed that women are less likely to be hired, start off with a lower salary and receive less career support than male applicants. These results point to a subconscious discrimination against women based on culture-specific stereotypical opinions on the supposedly lower abilities of women in sciences; stereotypical opinions that seem to prevail among male and even female experts.[378]

However, the "leaky pipeline" problem is not limited to the science sector. Also in the private sector and the public sector, the proportion of women in management positions is significantly lower than their proportion of the total labour force (cf. Figure 14).

When comparing the proportion of women in supervisory boards internationally, Germany only occupies a medium position, ranking behind the Scandinavian countries, France and Great Britain.[379] Thus, in October 2012, the proportion of female DAX 30 non-executive board *(Aufsichtsrat)* members amounted to 15.6 percent, and the proportion of female executive board *(Vorstand)* members amounted to 4.2 percent. In Finland, for instance, the proportion of female non-executive board members was almost twice as high (27.9 percent), and for executives more than three times as high (14.9 percent). Other European countries outperforming Germany in this respect include Denmark with 16.1 percent and 11 percent, respectively, and the Netherlands with 18.8 percent and 8.8 percent, respectively.[380] In Norway, a country with a mandatory quota for women in supervisory boards,[381] 25 percent of corporate board members and 15 percent of executive committee members are female.[382] This shows that Germany is lagging behind dramatically, not only with regard to non-executive boards, but particularly with regard to executive boards.

Conclusion and recommendations

If Germany does not succeed in taking more advantage of the qualification and innovative potential of women, the shortage of highly qualified scientists in STEM professions will increasingly become a problem. International comparison shows that there are no inevitable obstacles responsible for the low proportion of women in STEM subjects and senior scientist positions. Other countries are more successful in convincing women to enroll in engineering degree courses, in retaining them in the labour market and in promoting them into high-level scientific or management positions. Germany is thus posed with the question of how political decision-makers and other stakeholders can contribute to improving the utilisation of the innovation potential of women.

- As already suggested in the Annual Report 2012, the Expert Commission recommends putting particular emphasis on the mathematical and technical education of girls at school level. Schools need to foster an interest in and enthusiasm for mathematical and technical issues among female pupils, thereby creating a solid technical basis and facilitating the decision to enroll in an engineering degree course at a later stage more frequently. In order to achieve these goals, the government has to provide adequate resources and trained teachers to ensure a high quality of teaching in STEM subjects.
- Since the choice of a field of study is largely based on perceived future working conditions, the Expert Commission further recommends promoting the expansion of childcare facilities instead of using available resources to pay childcare supplements. This would make it easier for women to participate in the labour force, and would create long-term incentives for an improved utilisation of the labour force potential of women – also in engineering professions.
- At the same time, the Expert Commission recommends the introduction of measures to support companies in providing family-friendly working conditions. The Scandinavian countries could serve as an example here, as they are particularly successful in distributing family work more evenly between men and women and in ensuring a high labour force participation of women – also in STEM professions and executive positions. In the Scandinavian countries, flexible working hours and a solid infrastructure for childcare and early childhood education are considered to be self-evident. As a result, the issue of combining work and family automatically plays a much smaller role among girls and young women when choosing a field of study, when entering the labour market, and when making career choices.
- Companies and research institutions should increase their efforts to solve the "leaky pipeline" problem, especially in domains that are largely male-dominated. There is clear evidence that even committee members and experts, who regard themselves as being purely factual and objective, make biased gender-specific decisions that disadvantage women. In their own interest, companies are therefore advised to establish internal processes to avoid unintended gender bias in their recruitment and selection processes, in their promotion decisions, and in filling management positions. A first step would be to systematically review all existing selection and promotion decisions by means of statistical and qualitative procedures to check them for implicit gender biases. Based on such a review process, company and process-specific countermeasures should be developed.
- Ultimately, the Expert Commission also considers the introduction of quotas for leading positions in academia and business as an appropriate means of accelerating the transition towards greater gender equality.

STRUCTURE AND TRENDS

C

C STRUCTURE AND TRENDS

C 1 EDUCATION AND QUALIFICATION

The total number of school-leavers qualified for tertiary education (C 1 – 1) in Germany has increased between 1993 and 2013 from 290,000 to almost 520,000. Since the mid-1990s, the number of newly enrolled tertiary students (C 1 – 2) has also risen sharply. This trend can be observed in all of the OECD countries and is more pronounced in most of the analogue countries than it is in Germany. Thus, between 1995 and 2010, the OECD average entry rate has increased by approximately 24 percentage points, from 37 to 61 percent. In Germany, the entry rate increased between 1995 and 2010 by 16 percentage points to 42 percent.

In the winter semester of 2011/12, approximately 265,000 students without German citizenship were enrolled at German tertiary education institutions (C 1 – 3), the highest number recorded to date. From among these, mobile foreign students *(Bildungsausländer)* made up the largest group with 193,000 students. The number of mobile foreign students grew by 4.3 percent as compared with the previous year. Their proportion of all students, however, declined by 0.2 percentage points to 8.1 percent. This decline is attributable to a strong domestic demand caused by the suspension of mandatory military services and a double-intake in school-leavers, which is owing to a reduction of the mandatory period for upper secondary school in nearly all of the federal states.

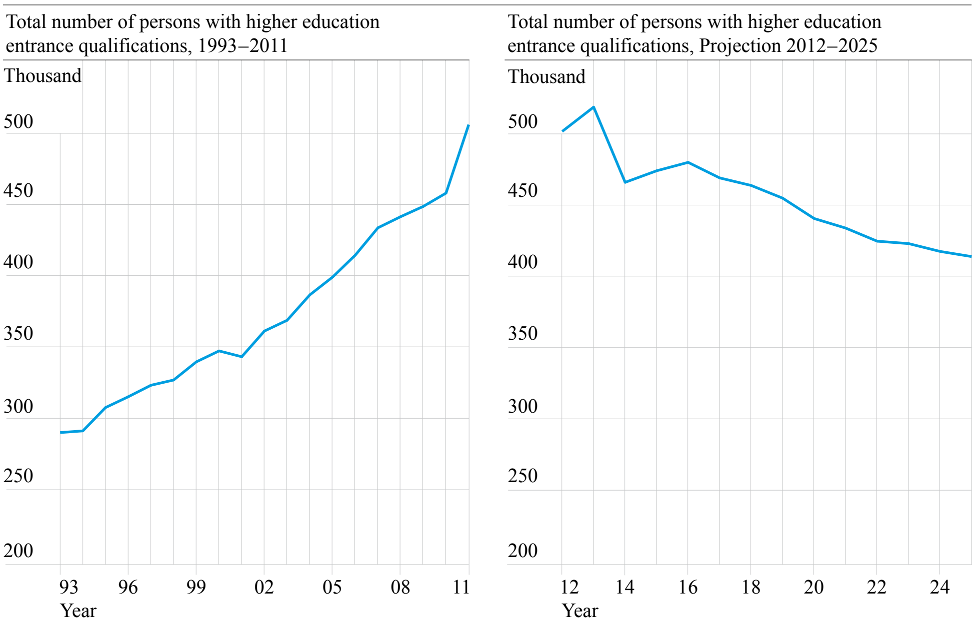
In 2011, the number of graduates in the subjects groups of engineering and mathematics/natural sciences developed along varying lines (C 1 – 4). While the number of first-degree graduates in the subjects group of mathematics/natural sciences increased by only 2 percent as compared with the previous year, the engineering sciences recorded an above-average increase of 11 percent. The proportion of graduates in the subjects group of engineering as a percentage of all first-degree graduates increased to 18.1 percent; an increase of 1.2 percentage points. The proportion of engineering graduates as a percentage of the total number of first-degree graduates thus continues to be well below 1990 levels. Yet, in absolute terms, engineering sciences reached a new high, with more than 55,000 graduates.

Participation in further training in Germany (C 1 – 5) experienced a downward trend over the period examined. The largest participation in further training is recorded among highly qualified individuals, irrespective of whether they are economically active (9.3 percent) or unemployed (9 percent). In contrast, training participation among low-skilled workers (1.6 percent) and unemployed individuals (2.4 percent) is lagging behind considerably. It can be observed that participation in further training increases according to a person’s level of education.

In an international comparison of the qualification levels of the workforce (C 1 – 6), it can be observed that Germany ranks low in terms of employment of graduates (ISCED 5a and 6). However, Germany has traditionally had a high proportion of workers with intermediate or vocational qualifications (ISCED 4 and 5b). Together, these two groups represent nearly 37 percent of employees. With regard to these important qualification levels, Germany ranks above the European average of 35.5 percent and is in the leading group of European countries.[383]

School-leavers qualified for higher education in Germany C 1–1

Persons with higher education entrance qualification: school-leavers who have obtained entitlement to enter general or subject-specific tertiary education at a university or a university of applied sciences.



Source (actual values): *Statistisches Bundesamt* (various years).
Source (projected values): statistical publications of the Conference of Ministers of Education and Cultural Affairs (*Kultusministerkonferenz*), in: Leszczensky et al. (2013).

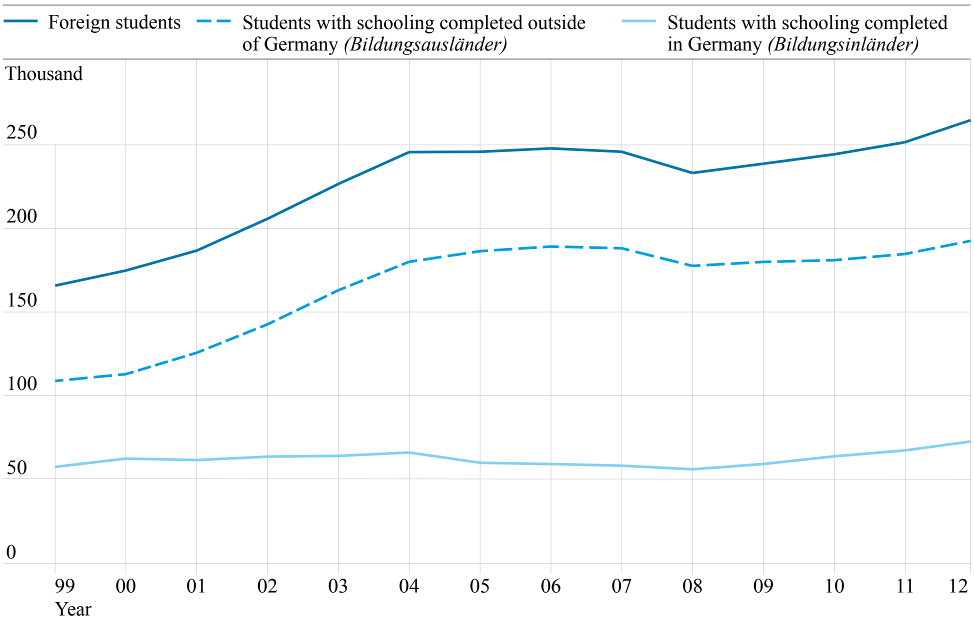
Share of new tertiary students in the relevant age group in selected OECD countries C 1–2
(figures in percent)

Entrance rate: proportion of newly enrolled students as a percentage of the population in the relevant age group. The entrance rate measures the extent to which demographic potential is exploited for the development of academic human capital.

OECD Countries	**1995**	**2000**	**2002**	**2004**	**2006**	**2008**	**2009**	**2010**	**2010**[1)]
Australia	–	59	77	70	84	87	94	96	67
Germany	*26*	*30*	*35*	*37*	*35*	*36*	*40*	*42*	*36*
Finland	39	71	71	73	76	70	69	68	–
France	–	37	37	–	–	–	–	–	–
Great Britain	–	47	48	52	57	57	61	63	41
Italy	–	39	50	55	56	51	50	49	–
Japan	31	35	39	40	45	48	49	51	–
Canada	–	–	–	–	–	–	–	–	–
Korea	41	45	–	49	59	71	71	71	–
Netherlands	44	53	54	56	58	62	63	65	61
Switzerland	17	29	–	38	38	38	41	44	33
Sweden	57	67	75	79	76	65	68	76	65
Spain	–	47	49	44	43	41	46	52	–
USA	–	43	64	63	64	64	70	74	–
OECD average	37	47	52	53	56	56	59	61	–
Other G20 countries									
China	–	–	–	–	–	–	17	17	–

[1)] Adjusted rate; foreign first-year students not included.
Sources: OECD (eds.): *Bildung auf einen Blick* (Education at a Glance) – OECD Indicators (various years), in: Leszczensky et al. (2013).

C 1–3 **Foreign students at German tertiary education institutions**



Source: *Statistisches Bundesamt* as well as Main Reports; research in HIS-ICE, in: Leszczensky et al. (2013).

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

C 1–4 **Graduates and subject structure rate**

	1993	1995	2000	2005	2008	2010	2011
Total number of graduates	**173,756**	**197,015**	**176,654**	**207,936**	**260,498**	**294,330**	**307,271**
Percentage of women	39.8	41.2	45.6	50.8	52.2	52.1	51.4
Percentage of university students	65.2	63.6	64.3	60.8	62.4	62.0	65.5
Linguistics, cultural studies	**22,601**	**27,125**	**29,911**	**35,732**	**50,680**	**54,808**	**56,140**
Percentage for subject group	13.0	13.8	16.9	17.2	19.4	18.6	0.2
Law, business and social sciences	**53,170**	**66,538**	**62,732**	**76,566**	**87,196**	**102,315**	**105,589**
Percentage for subject group	30.6	33.8	35.5	36.8	33.5	34.9	34.4
Medicine/health sciences	**13,515**	**12,075**	**10,620**	**11,817**	**14,345**	**15,222**	**15,686**
Percentage for subject group	7.8	6.1	6.0	5.7	5.5	5.2	5.1
Agriculture, forestry, nutrition sciences	**5,477**	**5,527**	**4,761**	**5,312**	**6,363**	**6,215**	**6,563**
Percentage for subject group	3.2	2.8	2.7	2.6	2.4	2.1	2.1
Art and art-related subjects	**7,045**	**7,280**	**7,630**	**9,678**	**11,185**	**11,820**	**12,525**
Percentage for subject group	4.1	3.7	4.3	4.7	4.3	4.0	4.1
Mathematics, natural sciences	**24,519**	**27,800**	**21,844**	**30,737**	**43,333**	**48,561**	**49,593**
Percentage for subject group	14.1	14.1	12.4	14.8	16.6	16.5	16.1
Engineering sciences	**44,629**	**47,295**	**35,725**	**34,339**	**42,558**	**49,860**	**55,631**
Percentage for subject group	25.7	24	20.2	16.5	16.3	16.9	18.1

Source: *Statistisches Bundesamt,* as well as research in HIS/ICE, in: Leszczensky et al. (2013).

Subject structure rate: the subject structure rate indicates the percentage of first-degree graduates who have completed their studies in a particular subject or group of subjects.

C 1–5

Further training according to employment status and qualification level
(figures in percent)

Further training rate: proportion of persons who participated in a further education measure within four weeks prior to the time of the survey.

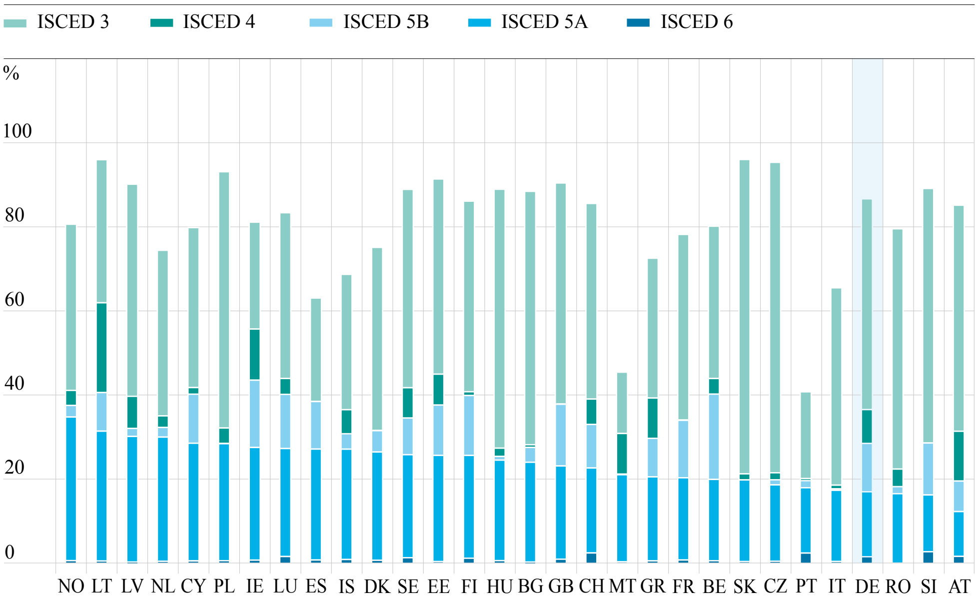
	2003	2004	2005	2006	2007	2008	2009	2010	2011
Gainfully employed persons	**4.1**	**6.7**	**5.7**	**5.1**	**5.2**	**5.4**	**5.1**	**5.0**	**5.0**
low (ISCED 0–2)	1.7	3.9	2.1	1.6	1.4	1.6	1.1	1.4	1.6
medium (ISCED 3–4)	3.2	5.0	4.2	3.6	4.0	3.9	3.9	3.6	3.7
high (ISCED 5–6)	7.7	11.9	11.2	10.5	10.2	11.0	9.6	9.9	9.3
Unemployed persons	**2.8**	**3.8**	**2.4**	**2.1**	**2.5**	**3.6**	**3.3**	**3.1**	**3.9**
low (ISCED 0–2)	1.4	2.4	1.7	0.4	2.0	2.3	2.3	2.7	2.4
medium (ISCED 3–4)	2.9	3.7	2.3	2.4	2.3	4.1	3.6	2.7	3.8
high (ISCED 5–6)	5.6	7.4	4.4	6.0	5.2	4.4	5.1	7.0	9.0
Persons outside the labour force	**1.3**	**3.0**	**1.2**	**1.0**	**0.8**	**1.0**	**1.0**	**1.2**	**1.0**
low (ISCED 0–2)	0.5	1.7	0.6	0.5	0.3	0.3	0.7	0.6	0.6
medium (ISCED 3–4)	1.9	3.7	1.6	1.2	1.0	1.3	1.1	1.6	1.3
high (ISCED 5–6)	2.2	4.8	2.0	1.9	1.8	2.4	2.0	2.0	1.1

Total population: all persons from the age of 15 to 64 years (excluding school-going juveniles, apprentices and students). For information on ISCED, cf. C 1–6.
Source: Eurostat, European Labour Force Survey (micro-data). Calculations by NIW, in: Leszczensky et al. (2013).

C 1–6

Qualification level of the European workforce in 2011
(figures in percent)

The classification of qualification levels is based on the International Standard Classification of Education (ISCED).[384]
ISCED 3: qualification to study at a university of applied sciences/university or completion of an apprenticeship
ISCED 4: qualification to study at a university of applied sciences/university and completion of an apprenticeship
ISCED 5B: Master craftsman or technician training, or equivalent degree from a university of applied sciences
ISCED 5A: degree from a tertiary education institution
ISCED 6: completion of doctoral degree



Source: Eurostat, European Labour Force Survey. Calculations by NIW, in: Leszczensky et al. (2013).

C 2 RESEARCH AND DEVELOPMENT

In 2011, Germany once again increased its R&D intensity, i.e. the share of public and private R&D expenditure as a percentage of GDP (C 2–1). The overall economy's R&D intensity increased from 2.80 percent in 2010 to 2.88 percent in 2011, which largely resulted from enhanced R&D efforts in the private sector. With a total of EUR 50.3 billion, German companies' investments in R&D surpassed the figures from the previous year by 7.2 percent, thereby reaching a new high. But also in Korea and China, additional funds were allocated to research and development. It is estimated that Korea's R&D intensity increased from 3.74 percent in 2010 to 3.8 percent in 2011. After a slight decline in 2009 and 2010, Japan's R&D intensity increased again in 2011, reaching a value of 3.3 percent. Sweden and Finland saw a moderate decline in R&D intensity, albeit declining from a very high level. Great Britain's R&D intensity also decreased, following a slight declining trend that commenced in the early 1990s.

The breakdown of R&D intensity in Germany according to industry – measured by internal R&D expenditure as a percentage of returns from domestic products (C 2–2) – shows that after 2009, the majority of industries recorded a decrease in R&D intensity. This drop is the result of a statistical artifact: as a result of the slump in revenue caused by the financial and economic crisis, the share of R&D spending increased in most industries to a record high. In the years 2010 and 2011, revenue increased again, and the share of R&D expenditure dropped in spite of an increase in investment. The air and spacecraft manufacturing sector clearly stands out in this regard, as this industry managed to significantly increase its revenue in the crisis year of 2009 – contrary to the general trend.

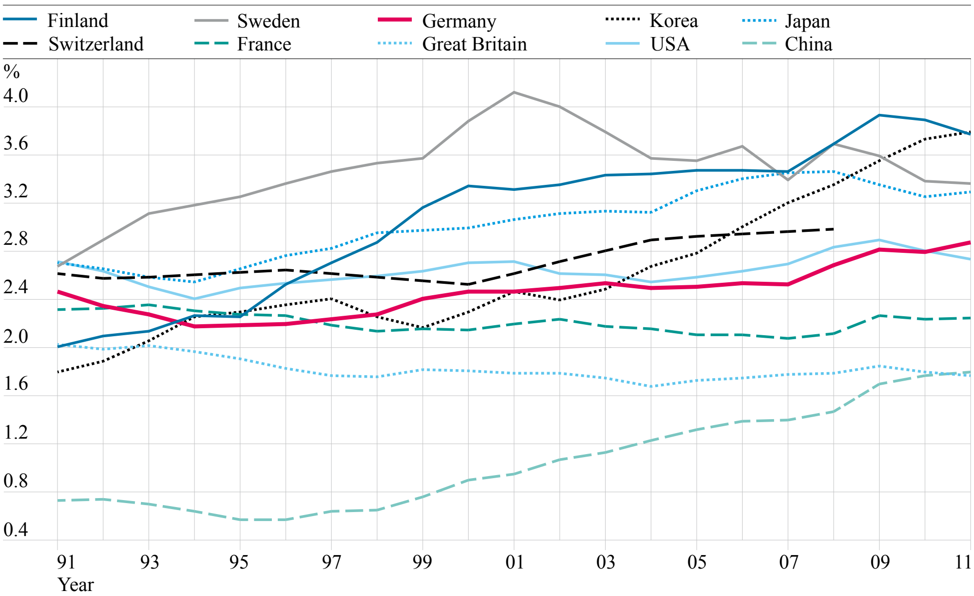
The budgets proposed for civil research and development (C 2–3) clearly show that southern European countries are having difficulties maintaining their respective levels of R&D investment. After the southern European countries experienced above-average growth for several years, their budget estimates have dropped dramatically since 2009. A decline, albeit slightly less pronounced, was recorded for the whole of the OECD countries. The group of EU-15 member states, however, was still slightly lagging behind in 2011, which can be explained mainly by the fact that the two large European economies, Germany and France, continue to stock up government resources for investments in civil R&D – a policy that is also being pursued by Japan.

In terms of internal R&D expenditures of tertiary education institutions and non-university research institutions, (C 2–4) Germany experienced an above-average development. Other central European countries also continued to increase their expenditures in real terms, while the southern European countries and the UK recorded a decrease in public R&D activities. Korea's positive trend in expenditure is particularly striking. The 2010 index value shows how R&D expenditures of tertiary education institutions and non-university institutions have tripled since 1995.[385]

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

C 2–1

R&D intensity: share of expenditure on research and development of an economy's gross domestic product.

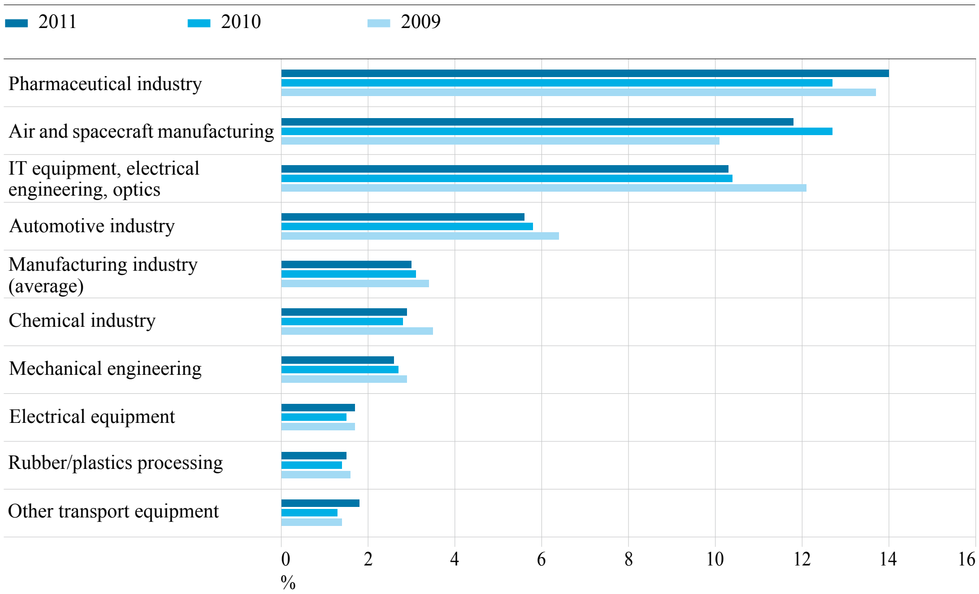


Source: OECD, Main Science and Technology Indicators (2012/1). Eurostat; *SV Wissenschaftsstatistik*. Calculations and estimates by NIW, in: Gehrke, Schasse et al. (2013).

Internal private sector R&D expenditure relative to revenue from domestic products

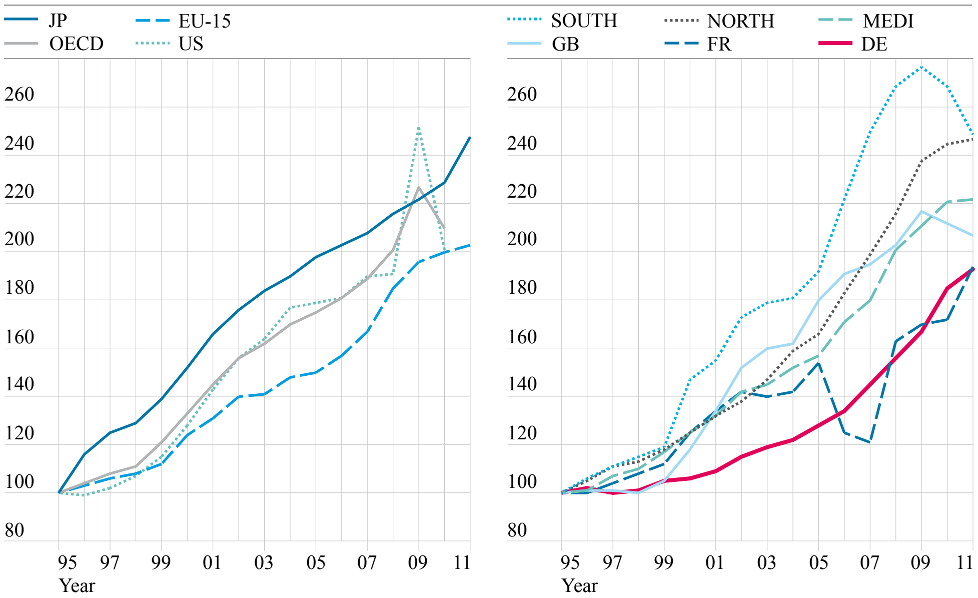
C 2–2

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



Source: *SV Wissenschaftsstatistik; Statistisches Bundesamt, Unternehmensergebnisse Deutschland,* unpublished charts, as well as *Fachserie 4, Reihe 4.3.* Calculations by NIW, in: Gehrke, Schasse et al. (2013).

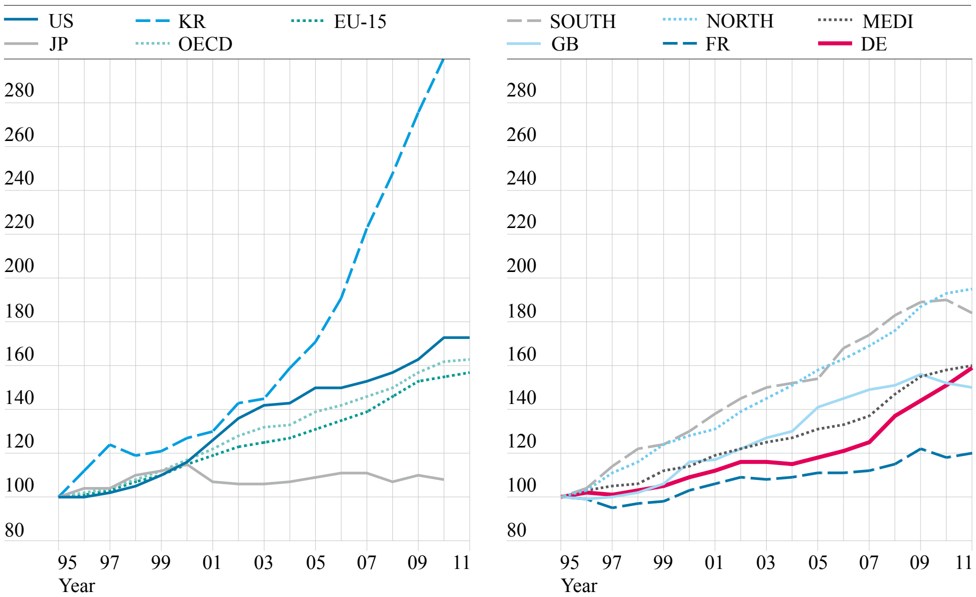
C 2–3 State budgets for civil R&D in selected world regions



Index: 1995 = 100. NORTH: SE, FI, NO, DK, IE, IS; SOUTH: IT, PT, ES, GR; MEDI: BE, NL, AT, CH.
Figures partially estimated.
Source: OECD, Main Science And Technology Indicators (2012/1); Eurostat. Calculations and estimates by NIW, in: Gehrke, Schasse et al. (2013).

R&D budget estimates: budget resources available for the financing of R&D as specified in the state budget.

C 2–4 Internal R&D expenditures of universities and non-university research institutions at constant prices, according to world regions



Index: 1995 = 100. NORTH: SE, FI, NO, DK, IE, IS; SOUTH: IT, PT, ES, GR; MEDI: BE, NL, AT, CH.
Figures partially estimated.
Source: OECD, Main Science And Technology Indicators (2012/1); Eurostat.
Calculations and estimates by NIW, in: Gehrke, Schasse et al. (2013).

Internal R&D expenditures: financial outlays for R&D personnel, R&D equipment, and investments in R&D within an organisation.

INNOVATION BEHAVIOUR IN THE GERMAN PRIVATE SECTOR C 3

Corporate innovation activities aim to achieve at least a temporary competitive advantage over other market participants. Graphs C 3–1 to C 3–5 illustrate the innovation behaviour of German businesses since 1993. Figures are based on data from the Mannheim Innovation Panel (MIP), which is the annual innovation survey by the Centre for European Economic Research (ZEW).[386] In 2011, the innovator rate (C 3–1) decreased both in industry and knowledge-intensive services. The rate was still above the level of the crisis year of 2009 in the R&D-intensive industries, while innovation participation in other industries and knowledge-intensive services remained below the value of 2009.

Technologically advanced innovation projects usually require continuous R&D activities.[387] Following a rise in 2010, the proportion of companies with continuous R&D (C 3–2) declined in 2011 both in industry and knowledge-intensive services. The share of occasional R&D-performing companies considerably declined both in R&D-intensive industries and other industries, while the ratio increased slightly in the knowledge-intensive services sector.

While innovation intensity (C 3–3) in the R&D-intensive industries increased in 2011, it decreased slightly in other industries and in knowledge-intensive services. The proportion of revenue generated by new products as part of innovation activities (C 3–4) shows a similar development trend: in the R&D-intensive industries, the ratio rose slightly in 2011, while it decreased in other industries and in knowledge-intensive services (excluding financial services).

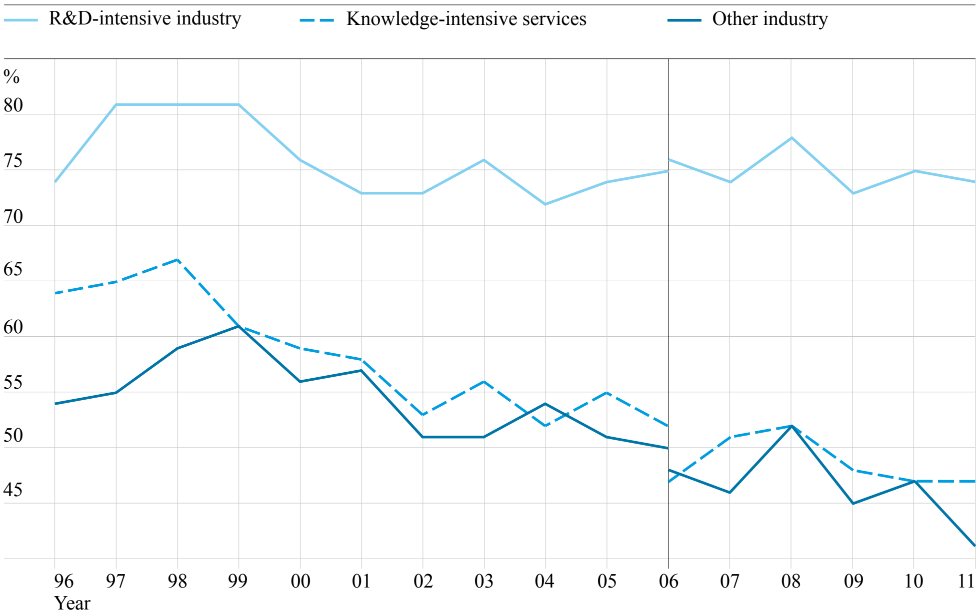
The surveyed companies have also provided projected figures on innovation expenditures in 2012 and 2013, based on estimates from the spring and summer 2012 (C 3–5). According to these figures, innovation expenditures are expected to increase further in 2012 across all three sectors. In 2013, companies from the R&D-intensive industries and knowledge-intensive services aim to achieve an increase in innovation expenditure, while a decrease is expected in other industries.

Equity plays a pivotal role in the financing of innovation activities in the private sector. According to data from the European BACH database[388], the equity ratios of small and medium-sized industrial enterprises in Germany (C 3–6) increased once again in 2010.

Young, innovative companies can often only successfully establish themselves on the market if they are supported during the start-up and development phases by venture capital from private investors. As shown by figures from the European Private Equity & Venture Capital Association (EVCA)[389], the volume of venture capital investments (C 3–7) increased in Germany in 2010 and 2011, after it had fallen sharply during the crisis year of 2009. Nevertheless, the proportion of venture capital investment as a percentage of GDP (C 3–8) in Germany continues to be relatively low. Other continental European countries such as Sweden, Denmark, Finland and Switzerland record significantly higher venture capital investments relative to GDP.

As a result of the work of the committees at the International Organization for Standardization (ISO) (C 3–9), countries can significantly influence the global technical infrastructure, thereby achieving competitive advantages.[390] German companies contribute to the work of ISO committees more frequently than representatives of all other countries.

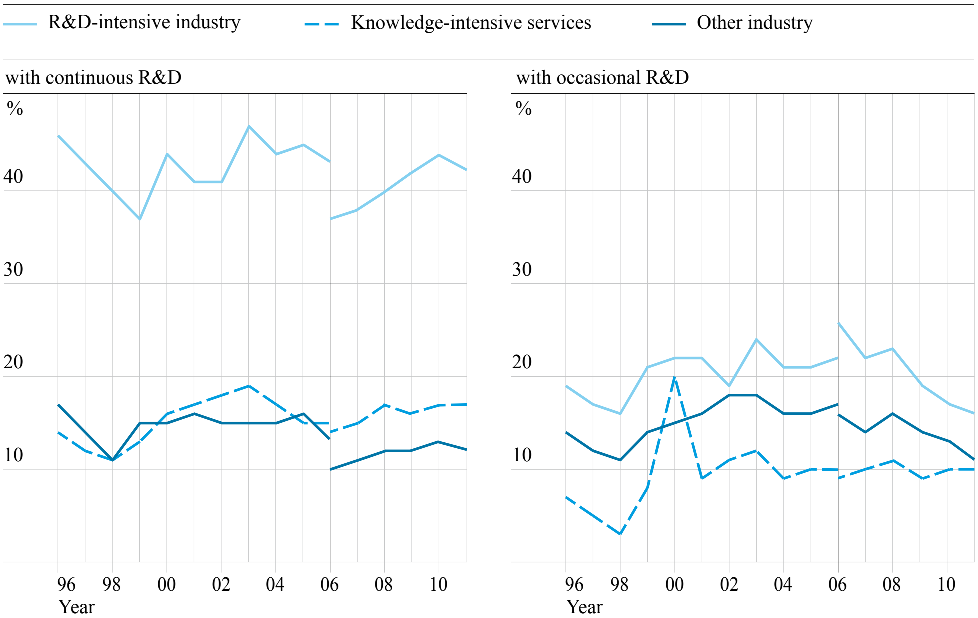
C 3–1 **Innovator rate in Germany's industry and knowledge-intensive services**
(figures in percent)



1995 not surveyed for knowledge-intensive services. Break in the time series in 2006. Figures for 2011 are provisional.
Source: Mannheim Innovation Panel (MIP). Calculations by ZEW.

Innovator rate: share of companies that, within a three-year period, have launched at least one new product on the market or introduced at least one new process.

C 3–2 **Companies with continuous or occasional R&D activities**
(figures in percent)



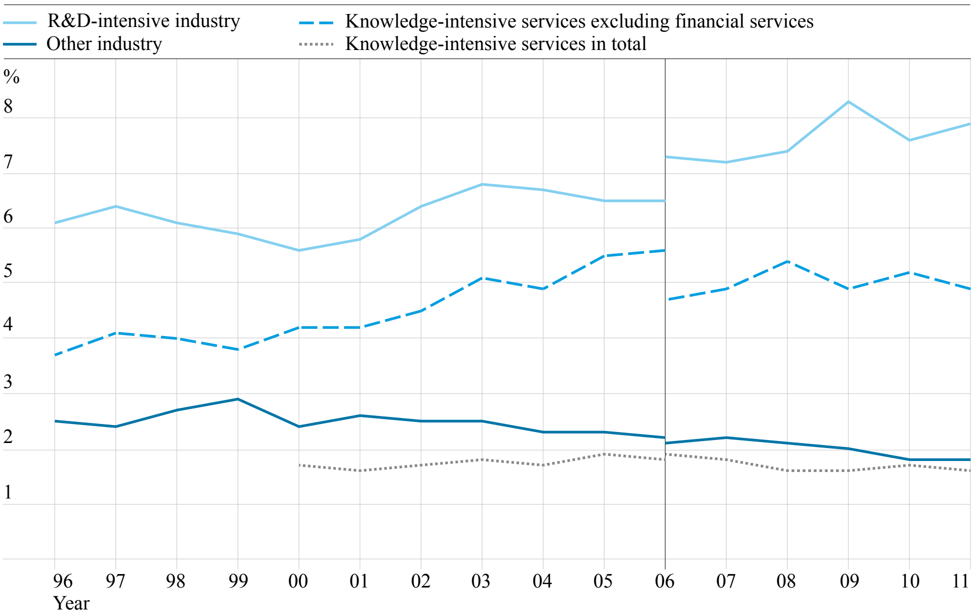
1995 not surveyed for knowledge-intensive services. Break in the time series in 2006. Figures for 2011 are provisional.
Source: Mannheim Innovation Panel (MIP). Calculations by ZEW.

Share of companies with continuous or occasional R&D activities: innovation-active companies that have, over the previous three-year period, pursued R&D either continuously or occasionally.

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

C 3–3

Innovation intensity: companies' innovation expenditures in relation to total revenue.

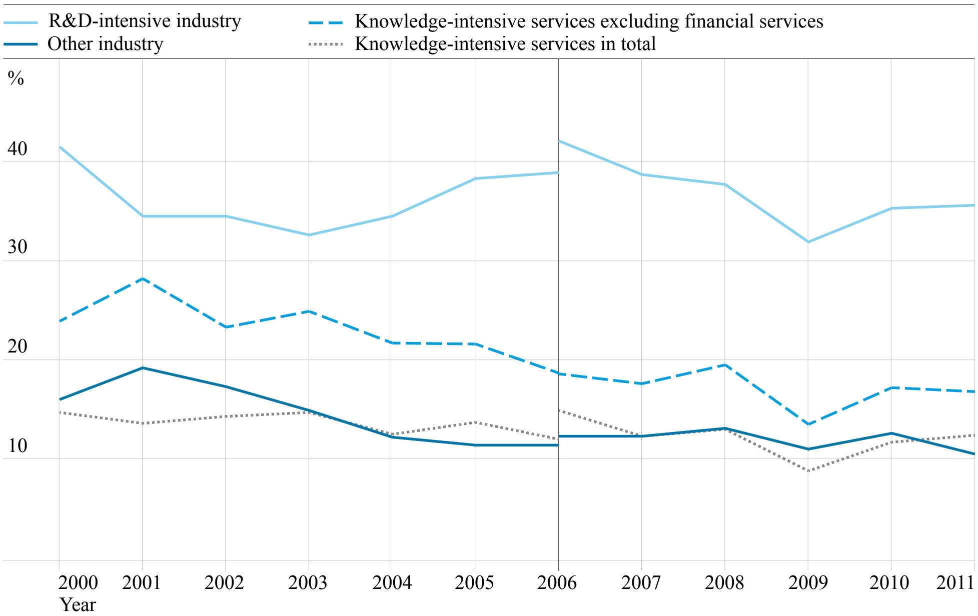


Break in the time series in 2006. Figures for 2011 are provisional.
Source: Mannheim Innovation Panel (MIP). Calculations by ZEW.

Proportion of revenue generated with new products in Germany's industry and knowledge-intensive services (figures in percent)

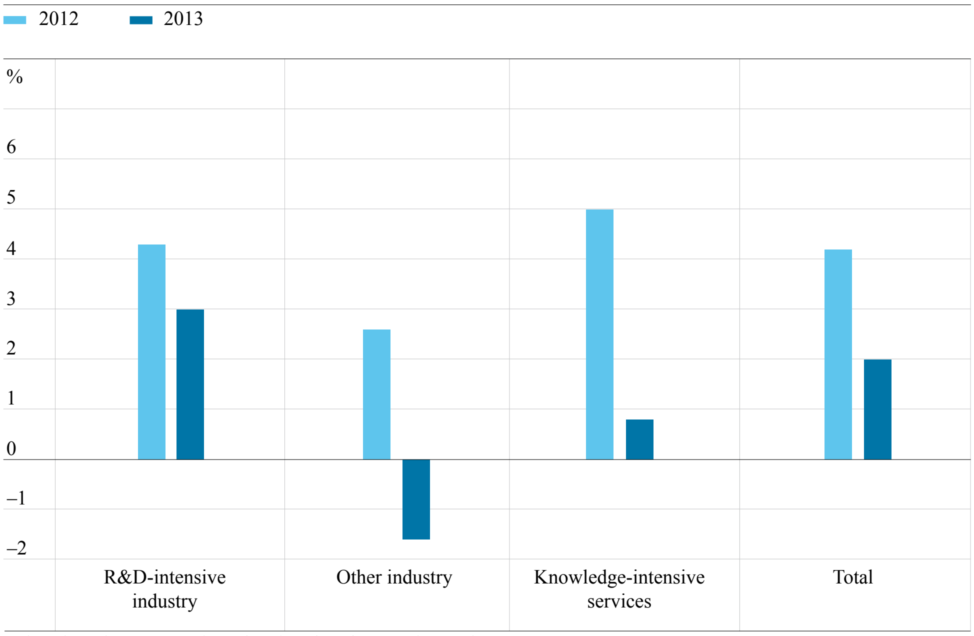
C 3–4

Proportion of revenue generated with new products: revenue from new or significantly improved products, newly introduced by innovating companies in the past three years, in relation to total revenue.



Break in the time series in 2006. Figures for 2011 are provisional.
Source: Mannheim Innovation Panel (MIP). Calculations by ZEW.

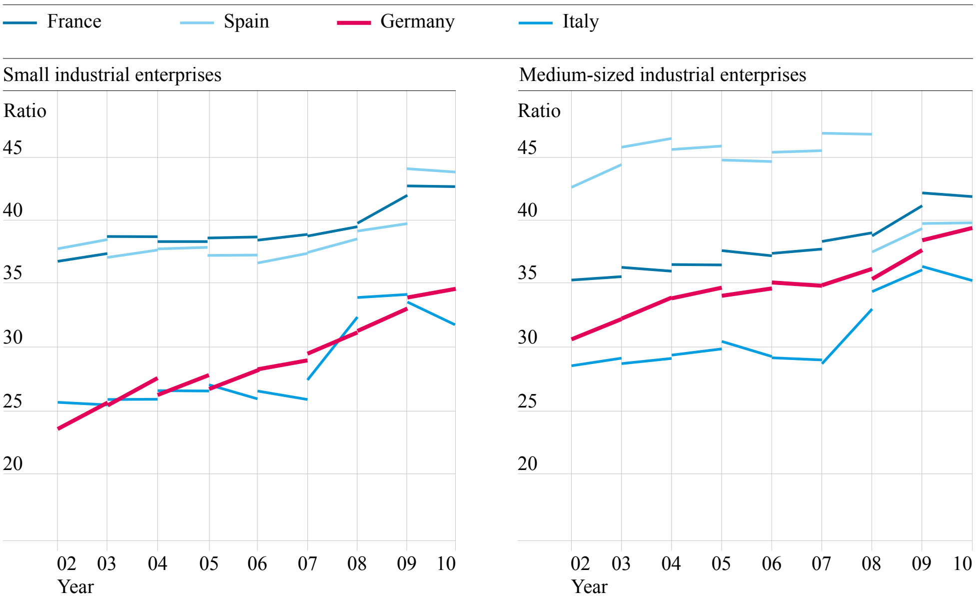
C 3–5 **Planned changes in innovation expenditures in Germany's industry and knowledge-intensive services** (figures in percent)



Values based on companies' planning data from spring and summer 2012.
Source: Mannheim Innovation Panel (MIP). Calculations by ZEW.

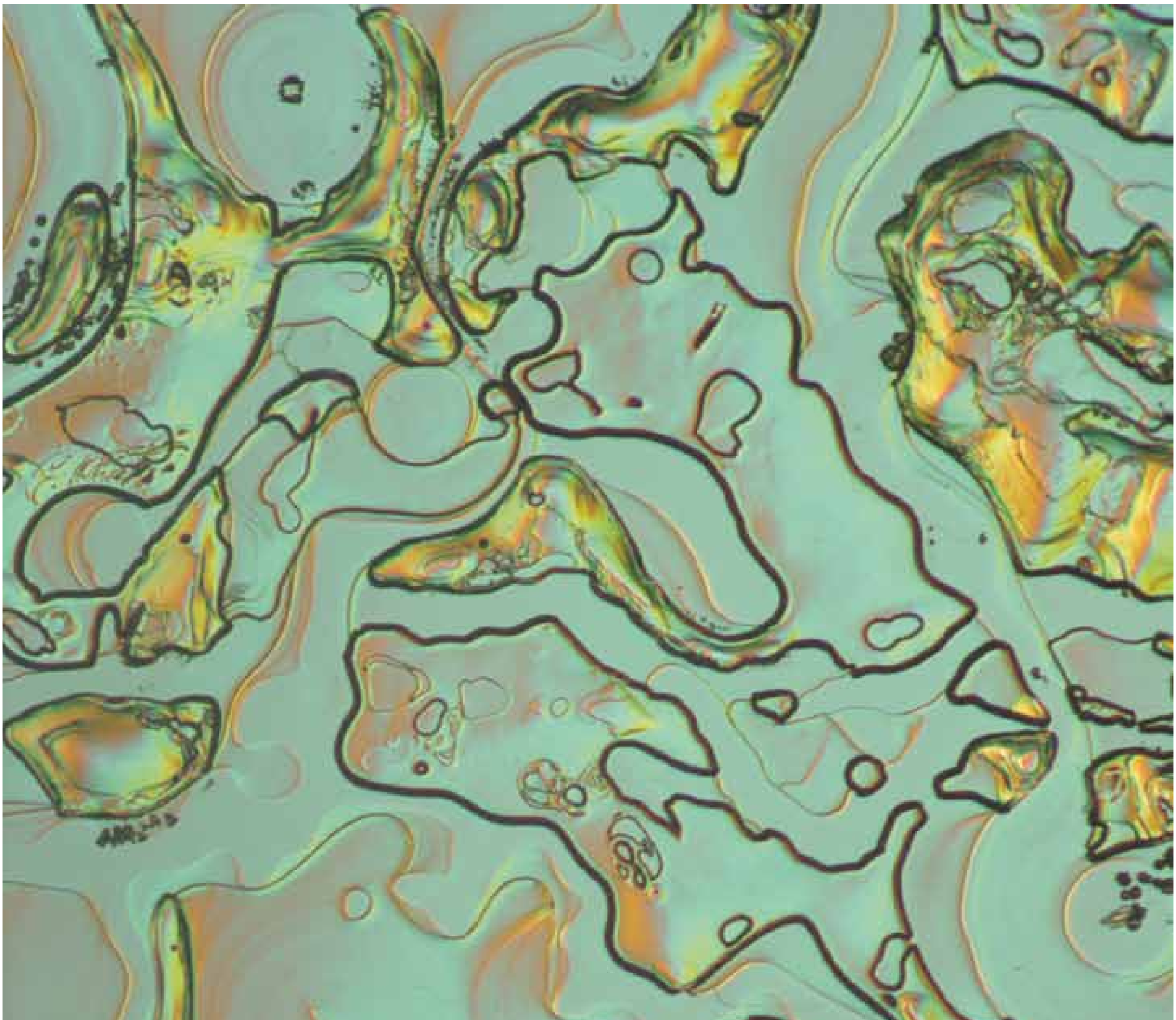
Planned innovation expenditures: data, obtained from the companies' planning figures, regarding changes in innovation-related expenditures compared with the previous year.

C 3–6 **Equity ratios of small and medium-sized industrial enterprises**[391]

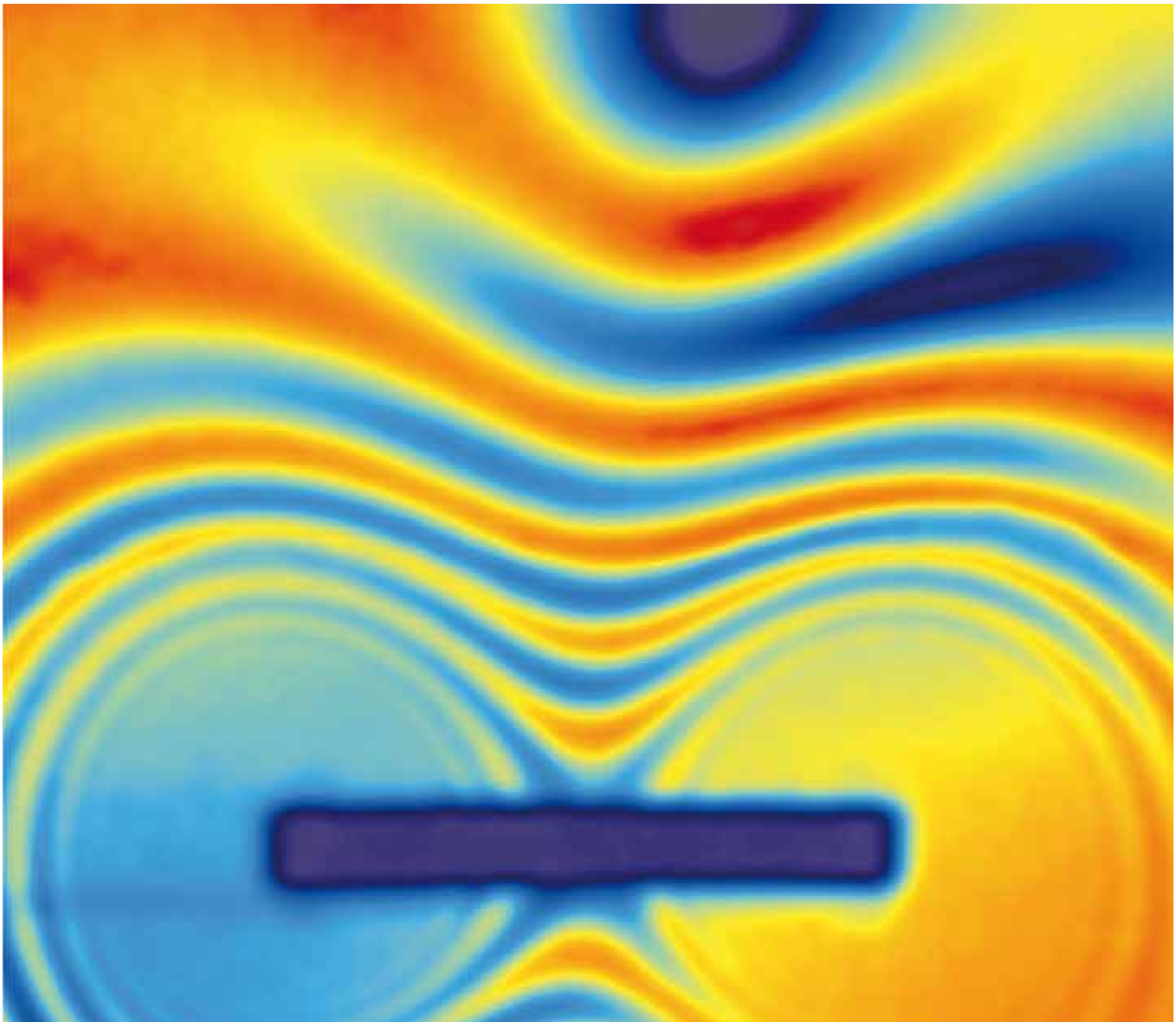


Source: BACH-ESD. Banque de France. Own depiction.

Equity ratio: a company's equity in relation to its total balance sheet.



A silicon sample viewed through a polarised-light microscope.



The magnetic field of a dipol magnet visualised by neutron tomography at the Berlin neutron source BER II.

Venture capital investments
(investments according to portfolio companies' registered office)

C 3–7

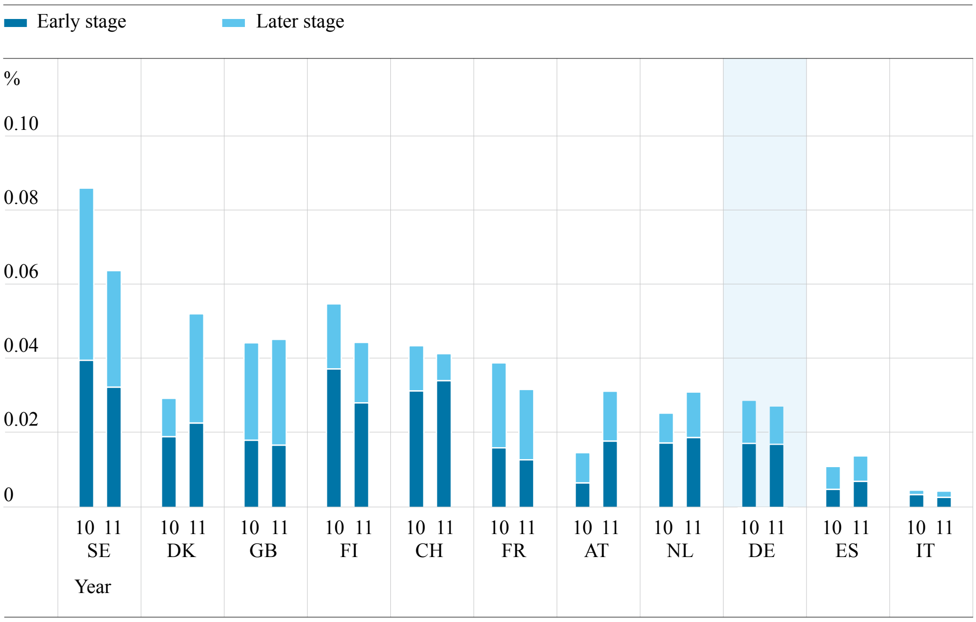
Venture capital: temporally limited equity participation in young, innovative, unlisted companies.

	2010				2011			
	Early Stage*	**Later Stage***	**Total venture capital***	**GDP****	**Early Stage***	**Later Stage***	**Total venture capital***	**GDP****
Denmark	45.0	24.4	69.4	235.6	54.6	70.7	125.3	239.8
Germany	*428.6*	*288.6*	*717.3*	*2,476.8*	*439.1*	*265.7*	*704.8*	*2,570.8*
Finland	67.2	31.5	98.7	179.7	54.1	31.2	85.3	191.6
France	312.5	443.7	756.2	1,937.3	257.6	378.8	636.3	1,996.6
Great Britain	310.0	448.3	758.3	1,706.3	292.4	495.7	788.1	1,737.1
Italy	54.4	18.8	73.2	1,553.2	43.8	26.5	70.2	1,580.2
Netherlands	102.4	47.5	149.9	588.4	113.7	74.0	187.7	602.1
Austria	19.0	23.4	42.4	286.2	53.8	40.4	94.3	300.2
Sweden	138.7	162.2	300.9	349.2	125.6	121.6	247.1	386.8
Switzerland	125.5	48.6	174.1	398.9	157.1	33.5	190.5	459.0
Spain	51.7	65.0	116.7	1,051.3	76.0	73.7	149.7	1,073.4

* In million euro. ** at current prices in billion euro. The early stage comprises the "seed" and "start-up" phases.
Source: EVCA (2012). Eurostat. Own calculations. Inaccuracies due to figure rounding.

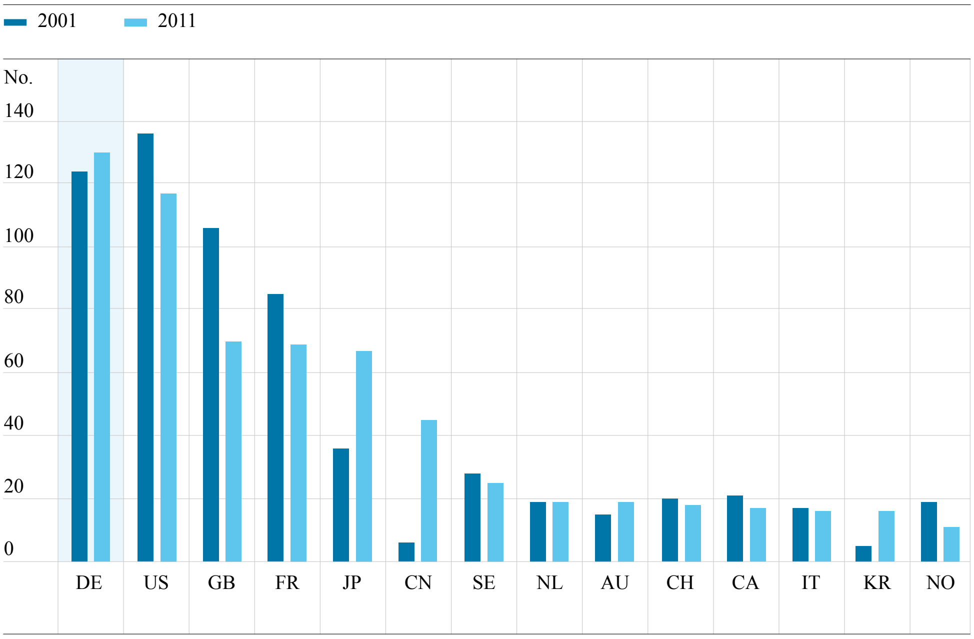
Proportion of venture capital investments as a percentage of national GDP
(Investments according to registered office of the portfolio companies; figures in percent)

C 3–8



The early stage comprises the "seed" and "start-up" phases.
Source: EVCA (2012). Eurostat. Own calculations.

C 3–9 **Number of assigned secretariats for technical committees and subcommittees of the International Organization for Standardization (ISO)**



Source: ISO (2002:17 and 2012:47). Own compilation.

Standardisation: harmonisation of important characteristics of products, processes and services.

NEW ENTERPRISES

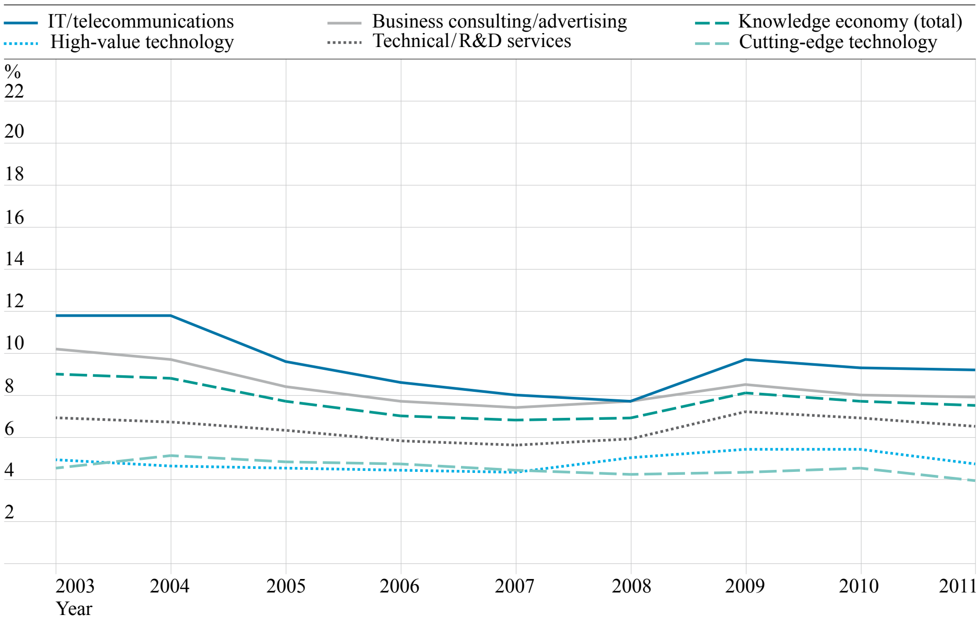
With their innovative products, processes and business models, business start-ups – and especially those in research and knowledge-intensive sectors – pose a challenge to existing companies. The creation of new enterprises and the market exit of unsuccessful or formerly successful companies signify the competition for the best solutions. Company dynamics are therefore an important aspect of structural change. Especially in new fields of technology, in the emergence of new trends in demand, and in the early phase of the transfer of scientific knowledge to the development of new products and processes new enterprises open up market niches , while also facilitating the breakthrough of innovative ideas that are not pursued by large companies.

The results displayed in graphs C 4–1 to C 4–3 of company dynamics in the knowledge economy are based on an evaluation of the Mannheim Enterprise Panel (MUP), conducted by the Centre for European Economic Research (ZEW).[392] According to this evaluation, the start-up rate (C 4–1) in the knowledge economy amounted to 7.6 percent in 2011 and thus once again decreased when compared with the previous year. The closure rate (C 4–2), however, remained almost stable at 7.2 percent in 2011.

Company dynamics (C 4–3) provide information on the direction and strength of structural change in the business sector. The intra-sectoral comparison for the 2010/2011 period reveals that the sector group with the strongest dynamics was energy supply, mining and waste disposal, while the weakest dynamics were recorded in cutting-edge technology and high-value technology. Between the 2006/2007 and 2010/2011 periods, company dynamics in the knowledge economy remained almost stable, albeit in most of the knowledge economy's sectors it remained well below the levels of 2003/2004, i.e. innovation competition has weakened in these fields.

Graphs C 4–4 and C 4–5 show results from the Global Entrepreneurship Monitor (GEM).[393] The rate of nascent entrepreneurs (C 4–4) denotes the proportion of the population aged 18 to 64 years that is actively involved in starting up a business. In 2011, this proportion increased in Germany for the second consecutive year, after a continuous decrease in the preceding years. The rate of opportunity entrepreneurs (C 4–5) shows the proportion of nascent entrepreneurs who start up a business in order to exploit a business idea, in contrast to those who start up a business for lack of alternative income sources. Compared with the previous year, this proportion increased significantly in 2011 in Germany, which indicates a positive effect in terms of economic structural change, since opportunity entrepreneurs much more frequently state that they offer products or services that are new to the customer.[394]

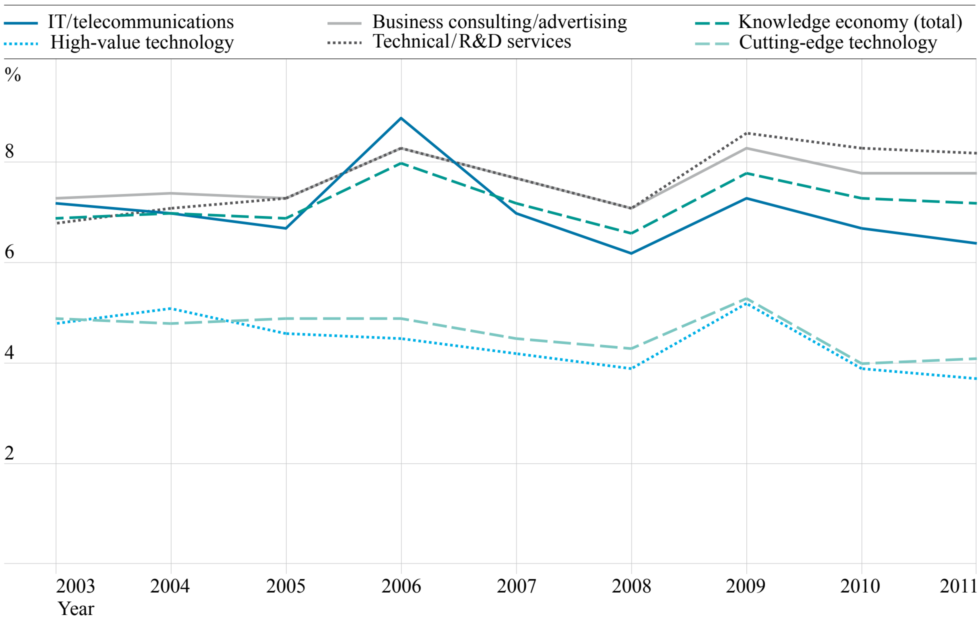
C 4–1 **Start-up rates in Germany's knowledge economy**
(figures in percent)



All figures are provisional.
Source: Mannheim Enterprise Panel (MUP). Calculations by ZEW.

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

C 4–2 **Closure rates in Germany's knowledge economy**
(figures in percent)



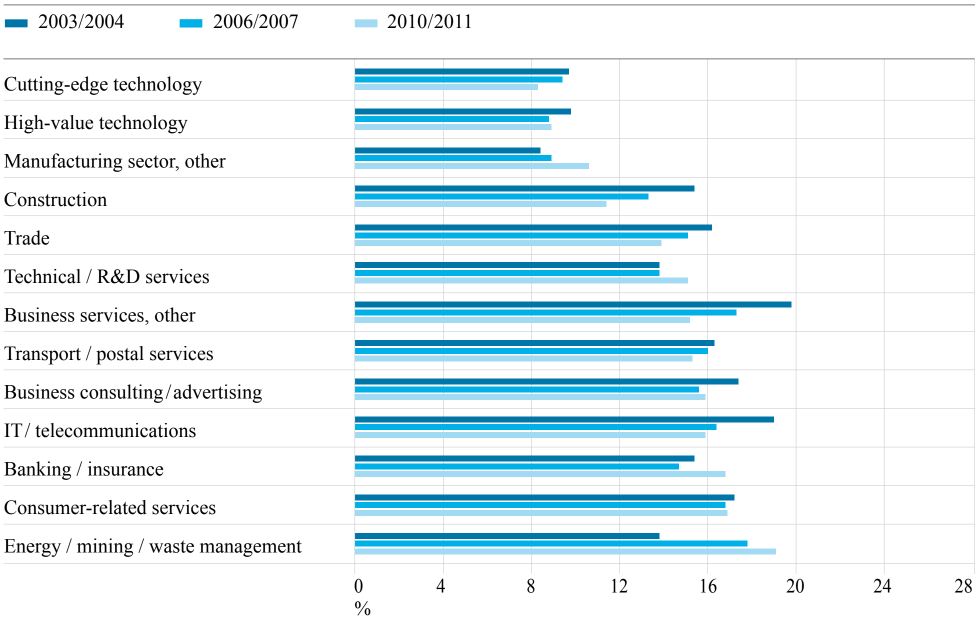
All figures are provisional.
Source: Mannheim Enterprise Panel (MUP). Calculations by ZEW.

Closure rate: number of companies shut down during the course of a year, as a percentage of total number of companies.

C 4–3

Company dynamics in Germany according to sector groups
(figures in percent)

Company dynamics: number of start-up businesses, plus number of company closures, as a percentage of total number of companies at mid-year.

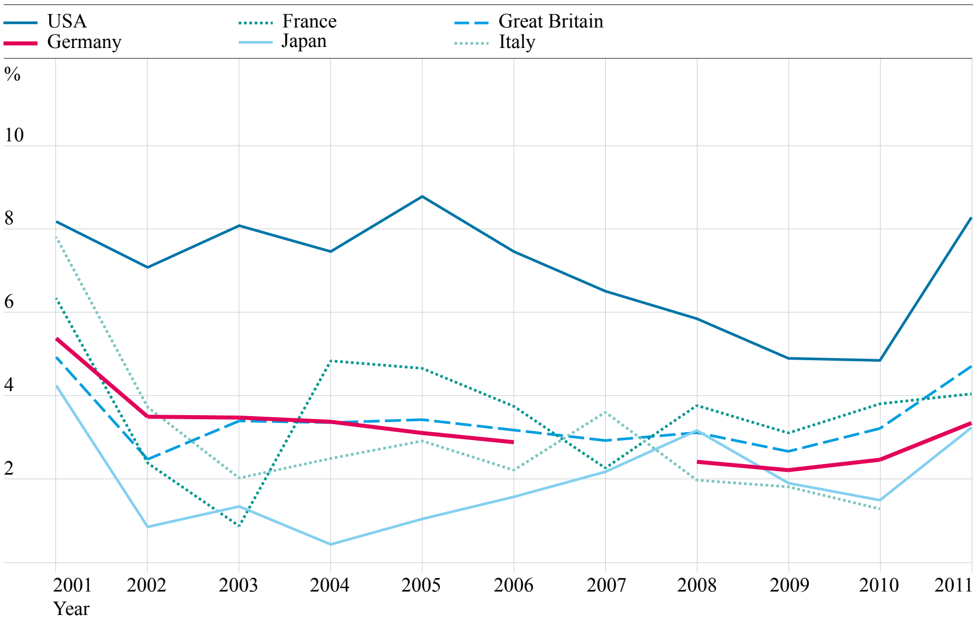


All figures are provisional.
Source: Mannheim Enterprise Panel (MUP). Calculations by ZEW.

C 4–4

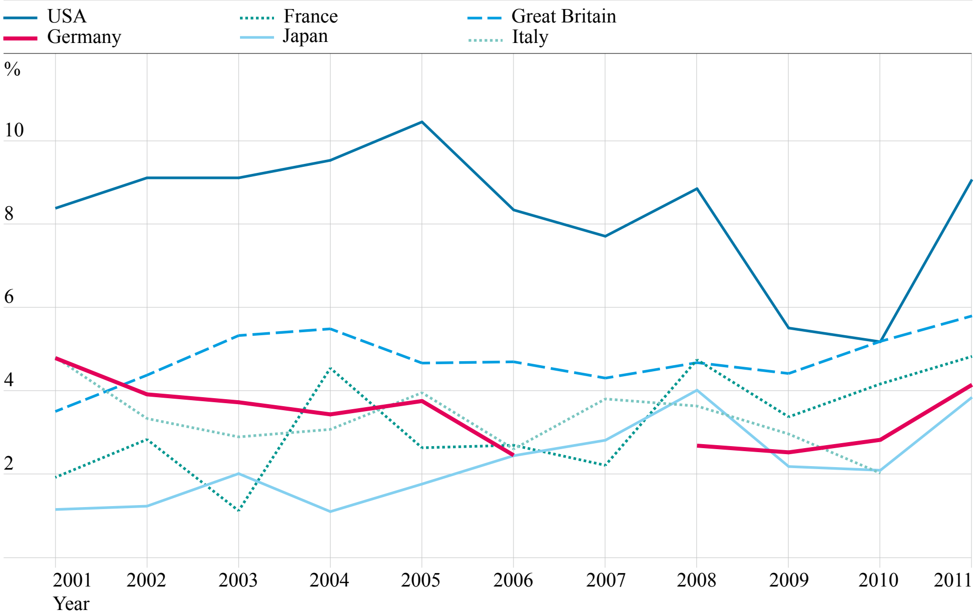
Rate of nascent entrepreneurs
(figures in percent)

Rate of nascent entrepreneurs: number of persons aged 18 to 64 who are actively involved in starting up a new business – which may include e.g. the following activities: acquiring equipment and locations, organising an entrepreneurial team, drawing up a business plan, providing capital – and who intend to be the owner of or a shareholder/partner in a company, and who have not paid any wages or salaries during a period of three months prior to the survey, as a percentage of all persons aged 18 to 64, in the relevant country.



Germany did not participate in GEM in 2007 and Italy did not participate in 2011.
Source: Global Entrepreneurship Monitor (GEM), Adult Population Surveys 2000–2011.

C 4–5 **Opportunity Entrepreneurs**
(figures in percent)



Germany did not participate in GEM in 2007 and Italy did not participate in 2011.
Source: Global Entrepreneurship Monitor (GEM), Adult Population Surveys 2000–2011.

Opportunity entrepreneurship: number of persons aged 18 to 64 who are nascent entrepreneurs (cf. C 4–4) and who intend to go into business in order to exploit a business idea, as a percentage of all persons aged 18 to 64, in the relevant country.

PATENTS IN INTERNATIONAL COMPARISON C 5

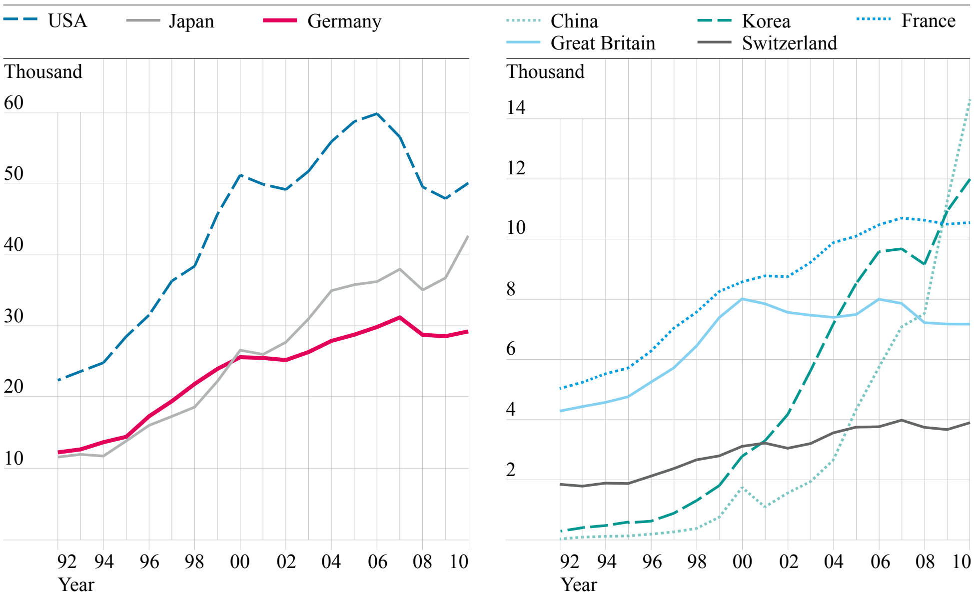
Patents are industrial property rights for new technical inventions. A patent confers on its holder the right to exclude third parties from utilising the protected invention for a certain period of time. Patents represent considerable application-oriented R&D output and can be interpreted as an indicator of the codified knowledge and technological potential of companies, regions or entire countries. Since filed patents provide not only technical details on the invention itself, but also additional information on the inventor, the patent applicant, and the date and place of registration, patent statistics are a valuable source for documenting the scientific and technological performance of national economies.

In its analyses of the patenting activities of selected countries, the Commission of Experts for Research and Innovation relies on transnational patents. These are patents or patent families[395] that comprise at least one application filed with the World Intellectual Property Organisation (WIPO) via the Patent Cooperation Treaty Procedure (PCT)[396] or an application filed with the European Patent Office (EPO). These patents usually comprise inventions of high technical and economic importance that are to be marketed internationally. Transnational patents thus provide a solid empirical basis for comparing economic systems in terms of their scientific and technological performance. The Expert Commission has analysed the patent activities of selected countries based on absolute trends and growth rates, and also on the basis of patent intensities and specialisation indices[397] which reflect patent activities in relation to the size of a country or for specific fields of technology, respectively.[398]

Based on the absolute number of transnational patent applications (C 5 – 1), it appears that the downward trend experienced by most countries,[399] which started in late 2007 as a result of the financial and economic crisis, came to an end in 2010. Thus, in most countries the number of transnational patent applications was at a similar level as in the years before the crisis. After the United States and Japan, Germany continues to be one of the world's leading economies with regard to transnational patent applications. However, in terms of growth rates, the strongest positive dynamics throughout the last decade were recorded in China and Korea. When considering the number of patent applications in relation to the size of the country (patent intensity), smaller countries such as Switzerland, Sweden and Finland are at the top (C 5 – 2). Here Germany comes fourth in international comparison and third in the area of high technology.

Patent activities in the field of high technology provide further insights into a country’s scientific and technological performance. This area includes all those industries that invest more than 2.5 percent of their revenue in R&D activities (R&D intensity). High technology comprises the areas of high-value technology (R&D intensity > 2.5 and max. 7 percent) and cutting-edge technology (R&D intensity > 7 percent).[400] As regards Germany, the patent statistics indicate a strong specialisation in high-value technology (C 5 – 3). Due to its traditional strengths in the automotive industry, mechanical engineering and the chemical industry, Germany is in second place after Japan when compared internationally. In the field of cutting-edge technology, however, Germany is still poorly positioned, remaining well behind leading countries such as China, Korea and the United States (C 5 – 4). Some of these countries are able to compensate for their lower-than-average patent activity in the area of high technology through their successful specialisation in cutting-edge technology, while Japan even takes a leading position in both high-value technology and cutting-edge technology.

C 5–1 **Development of numbers of transnational patent applications over time, for selected countries**



Source: EPA (PATSTAT), calculations by Fraunhofer ISI, December 2012.

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

C 5–2 **Transnational patent applications in the field of high technology: absolute number, intensity and growth rates in 2010**

	Absolute	Intensity	Intensity, high technology	Total growth* in percent	Growth* in high technology, in percent
Total	**211,711**	**–**	**–**	**133**	**131**
Switzerland	3,903	861	400	125	119
Finland	1,898	773	355	102	107
Sweden	3,477	771	352	105	99
Germany	*29,284*	*755*	*382*	*114*	*109*
Japan	42,722	681	401	160	165
Korea	12,001	511	280	431	475
Netherlands	3,384	393	187	91	78
France	10,555	393	204	123	128
USA	50,123	358	213	98	98
EU-27	71,694	329	162	115	112
Great Britain	7,178	249	125	90	87
Italy	5,404	235	104	119	121
Canada	3,774	224	117	142	130
China	14,649	19	8	836	527

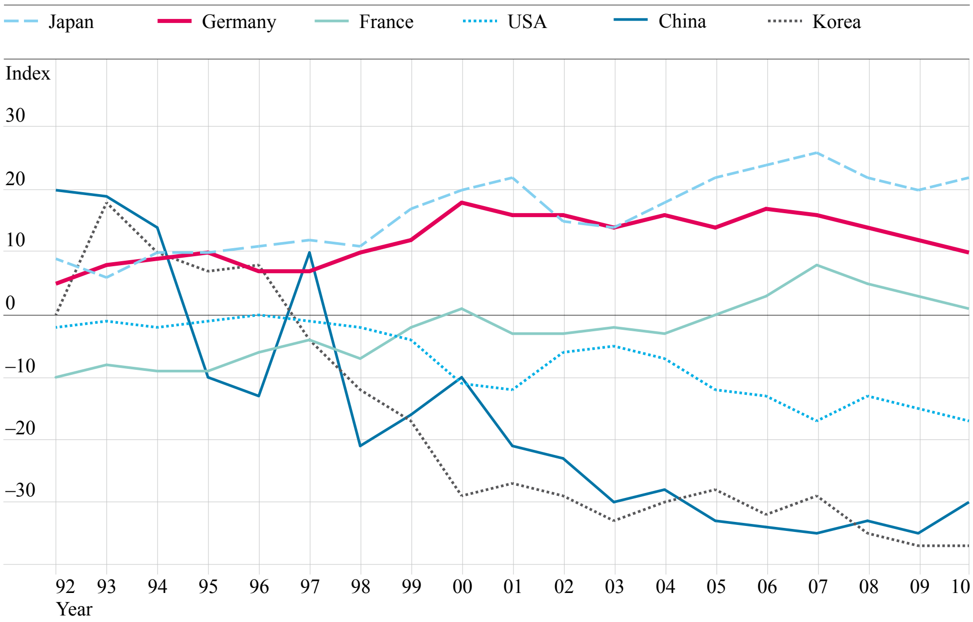
*Index: 2000 = 100
Source: EPA (PATSTAT). OECD (MSTI). Calculations by Fraunhofer ISI, December 2012.

The high technology industry sector comprises industry areas that invest more than 2.5 percent of their revenue in research and development. “Intensity” refers to the number of patents per one million gainfully employed persons.

C 5–3

Development of the high-value technology specialisation index over time, for selected countries

The specialisation index is calculated on the basis of all transnational patent applications worldwide. Positive or negative values indicate if the surveyed country's level of activity in a given field is disproportionately high or disproportionately low in comparison to the global average.

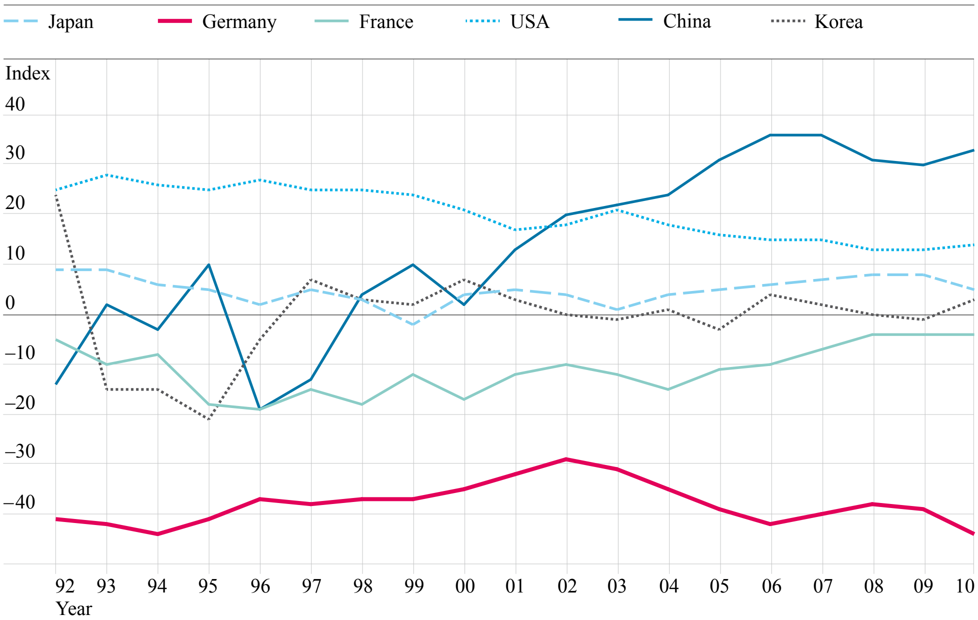


Source: Questel (EPPATENT, WOPATENT). EPA (PATSTAT). Calculations by Fraunhofer ISI. December 2012.

C 5–4

Development of the cutting-edge technology specialisation index over time, for selected countries

The specialisation index is calculated on the basis of all transnational patent applications worldwide. Positive or negative values indicate if the surveyed country's level of activity in a given field is disproportionately high or disproportionately low in comparison to the global average.



Source: Questel (EPPATENT, WOPATENT). EPA (PATSTAT). Calculations by Fraunhofer ISI. December 2012.

C 6 SCIENTIFIC PUBLICATIONS AND PERFORMANCE

The transition towards a knowledge society is accompanied by significant changes in an economy's structures. The stock of intangible knowledge and innovative products and services in the knowledge-based industry sectors often provides the decisive growth stimulus for a country's economy.[401]

The continuous generation of new knowledge particularly depends on the performance of the respective research and science system. With the help of bibliometrics, this performance is largely measurable now.[402] To put it simply, bibliometrics determine the performance of a country, institution, or even a single scientist, on the basis of publications in scientific journals. The perception and relevance of these publications for other scientists, and thus often enough also their quality, are measured by the number of citations.

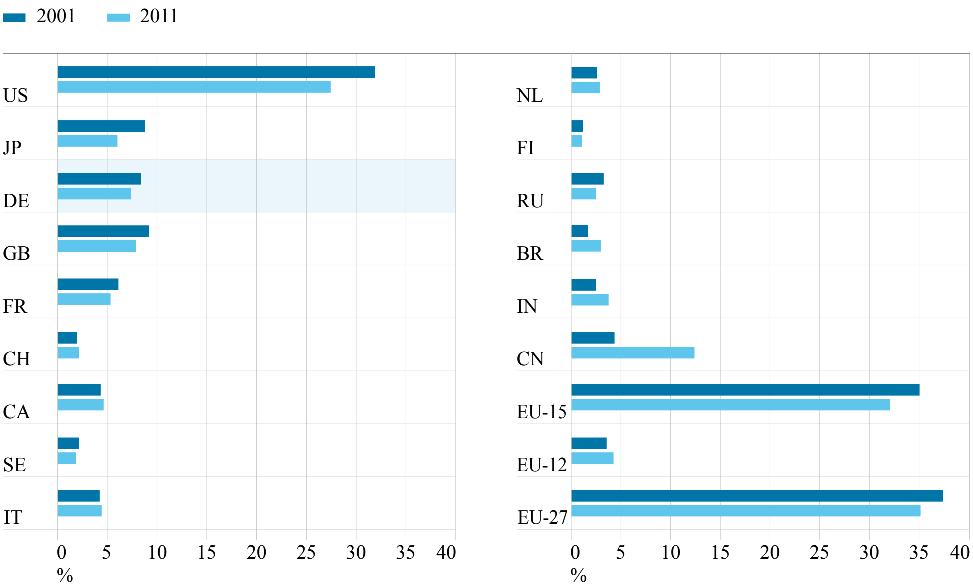
Here, the shares of numerous established industrialised countries in all global publications have markedly decreased in favour of the BRIC countries (C 6–1). On a medium to long-term basis, this trend also applies to Germany. Furthermore, it is particularly striking that over the past decade, China's share has more than doubled and that currently only scientists in the USA publish more than scientists in China.[403]

In 2009, scientists in Switzerland, the Netherlands, Denmark and the United States succeeded in placing their publications particularly in scientific journals with an international audience (C 6–2) and in writing publications that were relatively frequently cited (C 6–3). This is something that scientists in the BRIC countries achieve only rarely. Yet, when compared with 2001, the BRIC countries have also been catching up in this respect; China and India in particular. As regards Germany's research performance, these two indicators currently point to an increase in the number of publications in scientific journals with worldwide visibility, but also to a poorer positioning in the journal-specific scientific regard of publications.

Shares of selected countries and regions for Web of Science publications in 2001 and 2011 (figures in percent)

C 6–1

In order to take account of changes in the collection of publication data – continuous expansion in particular – countries' shares of publications, and not absolute numbers of publications, are considered here.

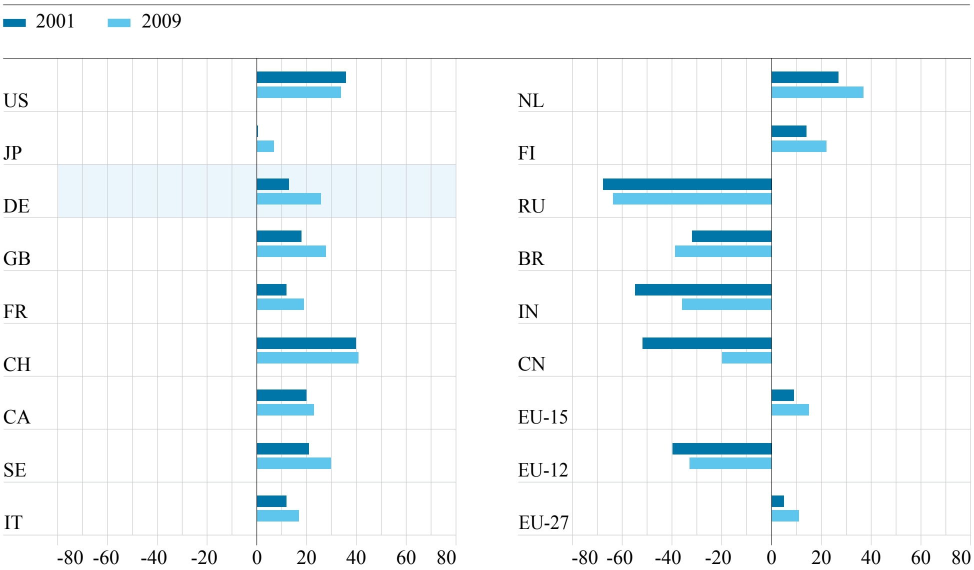


Source: Web of Science (WoS). Research and calculations by Fraunhofer ISI.

International alignment of selected countries and regions for Web of Science publications in 2001 and 2009 (index values)

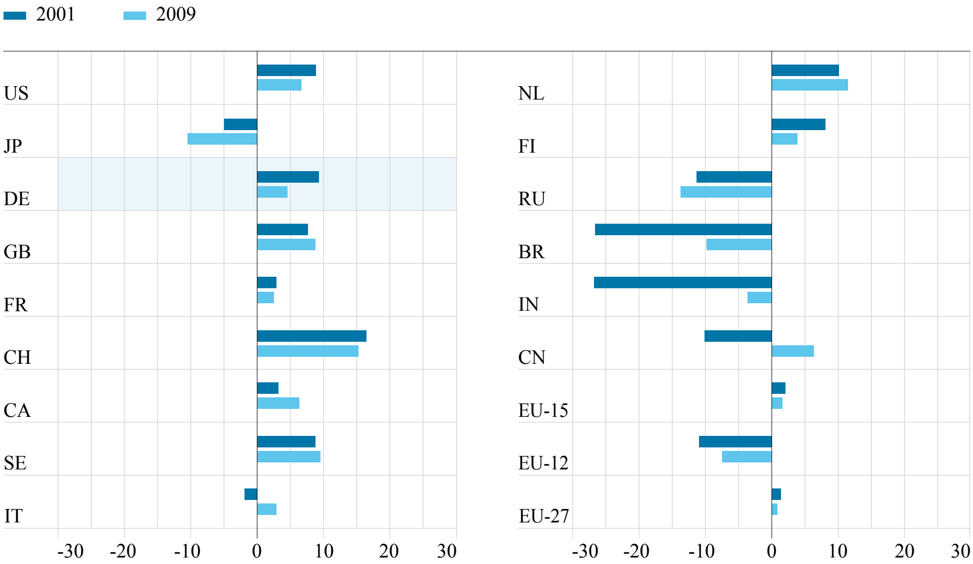
C 6–2

The international alignment (IA) index shows the extent to which a country's authors, in comparison to the world average, are publishing in internationally renowned journals and less-renowned journals. Positive values are indicative of above-average international alignment; negative values are indicative of below-average international alignment.



Source: Web of Science (WoS). Research and calculations by Fraunhofer ISI.

C 6–3 **Scientific regard for Web of Science publications from selected countries and regions in 2001 and 2009** (index values)



Source: Web of Science (WoS). Research and calculations by Fraunhofer ISI.

The scientific regard (SR) index shows whether a country's scientific articles are cited more or less frequently than average articles in specific journals. Positive values are indicative of above-average SR; negative values are indicative of below-average SR. Index calculations do not include self-citations.

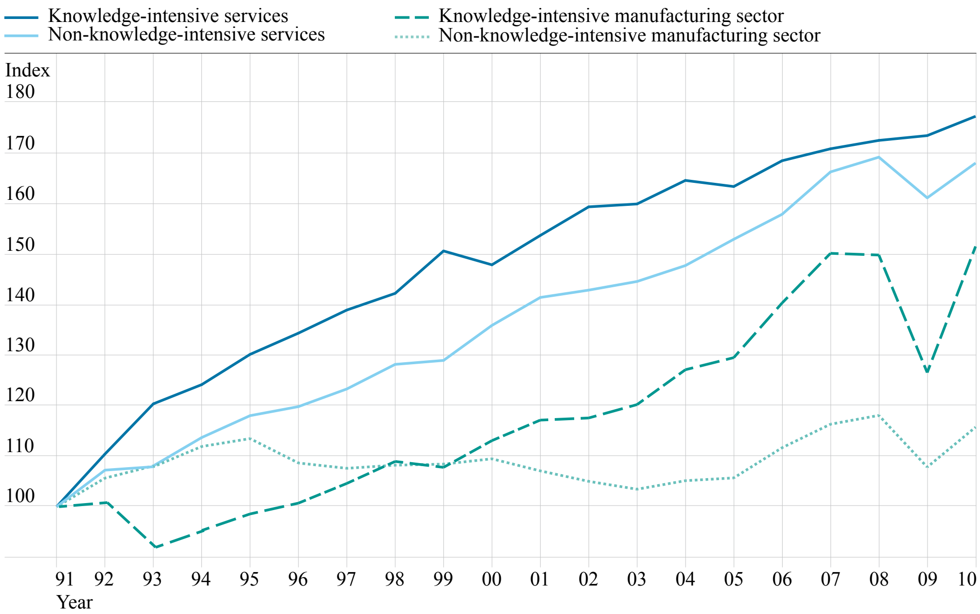
PRODUCTION, VALUE ADDED AND EMPLOYMENT

During the economic crisis, the development of value added in Germany experienced a sharp downward trend. In 2008 and 2009, the value added in the manufacturing sector and in non-knowledge-intensive services was almost at the level as it was in 2005. In 2010, the gross value added increased in all of the sectors and is now nearly at a pre-crisis level (C 7–1). A similar trend can be observed in the development of employees subjected to social insurance, whose numbers had increased across the entire industrial sector already in 2010. While employment in the knowledge-intensive and non-knowledge-intensive services had also increased in 2010, employment in the knowledge and non-knowledge-intensive manufacturing sector also increased in 2011 (C 7–2).

The proportion of labour input and value added in a country's research- and knowledge-intensive sectors reflects their importance and allows for conclusions on a country's technological productivity. Overall, proportions in the surveyed countries and regions have increased, indicating a growing importance of research- and knowledge-intensive sectors. As regards the proportion of labour input, a shift towards knowledge-intensive services can be observed. In all of the surveyed countries and regions, knowledge-intensive services have continuously grown in the past ten years, whereas the research-intensive industries have stagnated or declined (C 7–3). The increase in the proportion of R&D-intensive industries and knowledge-intensive services in value added is largely attributable to the knowledge-intensive services. In Germany, the share of R&D-intensive industries in value added steadily increased up until 2007. Following the decline in the crisis years of 2008 and 2009, the shares in value added continued to be below the figures of the pre-crisis year of 2007 – despite the subsequent recovery in 2010 (C 7–4).[404]

In 2011, as in previous years, Germany exhibited a positive relative export share in R&D-intensive goods trade, i.e. in this product group, Germany's share in world market supply was higher than its share of total manufactured goods. However, a closer look reveals that Germany has a positive relative export share only in high-value technology goods trade, while the relative export share in cutting-edge technology goods trade is negative. In the same year, China achieved a positive relative export share in trade with cutting-edge technology goods (C 7–5). With regard to Germany, these findings are confirmed by the RCA indicator, which measures a product group's export/import ratio relative to the export/import ratio of the manufacturing sector as a whole. China's RCA indicator for cutting-edge technology goods is negative, although a positive trend could be observed over the last 15 years (C 7–6).

C 7–1 **Development of gross value added in different business sectors in Germany**



Index: 1991 = 100. Not including agriculture and forestry, fisheries, public administration and services, real estate and housing, education, private households, etc.
Source: *Statistisches Bundesamt, Fachserie 18, Reihe 1.4.* Calculations by NIW.

Shares of gross value added in the business sector in 2010: knowledge-intensive manufacturing sector, 20.6 percent; non-knowledge-intensive manufacturing sector, 20.0 percent; knowledge-intensive services, 28.2 percent; non-knowledge-intensive services 31.2 percent.

C 7–2 **Development of employment covered by social security in the business sector in Germany**

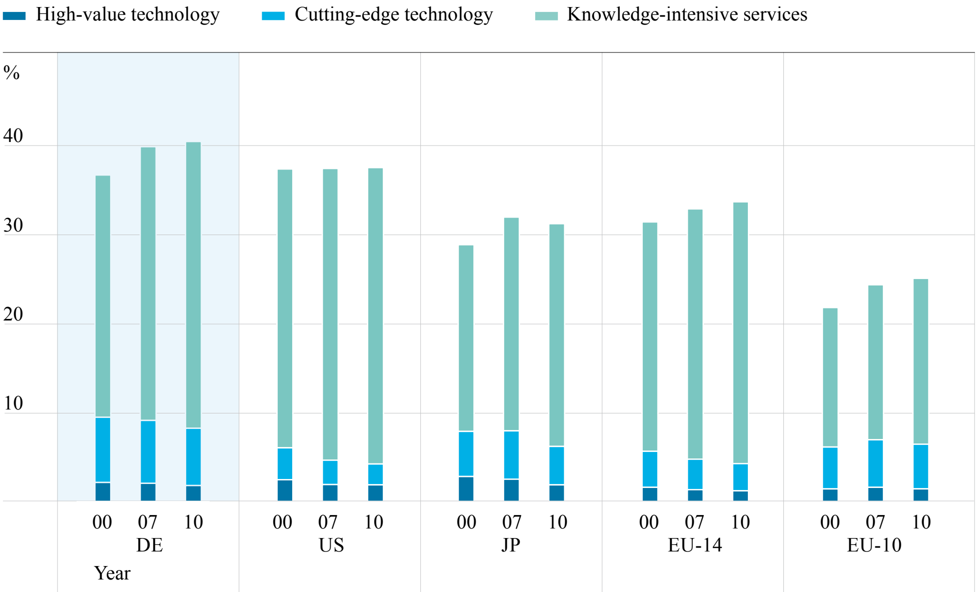
	2008	2009	2010	2011	2008-2009	2009-2011	2008-2011
	in 1,000				annual average changes in %		
Manufacturing sector	**8,625**	**8,472**	**8,394**	**8,559**	**–1.8**	**0.5**	**–0.3**
Knowledge-intensive sectors	3,083	3,045	2,999	3,062	–1.2	0.3	–0.2
Non-knowledge-intensive sectors	5,543	5,427	5,395	5,497	–2.1	0.6	–0.3
Services	**14,157**	**14,077**	**14,361**	**14,829**	**–0.6**	**2.6**	**1.6**
Knowledge-intensive sectors	5,522	5,569	5,621	5,772	0.9	1.8	1.5
Non-knowledge-intensive sectors	8,635	8,507	8,739	9,057	–1.5	3.2	1.6
Industry	**22,782**	**22,549**	**22,755**	**23,388**	**–1.0**	**1.8**	**0.9**
Knowledge-intensive sectors	8,604	8,615	8,620	8,834	0.1	1.3	0.9
Non-knowledge-intensive sectors	14,178	13,934	14,134	14,554	–1.7	2.2	0.9

Source: *Bundesagentur für Arbeit.* Calculations by NIW.

Shares of employment in the business sector in 2011: knowledge-intensive manufacturing sector, 13.1 percent; non-knowledge-intensive manufacturing sector, 23.5 percent; knowledge-intensive services, 24.7 percent; non-knowledge-intensive services, 38.7 percent.

Labour input shares of R&D-intensive industries and knowledge-intensive services C 7–3
(figures in percent)

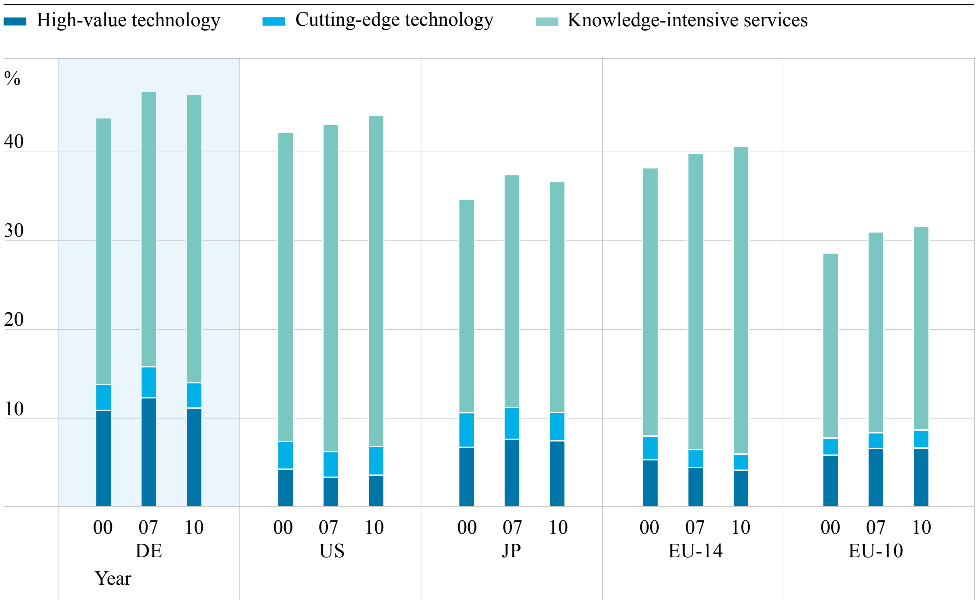
The increase in shares of the R&D-intensive industries and knowledge-intensive services relative to labour input is caused by the increase in knowledge-intensive services.



EU-14 refers to the old EU member states, excluding Germany. EU-10 refers to the new EU countries, excluding Romania and Bulgaria.
Source: WIOD (2012), OECD STAN (2012), Eurostat (2012), UNSD (2012).
Calculations and estimates by DIW Berlin.

Shares of R&D-intensive industries and knowledge-intensive services in value added C 7–4
(figures in percent)

The share of R&D intensive industries and knowledge-intensive services in value added has increased over the last decade in all countries surveyed.



EU-14 refers to the old EU member states, excluding Germany. EU-10 refers to the new EU countries, excluding Romania and Bulgaria.
Source: WIOD (2012), OECD STAN (2012), Eurostat (2012), UNSD (2012), Ministry of Economic, Trade & Industry Japan (2012), U.S. Bureau of Economic Analysis (2012). Calculations and estimates by DIW Berlin.

C 7–5 **Export specialisation (Relative Export Advantage, RXA) of selected countries, for R&D-intensive goods**

A positive RXA value means that the share of the world market supply for this product group is higher than it is for manufactured industrial goods as a whole.

Year	*DE*	FR	GB	IT	DK	SE	FI	EU-14	CH	CA	US	JP	KR	CN
R&D-intensive goods														
1995	*13*	–3	12	–32	–49	–5	–42	–11	5	1	24	37	2	–85
2000	*12*	2	17	–37	–36	1	–20	–7	1	1	21	33	8	–54
2005	*11*	0	10	–40	–29	–8	–20	–6	6	–9	18	28	18	–19
2010	*14*	8	11	–34	–32	–16	–41	–5	13	–13	9	27	17	–13
2011	*18*	10	13	–29	–27	–10	–41	–3	16	–11	9	30	17	–12
High-value technology														
1995	*32*	0	2	–10	–39	–5	–55	–3	27	20	4	43	–15	–88
2000	*33*	6	7	–8	–27	–1	–63	1	27	19	2	47	–19	–73
2005	*30*	8	9	–13	–24	1	–51	5	20	10	5	42	–5	–73
2010	*33*	5	24	–5	–26	1	–28	10	19	3	15	46	–1	–53
2011	*36*	5	22	–3	–24	6	–25	10	19	3	15	48	8	–50
Cutting-edge technology														
1995	*–46*	–9	24	–97	–71	–4	–20	–27	–59	–49	55	27	28	–78
2000	*–35*	–5	30	–108	–50	4	23	–20	–56	–34	44	6	39	–30
2005	*–36*	–15	13	–122	–40	–28	19	–30	–26	–58	37	–3	49	36
2010	*–38*	15	–22	–129	–43	–60	–73	–42	–1	–49	–3	–23	43	35
2011	*–32*	19	–13	–123	–33	–53	–85	–38	9	–46	–6	–19	33	37

World exports 2011 based on estimates. EU-14 refers to the old EU member states, excluding Germany; 2011 based on estimates.
Source: OECD, ITCS – International Trade By Commodity Statistics, Rev. 3 (various years). COMTRADE database. Calculations and estimates by NIW.

C 7—6

Comparative advantages (Revealed Comparative Advantage, RCA) of selected countries in foreign trade in research-intensive goods

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

Year	*DE*	FR	GB	IT	DK	SE	FI	EU-14	CH	CA	US	JP	KR	CN
							R&D-intensive goods							
1995	*22*	3	8	–22	–28	–10	–45	–8	14	–18	13	63	1	–80
2000	*13*	6	14	–24	–11	–1	–22	–1	11	–11	16	50	0	–58
2005	*10*	8	16	–28	–6	–1	–16	3	17	–13	21	47	19	–37
2010	*13*	10	18	–23	–3	–11	–21	4	21	–16	5	42	20	–39
2011	*15*	8	16	–21	–3	–8	–24	5	21	–17	2	44	18	–41
							High-value technology							
1995	*36*	0	2	–14	–26	–13	–60	–5	29	–12	–2	91	–10	–92
2000	*32*	4	14	–14	–9	–9	–64	3	29	–11	–3	96	0	–72
2005	*28*	9	8	–19	–2	–3	–49	7	23	–12	4	88	12	–54
2010	*30*	4	20	–10	–10	–4	–24	10	18	–18	10	75	11	–56
2011	*30*	2	17	–9	–10	–2	–24	10	14	–17	9	75	18	–60
							Cutting-edge technology							
1995	*–23*	11	13	–53	–32	–6	–20	–16	–32	–39	33	20	18	–54
2000	*–27*	8	15	–57	–15	10	19	–8	–32	–12	39	–10	0	–43
2005	*–36*	6	31	–66	–15	4	26	–6	3	–17	48	–18	27	–29
2010	*–33*	21	11	–83	14	–30	–11	–8	30	–10	–4	–31	33	–23
2011	*–29*	20	13	–77	14	–27	–21	–9	36	–14	–14	–27	17	–22

EU-14 refers to the old EU member states excluding Germany, 2011 based on estimates.
Source: OECD, ITCS – International Trade By Commodity Statistics, Rev. 3 (various years). COMTRADE database. Calculations and estimates by NIW.

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LIST OF ABBREVIATIONS

AIFM	Alternative Investment Fund Managers
approx.	approximately
BACH	Bank for the Accounts of Companies Harmonised
BaFin	*Bundesanstalt für Finanzdienstleistungsaufsicht* (Federal Financial Supervisory Authority)
BDEW	*Bundesverband der Energie- und Wasserwirtschaft* (German Association of Energy and Water Industries)
BEA	Bureau of Economic Analysis
BERD	Business Enterprise Research and Development Expenditure
BMBF	*Bundesministerium für Bildung und Forschung* (Federal Ministry of Education and Research)
BME	*Bundesverband für Materialwirtschaft, Einkauf und Logistik* (German Association Materials Management, Purchasing and Logistics)
BMELV	*Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz* (Federal Ministry of Food, Agriculture and Consumer Protection)
BMF	*Bundesministerium der Finanzen* (Federal Ministry of Finance)
BMFSFJ	*Bundesministerium für Familie, Senioren, Frauen und Jugend* (Federal Ministry of Family Affairs, Senior Citizens, Women and Youth)
BMU	*Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit* (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety)
BMVBS	*Bundesministerium für Verkehr, Bau und Stadtentwicklung* (Federal Ministry of Transport, Building and Urban Development)
BMWi	*Bundesministerium für Wirtschaft und Technologie* (Federal Ministry of Economics and Technology)
BRIC	Brazil, Russia, India, China
BVK	*Bundesverband Deutscher Kapitalbeteiligungsgesellschaften* (German Private Equity and Venture Capital Association)
ca.	circa
CDM	Clean Development Mechanism
CER	Certified Emission Reductions
cf.	confer
CIS	Community Innovation Survey
COMTRADE	Commodity Trade Statistics
CO2	carbon dioxide
DFG	*Deutsche Forschungsgemeinschaft* (German Research Foundation)
DHV	*Deutscher Hochschulverband* (German Association of University Professors and Lecturers)
DIW	*Deutsches Institut für Wirtschaftsforschung* (German Institute for Economic Research)
EC	European Commission
ECJ	European Court of Justice
EEG	*Erneuerbare-Energien-Gesetz* (Renewable Energy Sources Act)
EFI	*Expertenkommission Forschung und Innovation* (Commission of Experts for Research and Innovation)
e.g.	examples given

EPPATENT	European Patent Database
EPC	European Patent Convention
EPO	European Patent Office
ERC	European Research Council
ERU	Emission Reduction Units
ESD	European Sectoral References Database
etc.	et cetera
EU	European Union
EU ETS	European Union Emissions Trading System
Eurostat	Statistical Office of the European Union
EVCA	European Private Equity & Venture Capital Association
EXIST	*"Existenzgründungen aus der Wissenschaft"*, a funding programme of the Federal Ministry of Economics and Technology
FAGI	Foreign Applications of German Inventions
ff.	and the following
FhG	*Fraunhofer-Gesellschaft*
Fig.	Figure
GAFI	German Applications of Foreign Inventions
GDP	Gross Domestic Product
GEM	Global Entrepreneurship Monitor
GG	Grundgesetz (German Basic Law)
GPA	Government Procurement Agreement
HGF	*Helmholtz-Gemeinschaft deutscher Forschungszentren* (Helmholtz Association of German Research Centres)
HIS	*Hochschul-Informations-System GmbH* (Higher Education Information System)
IAB	*Institut für Arbeitsmarkt- und Berufsforschung* (Institute for Employment Research)
I&C	Information and Communication
ICT	Information and Communication Technology
i.e.	id est (that is)
ifo	*ifo Institut für Wirtschaftsforschung* (Ifo Institute for Economic Research)
IPO	Initial Public Offering
ISCED	International Standard Classification of Education
ISI	*Institut für System- und Innovationsforschung* (Fraunhofer Institute for Systems and Innovation Research)
ISO	International Organization for Standardization
IT	Information Technology
ITCS	International Trade by Commodity Statistics
IWH	*Institut für Wirtschaftsforschung Halle* (Halle Institute for Economic Research)
JI	Joint Implementation
JOBS	Jumpstart Our Business Startups
M&A	Mergers & Acquisitions
MIP	Mannheim Innovation Panel
MNC	multinational corporations
MPG	*Max-Planck-Gesellschaft* (Max Planck Society)
MUP	Mannheim Enterprise Panel

NAFTA	North American Free Trade Agreement
NIW	*Niedersächsisches Institut für Wirtschaftsforschung* (Lower Saxony Institute for Economic Research)
OECD	Organisation for Economic Co-operation and Development
p.a.	per annum
PATSTAT	EPO Worldwide Patent Statistical Database
PISA	Programme for International Student Assessment
PCP	Pre-Commercial Procurement
PCT	Patent Cooperation Treaty
RCA	Revealed Comparative Advantage
R&D	Research and Development
R&I	Research and Innovation
RXA	Relative Export Advantage
SEC	United States Securities and Exchange Commission
SME	small and medium-sized enterprises
SR	Scientific Regard
STEM	Science, Technology, Engineering, Mathematics
SVR	*Sachverständigenrat zur Begutachtung der gesamtwirtschaftlichen Entwicklung* (German Council of Economic Experts)
Tab.	Table
TED	Tenders Electronic Daily
UAFI	U.S. based Applications of Foreign Inventions
UNSD	United Nations Statistics Division
WGL	*Wissenschaftsgemeinschaft Gottfried Wilhelm Leibniz* (Leibniz Association)
WIPO	World Intellectual Property Organization
WIOD	World Input-Output Database
WOPATENT	World Intellectual Property Organization Database
WoS	Web of Science
WR	*Wissenschaftsrat* (German Council of Science and Humanities)
WTO	World Trade Organization
WZ 2008	Classification of Economic Activities, 2008 edition
ZEW	*Zentrum für Europäische Wirtschaftsforschung* (Centre for European Economic Research)
ZIM	*Zentrales Innovationsprogramm Mittelstand* (Central Innovation Programme for SMEs), a funding programme of the Federal Ministry of Economics and Technology

LIST OF ABBREVIATIONS OF NAMES OF COUNTRIES

AT	Austria
AU	Australia
BE	Belgium
BG	Bulgaria
CA	Canada
CH	Switzerland
CN	China
CY	Cyprus
CZ	Czech Republic
DE	Germany
DK	Denmark
EE	Estonia
ES	Spain
FI	Finland
FR	France
GB	Great Britain
GR	Greece
HU	Hungary
IE	Ireland
IN	India
IS	Iceland
IT	Italy
JP	Japan
KR	Korea
LU	Luxembourg
LT	Lithuania
LV	Latvia
MT	Malta
NL	Netherlands
NO	Norway
PL	Poland
PT	Portugal
RO	Romania
SE	Sweden
SI	Slovenia
SK	Slovakia
US	United States of America

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CLASSIFICATION OF ECONOMIC ACTIVITIES FOR R&D-INTENSIVE INDUSTRY AND KNOWLEDGE-INTENSIVE INDUSTRY SERVICES[405]

R&D-INTENSIVE INDUSTRIAL SECTORS WITHIN THE CLASSIFICATION OF ECONOMIC ACTIVITIES, 2008 EDITION (WZ 2008) (4-DIGIT CLASSES)

WZ 2008	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
24.46	Processing of nuclear fuel
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
26.40	Manufacture of consumer electronics
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
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
20.16	Manufacture of plastics in primary forms
20.42	Manufacture of perfumes and toilet preparations
20.51	Manufacture of explosives
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
23.19	Manufacture and processing of other glass, including technical glassware
23.44	Manufacture of other technical ceramic products
26.12	Manufacture of loaded electronic boards
27.11	Manufacture of electric motors, generators and transformers
27.12	Manufacture of electricity distribution and control apparatus
27.20	Manufacture of batteries and accumulators
27.31	Manufacture of fibre optic cables
27.33	Manufacture of wiring devices
27.40	Manufacture of electric lighting equipment
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
28.92	Manufacture of machinery for mining, quarrying and construction
28.93	Manufacture of machinery for food, beverage and tobacco processing
28.94	Manufacture of machinery for textile, apparel and leather production
28.99	Manufacture of other special-purpose machinery n.e.c.
29.10	Manufacture of motor vehicles
29.31	Manufacture of electrical and electronic equipment for motor vehicles
29.32	Manufacture of other parts and accessories for motor vehicles
30.20	Manufacture of railway locomotives and rolling stock
33.20	Installation of industrial machinery and equipment n.e.c.

KNOWLEDGE-INTENSIVE INDUSTRIAL SERVICES WZ 2008 (3-DIGIT CLASSES)

	Knowledge-intensive services
	Emphasis on finances and assets
411	Development of building projects
641	Monetary intermediation
642	Activities of holding companies
643	Trusts, funds and similar financial entities
649	Other financial service activities, except insurance and pension funding
651	Insurance
652	Reinsurance
653	Pension funding
661	Activities auxiliary to financial services, except insurance and pension funding
663	Fund management activities
681	Buying and selling of own real estate
683	Real estate activities on a fee or contract basis
774	Leasing of intellectual property and similar products, except copyrighted works
	Emphasis on communication
611	Wired telecommunications activities
612	Wireless telecommunications activities
613	Satellite telecommunications activities
619	Other telecommunications activities
620	IT services
631	Data processing, hosting and related activities, web portals
639	Other information service activities
	Emphasis on technical consulting and research
711	Architectural and engineering activities and related technical consultancy
712	Technical testing and analysis
721	Research and experimental development on natural sciences and engineering
749	Other professional, scientific and technical activities n.e.c.

	Emphasis on non-technical consulting and research
691	Legal activities
692	Accounting, bookkeeping and auditing activities; tax consultancy
701	Administration and management of companies and plants
702	Public relations and business consultancy
722	Research and development in the area of law, economics and social sciences, as well as humanities
731	Advertising
732	Market research and public opinion polling
821	Office administrative and support activities
	Emphasis on media and culture
581	Publishing of books and periodicals; other publishing activities
582	Software publishing
591	Motion picture, video and television programme activities
592	Sound recording and music publishing activities
601	Radio broadcasting
602	Television programming and broadcasting activities
741	Specialised design activities
743	Translation and interpreting activities
823	Organisation of conventions and trade fairs and exhibitions
900	Creative, arts and entertainment activities
910	Libraries, archives, museums, botanical and zoological gardens
	Emphasis on health
750	Veterinary activities
861	Hospital activities
862	Medical and dental practice activities
869	Other human health activities n.e.c.

GLOSSARY

Apps:

The abbreviation of application software refers to any type of application program. In German-speaking countries, the term apps is especially equated with application software for mobile devices such as smartphones and tablet computers.

Bibliometrics:

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

Business angels:

Business angels are private persons who provide capital and entrepreneurial know-how to innovative start-up businesses or young, innovative companies. Business angels invest parts of their private assets directly in a company, without the aid of an intermediary, and receive shares of the company in return.

Clean Development Mechanism:

The Clean Development Mechanism (CDM) is one of the flexibility mechanisms defined in the Kyoto Protocol. Under certain circumstances, tradable emission reduction certificates (CER – Certified Emission Reductions) are issued to projects financed by industrialised countries to reduce emissions in developing countries. On the one hand, the CDM serves as a means of tapping emission reduction potentials, helping countries to reach their reduction targets cost-effectively. On the other hand, CDM projects aim to contribute to sustainable development in the host countries.

Cluster:

Economic clusters are agglomerations and co-operation networks of corporate and academic players in R&D and production. Clusters are often characterised by a thematic and geographic proximity of the stakeholders to each other.

Community Innovation Survey:

The Community Innovation Survey (CIS) is the European Union's major statistical instrument for surveying innovation activities in Europe. The CIS analyses the innovation impact on the economy (competition, employment, economic growth, trade models, etc.) based on a survey of a representative sample of companies.

Cooperation ban:

Pursuant to Article 104 b of the Basic Law, the German Federal Government is prohibited from providing financial resources to support the statutory education tasks of the federal states (cooperation ban). Legislative competence for the provision of school education lies exclusively with the federal states. Under the Federalism Reform I (c.f "Federalism Reform I"), the joint task of "educational planning", which was anchored in the Basic Law until this point, was abolished. Federal and *Länder* governments can now only cooperate, based on agreements, to monitor the performance of Germany's education system in international comparisons (Art. 91b Par. 2). The Federal and *Länder* governments can cooperate in the area of university research to fund science and research ventures with transregional significance, provided all states have given their consent (Art. 91 b Par. 1). The framework conditions for the development of research at universities deteriorated markedly as a result of the now regulations. In the area of non-university research, the Federal Government can continue to fund facilities and ventures, while funding of tertiary education institutions is confined to the funding of ventures, i.e. projects.

Crowdfunding:
Crowdfunding is an innovative form of financing for business projects or small enterprises, designed to accumulate financial contributions from numerous individuals within a relatively short period of time. Crowdfunding activities are often conducted via the internet, e.g. by the use of social networks.

Crowdsourcing:
Crowdsourcing refers to a company's utlilisation of "swarm intelligence". Thus, for instance, preferences of many internet users are fed into a company's brainstorming and decision-making processes.

Cultural and creative industries:
The term refers to businesses that are predominantly commercial and are concerned with the creation, production, distribution and/or media coverage of cultural and creative goods and services. The cultural and creative industries sector comprises eleven core segments or submarkets: the music industry, book market, art market, film industry, broadcasting, the performing arts, the design industry, the architecture market, press market, advertising industry and the software/gaming industry.[406]

Cutting-edge technology:
Cutting-edge technology goods refer to R&D-intensive goods in the production of which, on an annual average, more than seven percent of revenue is spent on research and development.

Departmental research:
Departmental research refers to all federal institutions that perform research and development activities. The identification of departmental research needs falls within the remit of the individual government departments and is part of the individual department's area of responsibility (departmental principle).

Directive on Alternative Investment Fund Managers (AIFM):
The European Directive on Alternative Investment Fund Managers (AIFM) regulates the investment behaviour of hedge funds, venture capital and a diverse range of other institutional funds. The overall objective of the AIFM is to limit systemic risks and enhance investor protection in the context of the financial crisis. In many EU countries, including Germany, the Directive is currently being transposed into national law.

E-commerce:
The term electronic commerce (e-commerce) is used inconsistently in academic discourse. In the context of this Report, e-commerce shall refer to the sale of goods and services via the internet.

Economies of scale:
Economies of scale refer to size-related advantages, which are reflected in the fact that the cost per unit – i.e. costs for a single product incurred within the company – declines with increasing production volume. Economies of scale explain why many companies strive for size by entering new markets and acquiring other companies.

Editorial reviewing:
A quality assurance procedure for scientific literature. An internal expert from a publishing house, who is from the same discipline an author, assesses the author's publication.

Endowment ban:

Current legislation (as of 11/01/2013) provides for the timely use of financial resources to promote other tax-exempt entities such as universities. Thus the legislation in force does not provide for long-term, foundation-funded financing that utilises long-term returns from an endowment, such as the financing of a chair.

Enhanced cooperation:

Enhanced cooperation is a procedure established by the Treaty of Amsterdam. It allows a group of European Union member states to introduce joint regulations even without a unanimous decision. Enhanced cooperation projects have to be supported by at least nine member states and require approval from the European Commission.

Equity capital:

Liable capital of a company. Financial resources that are raised by the company's owners themselves, or provided by surplus earnings 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-12 countries:

Countries that have joined the EU since 2004 (Bulgaria, Estonia, Latvia, Lithuania, Malta, Poland, Romania, Slovakia, Slovenia, the Czech Republic, Hungary, and Cyprus).

EU-14 countries:

The EU-15 countries excluding Germany.

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-27 countries:

The EU currently comprises 27 member states (the EU-12 countries plus the EU-15 countries).

EU Research Framework Programme:

Public support for research and development in the European Union is implemented through specific programmes, each of which address a specific research area and usually run for several years. These programmes are assigned to a larger unit, the Research Framework Programme.

Excellence Initiative:

An agreement between the Federal and *Länder* governments to promote science and research at German tertiary education institutions with a view to enhancing international competitiveness. The initiative is being implemented by the German Research Foundation (DFG) and the German Council of Science and Humanities (WR).

Externalities:

Externalities are defined as the consequences of economic activities on third parties for which no compensation is paid.

FAGI:

The FAGI (Foreign Applications of German Inventions) indicator refers to patent applications with at least one inventor residing in Germany (German inventor) and one applicant residing outside of Germany (foreign applicant). To determine the FAGI ratio, the FAGI value is calculated in relation to the total number of patent applications (German and foreign applicants) with at least one inventor residing in Germany (German inventor).

Federalism Reform I:

The Federalism Reform I, which came into force in September 2006, reorganised relations between the Federal Government and *Länder* governments with regard to the balance of legislative power at national and state levels, and with regard to the federal states' responsibilities and participation rights in national legislation. The aim was to reduce the number of laws that require approval by the Federal Council *(Bundesrat)*. The central element of the Federalism Reform II, which came into force in August 2009, was the reform of financial relations between the Federal and *Länder* governments.

Financial intermediaries:

Financial intermediaries mediate between capital providers and capital demanders. Financial intermediaries in the strictest sense are banks, insurance companies, investment companies, other bancassurance providers, and stock markets. In a broader sense, a financial intermediary is any institutions that supports the matching of supply and demand.

First come, first served principle:

A selection principle that is employed e.g. in the process of granting subsidies, whereby applications for funding are approved in the order of applications submitted.

Foreign students:

Students who hold foreign citizenship are referred to as foreign students. Foreign students who have obtained their tertiary education entrance qualification in Germany are termed *Bildungsinländer*. Foreign students who have obtained their tertiary education entrance qualification outside of Germany are termed *Bildungsausländer*.

Frascati Manual:

The OECD's Frascati Manual specifies methods for collecting and analysing data on research and development. In 1963, OECD experts met for the first time with members of the NESTI group (National Experts on Science and Technology Indicators), in Frascati (Italy), in order to define key concepts such as "research and development". The results of 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.

Freedom of Science Act:

The Freedom of Science Act was adopted by the Federal Government in the summer of 2008. Non-university research institutions are gradually to be given greater freedom in managing their financial resources as well as greater freedom in the areas of personnel, cooperation, construction and procurement.

Full-time equivalent:

Full-time equivalent is the number of hours worked converted into full-time positions.

GAFI:
The GAFI (German Applications of Foreign Inventions) indicator refers to patent applications with at least one inventor residing outside of Germany (foreign inventor) and one applicant residing in Germany (German applicant). To determine the GAFI ratio, the GAFI value is calculated in relation to the total number of patents filed (German and foreign inventors) that include at least one applicant based in Germany.

Governance:
Governance refers to the structural control and regulation (structure and process organisation) of an political and societal unit, such as states, authorities, municipalities, and private or public institutions. The term is also often used to refer to the management or regulation of any type of organisation (such as companies or establishments).

Higher Education Pact 2020:
The Higher Education Pact 2020 is an agreement between the Federal and *Länder* governments to continue the existing Higher Education Pact I. This financing agreement includes provisions for accommodating additional student intakes as well as provisions for research ventures that receive overhead funding from the German Research Foundation (DFG) in the 2011 to 2015 period.

High technology:
High technology goods comprise cutting-edge technology (ibid), and high-value technology (ibid) goods.

High-Tech Strategy:
A policy initiative by the Federal Government to integrate innovation funding across all federal departments. It was launched in August 2006, and extended in 2010. The High-Tech Strategy focusses in particular on the holistic management of complex technology systems, and on market relevance. A key characteristic of the strategy is that it concentrates on selected fields of innovation. Its key emphases include designing and structuring R&I policy on an interministerial basis, aligning research and innovation more strongly to markets, and optimising relevant framework conditions. The Federal Government's High-Tech Strategy is managed by the Federal Ministry of Education and Research (BMBF).

High-value technology:
High-value technology refers to R&D-intensive goods that require more than 2.5 percent, but not more than 7 percent, of an entity's average annual revenue for the purpose of research and development in the production process.

Incremental innovation:
Incremental innovation refers to innovation achieved through improvements to an existing product. In contrast to this, radical innovation refers to fundamental innovations that lead to entirely new product concepts and technical solutions.

Infant industries:
Infant industries are young industries and new industry branches within an economy. These are mostly in their early stages of development and unable to compete with established competitors in other economies. Infant industries therefore require government support in the form of direct funding or shielding against external competition – usually through subsidies or tariffs.

Innovation intensity:
Innovation expenditures in relation to revenue.

Intangible assets:

Intangible assets (e.g. knowledge, reputation) are a person's or an organisation's nonphysical goods that may constitute an important element of the enterprise value.

Joint Implementation:

Joint Implementation (JI) is one of the flexibility mechanisms defined in the Kyoto Protocol. Under certain circumstances, tradable certified emission reduction credits (ERU – Emission Reduction Units) are issued to projects financed by industrialised countries to reduce emissions in other industrialised countries. Thus, Joint Implementation facilitates the tapping of emission reduction potentials, while also helping countries reach their reduction objectives cost-efficiently. Foreign investment and potential technology transfer provide incentives for the respective host countries.

Journal Impact Factor:

The Journal Impact Factor (or Impact Factor), measures the influence of a specialist journal. It indicates the average citation frequency of a journal's article within a specified period of time.

Knowledge-intensive services:

Knowledge-intensive services are primarily characterised by the fact that they are performed by a workforce comprising an above-average proportion of individuals with tertiary education qualifications.

Labour force:

The labour force is the subgroup of the labour potential (ibid) and comprises individuals who are employed and individuals who are registered as unemployed.

Labour potential:

The labour potential includes the residential population aged between 15 and 65 years or members of the population of working age, respectively. It comprises employed persons, unemployed persons, and the "hidden labour reserve". The "hidden labour reserve" comprises unemployed persons who are not registered jobseekers.

Leaky pipeline:

The leaky pipeline phenomenon refers to the continuous decrease in the proportion of women at each higher level of the education and employment system.

Lock-in effect:

A lock-in effect occurs when the costs of a potential system change, such as the change from one particular internet provider to another, exceed the expected additional benefits. From a macroeconomic perspective, lock-in effects are generally regarded to have a negative impact on welfare.

Market failure:

Market failure is a situation resulting when market coordination deviates from the economically optimal allocation of goods and resources. Reasons for market failure can be the presence of externalities, public goods, and information asymmetries.

Mobile foreign students:

Cf. Non-mobile foreign students.

Network externalities:
A network externality is a change in the derived benefit for the consumer of a product when the number of other consumers consuming the same product type changes. Network externalities may be negative or positive. Positive network externalities occur when the benefits of an object, e.g. a telephone, depend on the number of other consumers who already use this object. Negative network externalities occur e.g. when the additional number of consumers causes an overload in the telephone network.

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 (ibid), as it makes a disctinction between different types of innovation. The Oslo Manual serves as the basis for the Community Innovation Surveys, which have been coducted six times in Europe to date. The most recent revision of the Oslo Manual dates from 2005.

Pact for Research and Innovation:
The pact regulates the financing growth of Germany's five non-university science and research organisations supported by the Federal and *Länder* governments between 2011 and 2015. The science and research organisations have in turn committed themselves to improve the quality, efficiency and performance of their respective research and development activities.

Patent-box regluations:
Patent-box regulations, such as those introduced in e.g. Belgium, the Netherlands and Great Britain, enable companies, under certain conditions, to apply a reduced tax rate of up to 10 percent on income from self-generated intagible assets such as patents.

Patent family:
A patent family is a group of patents or patent applications that are directly or indirectly linked via a priority, that have at least one common priority, exactly the same priority or a combination of priorities.

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 states can submit prior notification of an application to the WIPO – or other registered authorities – and submit their patent application in the respective treaty country within one year, instead of filing several individual national or regional applications. The priority date of the patent is the date the application is submitted to the WIPO. The granting of patents in the true sense remains in the area of responsibility of the national or regional patent offices.

Peer reviewing:
A quality assurance procedure for scientific literature. An independent expert from the same discipline as an author assesses the author's publication.

Price elasticity of demand:
The price elasticity of demand indicates the percentage change in the quantity demanded in response to a one percent change in price. Demand is elastic when a one percent change in price results in a change in quantity of more than one percent. Demand is inelastic when a one percent change in price results in a change in quantity of less than one percent.

Prospectus requirement:

Corporations seeking to float shares on the stock market or seeking to make their securities available to a larger base of institutional and private investors are obliged by law to publish a prospectus in advance. The prospectus facilitates the potential investors' assessment of both the securities and the issuing company.

R&D intensity:

Expenditures for research and development (R&D), as a percentage of a company's or a sector's revenue or of a country's gross domestic product, respectively.

R&D intensive goods:

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

Radical innovation:

Fundamental innovations that lead to entirely new product concepts, technical solutions or services – in contrast to incremental innovation, which refers to the improvement of an existing product or process.

Research and Development (R&D):

The OECD's Frascati Manual (ibid) defines research and development as systematic, creative work aimed at increasing the stock of 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 (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 (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.

Separation principle:

In patent law, the separation principle applies whenever infringement and validity actions are heard by two different jurisdictions. This is the case e.g. in Germany, where infringement claims are brought before first instance district courts, while actions for annulment are brought before technically qualified judges at the Federal Patent Court. Thus infringement and invalidity proceedings relating to one and the same patent can run parallel.

Set-asides:

A measure discussed in the context of European emissions trading, which refers to the "setting aside" of certificates as a means of stabilising allowance prices.

Smart Specialisation:

This EU policy concept describes an R&I strategy development and implementation process at regional level that aims to enhance economic growth through regional specialisation in the fields of science and technology.

Social media:

Social media are internet-based media services that enable users to exchange ideas and to shape multimedia content individually or as part of a community.

Start-ups:

Newly established businesses.

Three-percent target:

In Barcelona in 2002, the European Council decided that the EU's R&D expenditures shall be increased to three percent of a country's GDP by 2010. In addition, two-thirds of the relevant expenditure are to be financed by the private sector.

Transfer price:

The price at which cross-border deliveries or services are traded between subsidiaries of a multinational corporation.

Transnational patents:

Inventions that are the subject of at least one application filed with the World Intellectual Property Organization (WIPO) through the PCT process, 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.

Triad countries:

At the time the term was coined in the early 1990s, it referred to the then three strongest economic regions in the world, i.e. the signatory countries to the North American Free Trade Agreement (NAFTA), the EU, and the industrialised East Asian countries (Japan, Taiwan, Korea, Hong Kong and Singapore).

Value creation:

Total of all factor income generated in a given period (wages, salaries, interest, rent, lease income, sales profits) included in the national accounts. The term is equivalent to national income (national product). In a business sense, value creation refers to the production value generated in a given period, minus the value of the preliminary work/services received from third companies in the same period.

Venture capital:

Venture or risk capital refers to initial capital for start-ups and young enterprises. It includes funding used to strengthen the equity capital bases of small and medium-sized enterprises, in order to enable such companies to expand and to implement innovative, even very risky projects. For capital providers/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.

RECENT STUDIES RELATING TO THE GERMAN INNOVATION SYSTEM

The Commission of Experts for Research and Innovation (EFI) regularly commissions studies on topics that are relevant 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 Annual Report.

1-2013 Leszczensky, M.; Cordes, A.; Kerst, C.; Meister, T.; Wespel, J. (2013): Bildung und Qualifikation als Grundlage der technologischen Leistungsfähigkeit Deutschlands, Studien zum deutschen Innovationssystem, Berlin: EFI.

2-2013 Gehrke, B.; Schasse, U.; Kladroba, A.; Stenke, G. (2013): FuE-Aktivitäten von Wirtschaft und Staat im internationalen Vergleich, Studien zum deutschen Innovationssystem, Berlin: EFI.

3-2013 Rammer, C.; Hünermund, P. (2013): Innovationsverhalten der Unternehmen in Deutschland 2011, Aktuelle Entwicklungen – europäischer Vergleich, Studien zum deutschen Innovationssystem, Berlin: EFI.

4-2013 Müller, B.; Bersch, J.; Niefert, M.; Rammer, C. (2013): Unternehmensdynamik in der Wissenswirtschaft in Deutschland 2011, Gründungen und Schließungen von Unternehmen, Beschäftigungsbeitrag von Gründungen, Vergleich von Datenquellen mit Informationen zu Gründungen, Studien zum deutschen Innovationssystem, Berlin: EFI.

5-2013 Neuhäusler, P.; Rothengatter, O.; Frietsch, R. (2013): Patent Applications – Structures, Trends and Recent Developments, Studien zum deutschen Innovationssystem, Berlin: EFI.

6-2013 Michels, C.; Fu, J.; Neuhäusler, P.; Frietsch, R. (2013): Performance and Structures of the German Science System 2012, Studien zum deutschen Innovationssystem, Berlin: EFI.

7-2013 Cordes, A.; Gehrke, B.; Gornig, M.; Mölders, F.; Schiersch, A. (2013): FuE-intensive Industrien und wissensintensive Dienstleistungen im internationalen Vergleich, Studien zum deutschen Innovationssystem, Berlin: EFI.

8-2013 Gehrke, B.; Frietsch, R.; Neuhäusler, P.; Rammer, C. (2013): Re-definition of research-intensive industries and goods – NIW/ISI/ZEW-Lists 2012, Studien zum deutschen Innovationssystem, Berlin: EFI.

9-2013 Gehrke, B.; Schasse, U. (2013): Position Deutschlands im Außenhandel mit Gütern zur Nutzung erneuerbarer Energien und zur Steigerung der Energieeffizienz, Studien zum deutschen Innovationssystem, Berlin: EFI.

10-2013 Rave, T.; Triebswetter, U.; Wackerbauer, J. (2013): Koordination von Innovations-, Energie- und Umweltpolitik, Studien zum deutschen Innovationssystem, Berlin: EFI.

11-2013 IWH; DIW; LMU; WU – Institut für Wirtschaftsforschung Halle; Deutsches Institut für Wirtschaftsforschung; Ludwig-Maximilians-Universität München; Wirtschaftsuniversität Wien (2013): Internationale FuE-Standorte, Studien zum deutschen Innovationssystem, Berlin: EFI.

12-2013 Falck, O.; Wiederhold, S. (2013): Nachfrageorientierte Innovationspolitik, Studien zum deutschen Innovationssystem, Berlin: EFI.

13-2013 Dauchert, H. (2013): Internet- und IT-Unternehmensgründungen in Berlin, Studien zum deutschen Innovationssystem, Berlin: EFI.

14-2013 Meurer, P. (2013): Open Access – Entwicklung und Perspektiven, Studien zum deutschen Innovationssystem, Berlin: EFI.

ENDNOTES

1 Cf. EFI (2008), Chapter C 4 and EFI (2010), Chapters A 6 and B 2.
2 Cf. Bos et al. (2012).
3 Cf. EFI (2012), Chapter A 1.
4 Cf. Egger et al. (2012).
5 Cf. EFI (2011), Chapter B 2.
6 Cf. EFI (2012), Chapter B 1.
7 Cf. EFI (2011), Chapter B 1.
8 Cf. EFI (2012), Chapter B 1, p. 73.
9 Cf. EFI (2012), Chapter B 1.
10 Cf. EFI (2012), Chapter B 1, p. 58 ff.
11 Cf. Bundesregierung (2012) There are currently signs of a corresponding measure, which is due to be adopted by the *Bundesrat* on 01/03/2013.
12 Cf. EFI (2012), Chapter B 3.
13 Cf. OECD (2011a).
14 Cf. Chapter A 3 in this Report.
15 Cf. Chapter A 2 in this Report.
16 Cf. Chapter A 6 in this Report.
17 Cf. EFI (2011), Chapter B 1.
18 Cf. Chapter B 1 in this Report.
19 To date, the Federal Government's High-Tech Strategy 2020 has been focusing its efforts on several requirement areas (such as mobility and communication), on key technologies and on future projects. The objective is to strengthen start-ups and SMEs in Germany's ICT sector. Some of these objectives had been established in 2010 as part of the Federal Government's ICT strategy "Digital Germany 2015".
20 Cf. EFI (2012), Chapter B 2.
21 In many other countries, residence and work-related framework conditions for foreign entrepreneurs have been loosened considerably in recent years. Thus, regulations for foreign entrepreneurs in the UK, Ireland or Singapore are required to make a minimum investment of only EUR 30,000 to 70,000, in combination with a residence permit of up to three years. In Chile, foreign founders are even supplied with a EUR 30,000 start-up grant (cf. *The Economist* 2012 and The Partnership for a New American Economy and the Partnership for New York City 2012). In Germany, the required minimum investment is EUR 250,000 and is thus significantly higher than in the above countries. An exception only applies to start-ups by foreign graduates of German tertiary education institutions. For this group of foreign founders, the minimum investment requirement has been abolished by the Act to transpose the EU Directive on highly qualified employment into German law (effective August 2012).
22 Cf. EFI (2012), Chapter B 2.
23 At the end of 2012 – and thus almost six months after the adoption of the law on the recognition of foreign qualifications – a mere 1,500 recognitions had been applied for and only 300 favourable foreign skills approvals had been issued for professions listed with the Chamber of Commerce and Industry. In contrast to this, as many as 12,000 approvals had been originally expected. Cf. BMBF (2012a).
24 Cf. Chapter B 4 in this Report.
25 The overall proportion of female professors in mathematics and natural sciences increased slightly between 2003 and 2011 from approximately 8 to 11 percent. Yet, in the engineering sciences, this proportion remained almost unchanged throughout the same period (from 7 to 8 percent) and even declined in some of the subdisciplines (cf. Statistisches Bundesamt 2012a).
26 Cf. Chapter B 4 in this Report.

27 Cf. Chapter B 4 in this Report.
28 Cf. McCabe (2002).
29 Cf. http://open-access.net/de_en/general_information/pros_and_cons_of_open_access/arguments_in_favour_of_open_access/ (last accessed on 11 January 2013).
30 The following exposition refers to the publishing of scientific research results and on original data and other sources, but not to textbooks and reference books.
31 Regarding this chapter, cf. also Meurer (2013).
32 Cf. Sietmann (2007: p. 15).
33 Yet authors do not only intend to disseminate their research results: publications in prestigious scientific journals increase a scientist's reputation and also pay off financially. Cf. Haucap et al. (2005: p. 93).
34 Many scientists regard peer reviewing as a mandatory task. Furthermore, peer-reviewing for reputed journals can increase a scientist's prestige and may also contribute to the experts' own standing with regard to their own publications. Cf. Haucap et al. (2005: p. 93).
35 In this regard, cf. Haucap et al. (2005: p. 86ff.).
36 In the case of Elsevier, figures are based on a revenue of GBP 2,058 million and an adjusted operating profit of GBP 768 million (cf. Reed Elsevier 2012: p. 9). In the case of Wolters Kluwer, the revenue amounted to EUR 3,354 million, with an operating profit of EUR 436 million. Cf. http://reports.wolterskluwer.com/2011/ar/reportoftheexecutiveboard/financialdevelopments/financial-performance.html?cat=m (last accessed on 11 January 2013). The revenue of Wiley amounted to USD 1,743 million, with an adjusted operating income of USD 257 million. Cf. http://eu.wiley.com/WileyCDA/Section/id-301733.html (last accessed on 11 January 2013). Among German publishing houses, the proportion of the annual profit before tax amounted to 9 percent in 2010 (figures: Deutsche Bundesbank 2012).
37 In this regard, cf. http://isites.harvard.edu/icb/icb.do?keyword=k77982&tabgroupid=icb.tabgroup143448 (last accessed on11 January 2013).
38 Cf. http://www.thecostofknowledge.com/ und Kesselhut (2012) (last accessed on 11 January 2013).
39 Cf. http://www.ma.tum.de/Mathematik/BibliothekElsevier und Spiegel-Online (2012) (last accessed on 11 January 2013).
40 In this regard and in the following, cf. http://open-access.net/de/allgemeines/gruende_und_vorbehalte/gruende_fuer_oa/#c581 (last accessed on 11 January 2013).
41 Cf. Evans and Reimer (2009).
42 For comparative analyses of empirical studies examining the relationship between open access and citations, cf. Craig et al. (2007), Davis and Walters (2011), Swan (2010) and Turk (2008). Gaule and Maystre (2011) provide an approach for explaining differing results in cross-sectional studies and quasi-experimental investigations.
43 Cf. http://www.doaj.org/doaj?func=byCountry&uiLanguage=en (last accessed on 11 January 2013).
44 Based on a public expert meeting of the "education and research" project group, the *Enquetekommission Internet und digitale Gesellschaft* (Commission of Enquiry "Internet and Digital Society") notes that the use of the term "golden path" seems to be limited to open access publishing of commercial publishers. Cf. Enquetekommission Internet und digitale Gesellschaft (2012).
45 Besides preprints and postprints, other printed works such as monographs, research reports and conference proceedings are archived here.
46 Overviews of repositories can be viewed on the following websites: http://opendoar.org/index.html; http://roar.eprints.org/ (last accessed on 11 January 2013).
47 However, some of the journals do not accept texts that have been published as a preprint, while others request that preprint versions shall not be available online for the duration of the review.
48 Cf. in the following: Enquetekommission Internet und digitale Gesellschaft (2012: p. 74).
49 These comprise the German Research Foundation (DFG), the Fraunhofer-Gesellschaft, the Helmholtz Association, the German Rectors' Conference, the Leibniz Association, the Max Planck Society and the German Council of Science and Humanities.

50 Cf. http://oa.mpg.de/files/2010/04/Berliner_Erklaerung_dt_Version_07-2006.pdf (last accessed on 11 January 2013) and http://oa.mpg.de/files/2010/04/berlin_declaration.pdf (last accessed on 11 January 2013); the wording of the English version shall prevail.

51 Cf. http://oa.mpg.de/lang/de/berlin-prozess/signatoren/ (last accessed on 11 January 2013).

52 Open access publications must satisfy two prerequisites: first, users shall be granted "a free, irrevocable, worldwide right of access to, and a license to copy, use, distribute, transmit and display the work publicly and to make and distribute derivative works; in any digital medium and for any responsible purpose, subject to proper attribution of authorship". Second, the publication shall be deposited "in an appropriate standard electronic format […] in at least one online repository […] that is supported and maintained by an academic institution, scholarly society, government agency, or other well-established organization that seeks to enable open access, unrestricted distribution, inter operability, and long-term archiving", http://oa.mpg.de/lang/en-uk/berlin-prozess/berliner-erklarung/ (last accessed on 11 January 2013).

53 Cf. in the following: http://oa.mpg.de/lang/en-uk/berlin-prozess/berliner-erklarung/ (last accessed on 11 January 2013).

54 http://www.fraunhofer.de/content/dam/zv/en/Publications/Fraunhofer_open-access-policy.pdf (last accessed on 11 January 2013).

55 Cf. http://open-access.net/de_en/information_on_oa_by/fraunhofer_gesellschaft/ (last accessed on 11 January 2013).

56 Cf. http://open-access.net/de_en/information_on_oa_by/fraunhofer_gesellschaft/ (last accessed on 11 January 2013).

57 Cf. http://eprints.fraunhofer.de/newsletter/Fraunhofer%20Open%20Access%20Newsletter%201-2009.pdf (last accessed on 11 January 2013). According to information provided by telephone, the modalities of granting funds have been modified since the introduction of the promotion fund. The Fraunhofer-Gesellschaft also publishes an open access newsletter designed to provide current information on open access. Cf. http://publica.fraunhofer.de/starweb/ep09/newsletter.htm (last accessed on 11 January 2013).

58 Cf. http://eprints.fraunhofer.de/newsletter/Fraunhofer%20Open%20Access%20Newsletter%201-2009.pdf (last accessed on11 January 2013).

59 Resolution of the Assembly of Members from 27/09/2004, cf. http://open-access.net/de/oa_informationen_der/helmholtz_gemeinschaft/ (last accessed on 11 January 2013).

60 In this regard and in the following, cf. http://open-access.net/de/oa_informationen_der/helmholtz_gemeinschaft/ (last accessed on 11 January 2013). In this context, the *Helmholtz* Association's open access coordination office was also established. It initiates debates, advises, and publishes the *Helmholtz Open Access Newsletter*.

61 Cf. http://oa.helmholtz.de/index.php?id=61 (last accessed on11 January 2013).

62 Cf. http://oa.helmholtz.de/index.php?id=62 (last accessed on 11 January 2013).

63 Information in writing from the Helmholtz open access coordination office. Cf. also http://www.helmholtz.de/aktuelles/presseinformationen/artikel/artikeldetail/helmholtz_unterstuetzt_open_access_publizieren/ (last accessed on 11 January 2013), http://www.helmholtz.de/aktuelles/presseinformationen/artikel/artikeldetail/helmholtz_unterstuetzt_open_access_publikationen/, http://oa.helmholtz.de/index.php?id=294#c1727 (last accessed on 11 January 2013), as well as http://www.helmholtz.de/aktuelles/presseinformationen/artikel/artikeldetail/helmholtz_zentren_erleichtern_das_open_access_publizieren_mit_copernicus_publications/ (last accessed on 11 January 2013).

64 Cf. http://open-access.net/de/oa_informationen_der/leibniz_gemeinschaft/ (last accessed on 11 January 2013).

65 Cf. http://www.leibniz-gemeinschaft.de/fileadmin/user_upload/downloads/Infrastruktur/OpenAccess-Leitlinie.pdf (last accessed on 11 January 2013).

66 Cf. http://www.leibniz-gemeinschaft.de/fileadmin/user_upload/downloads/Infrastruktur/LG_LeibnizOpen2012_WEB.pdf (last accessed on11 January 2013), as well as http://www.leibnizopen.de/ueber-leibnizopen/ (last accessed on 11 January 2013).

67 Cf. http://open-access.net/de/oa_informationen_der/leibniz_gemeinschaft/ (last accessed on 11 January 2013).

68 Cf. http://oa.mpg.de/lang/de/mpg-open-access-policy/ (last accessed on 11 January 2013). The open access policy team is located at the Max Planck Digital Library (MPDL) and serves as an information point for any queries relating to open access publishing. Cf. http://oa.mpg.de/lang/de/informationen-fur-autoren/ (last accessed on11 January 2013).

69 In this regard and in the following, cf. http://oa.mpg.de/lang/de/informationen-fur-autoren/open-access-publizieren/ (last accessed on 11 January 2013).

70 Cf. http://www.dfg.de/dfg_magazin/forschungspolitik_standpunkte_perspektiven/open_access/index.html (last accessed on 11 January 2013).

71 Europäische Kommission (2012a). The 7th Research Framework Programme had already comprised a pilot project that obliged scientists in selected fields of research (among them energy, environment and health) to meet open access requirements, cf. https://www.openaire.eu/en/component/attachments/download/4.html (last accessed on 11 January 2013), as well as http://open-access.net/de/austausch/open_access_projekte/openaire/ (last accessed on11 January 2013)

72 Subsidies only partially cover the costs; full financing is not provided.

73 Cf. http://www.dfg.de/formulare/12_20/12_20.pdf (last accessed on 11 January 2013). In 2011, the sums granted in the context of this programme amounted to EUR 0.3 million (cf. DFG (no year): p. 106).

74 Cf. http://www.dfg.de/formulare/12_17/12_17.pdf (last accessed on 11 January 2013). In 2011, the sums granted in the context of this programme amounted to EUR 0.67 million (cf. DFG (no year): 106).

75 Cf. http://www.dfg.de/formulare/12_11/12_11.pdf (last accessed on 11 January 2013) and information from the DFG provided by telephone. In 2011, projects supported in the context of this programme received a total of EUR 2.8 million (cf. DFG (no year): p. 106, telephone information from the DFG).

76 Cf. http://www.driver-repository.eu/Driver-About/About-DRIVER.html (last accessed on 11 January 2013).

77 Cf. http://www.driver-repository.eu/PublicDocs/FACT_SHEET_I3_driver_ii.pdf (last accessed on 11 January 2013).

78 Cf. https://www.openaire.eu/, http://open-access.net/fileadmin/OpenAIRE/openaire_leaflet_online_201009_en.pdf, http://open-access.net/de/austausch/open_access_projekte/openaire/ (last accessed on 11 January 2013), as well as http://www.ub.uni-konstanz.de/bibliothek/projekte/openaire/ (last accessed on 11 January 2013). OpenAIRE received EUR 4.1 million in EU funding (cf. Hagerlid 2010).

79 Cf. https://www.openaire.eu/en/component/content/article/104-plusprojectfaq/377-differences (last accessed on 11 January 2013), as well as http://www.ub.uni-konstanz.de/bibliothek/projekte/openaireplus/ (last accessed on 11 January 2013). OpenAIREplus has received EUR 4.2 million in EU funding. Cf. http://www.openaire.eu/it/about-openaire/openaireplusproject/fact-sheet (last accessed on 11 January 2013).

80 The open access journal *Living Reviews in Relativity*, for instance, which is published by the Max Planck Institute for Gravitational Physics based in Potsdam, has an impact factor of 17,462, thus ranking in first position in the physics, particles & fields category, cf. http://www.mpg.de/5888876/impact_open_access (last accessed on 11 January 2013). On the impact of open access journals, cf. Gumpenberger et al. (2012).

81 Cf. in the following http://www.hochschulverband.de/cms1/index.php?id=777&no_cache=1&tx_ttnews[tt_news]=&type=98 (last accessed on11 January 2013).

82 In this regard and in the following, cf. http://www.boersenverein.de/sixcms/media.php/976/Stellungnahme%20KII%2020111008.pdf (last accessed on 11 January 2013).

83 Regarding second publication rights, cf. http://www.allianzinitiative.de/fileadmin/user_upload/2011-04-04_allianz.pdf (last accessed on 11 January 2013), as well as Enquetekommission Internet und digitale Gesellschaft (2012: p. 85ff.).

84 Problems in implementing second publication rights can occur whenever the academic publisher is based in another country, which is often the case.

85 Cf. http://www.cy2012.eu/index.php/de/news-categories/areas/competitiveness/press-release-agreement-on-the-unitary-patent-protection-package-signifies-successful-end-to-long-pr (last accessed on 11 January 2013).

86 In their earlier Reports, the Expert Commission already commented on the development of the European patent system. Cf. e.g. EFI (2010: Chapter B5) and EFI (2011: 31ff.).

87 Regarding the level of fees and translation costs and how these affect the validation behaviour of applicants, cf. Harhoff et al. (2009).

88 Harhoff (2009) presents estimates according to which approximately 70 percent of all patent infringement suits in Europe are brought before German courts.

89 Cf. Harhoff (2009).

90 Cf. Europäisches Parlament, Rat der Europäischen Union (2012), as well as Council of the European Union (2012a).

91 Patent applications in other languages have to be accompanied by a (machine-written) translation into one of the three languages. The European patent with unitary effect shall be published in the language filed. Once a patent has been granted, patent claims have to be translated into the respective other two official languages. The costs of translation shall be reimbursed to SMEs, non-profit organisations, universities and public research institutions within the EU. Cf. Council of the European Union (2012a).

92 Cf. Rat der Europäischen Union (2012b).

93 Regional and local divisions are distributed according to the distribution of patent disputes within the EU. While local divisions shall be established in countries that negotiate a certain number of patent litigation cases per year, cross-border regional divisions shall be established by those member states that remain below this threshold.

94 Cf. Rat der Europäischen Union (2012b).

95 These proceedings correspond with the German national patent litigation system's separation of infringement and nullity suits.

96 Complaint lodged on 10 June 2011 – Italian Republic v. Council of the European Union (Case C-295/11) and complaint lodged on 3 June 2011 – Kingdom of Spain v. Council of the European Union (Case C-274/11). With their complaints lodged against enhanced cooperation, Spain and Italy aim to prevent a two-speed Europe.

97 The European Commission estimates that the unified patent court will reduce European companies' litigation costs by approximately EUR 289 million annually. Cf. http://www.european-council.europa.eu/home-page/highlights/eu-unitary-patent-%E2%80%93-a-historical-breakthrough?lang=en (last accessed on 11 January 2013).

98 This applies to the opt-out choice in the context of adapting the new regulations, and to countries that have not (yet) ratified the Unitary Patent Court regulations, as well as to non-EU member states.

99 Cf. Hilty et al. (2012).

100 Cf. Hilty et al. (2012).

101 Cf. BMWi (2007).

102 Cf. Winter (2012), Smith (2011), Hommels (2011).

103 There are currently no in-depth analyses or statistics to provide reliable figures on Berlin's IT and internet start-up boom that would provide a basis for comparing its development with that of other German cities. Cf. Dauchert (2013).

104 The BVK data also show that Berlin-based businesses were able to attract larger investment sums than businesses from Munich/Bavaria. In the years 2011 and 2012, the sum of the ten largest transactions in Berlin amounted to EUR 145.5 million, while the sum of the ten largest transactions in Munich/Bavaria amounted to EUR 103.1 million. Cf. BVK (2012).

105 Venture capital investments in the health sector (Life Science) in Berlin increased from EUR 6.1 million in 2009 to EUR 33.6 million in 2011. Cf. BVK (2012).

106 According to the BVK, the following venture capital companies have opened offices in Berlin in the recent past: Earlybird (headquarters: Munich), Demeter (headquarters: Paris), Nanostart (headquarters: Frankfurt). Regarding venture capital investments in Berlin, cf. Berberich (2012), Hawley (2011), and Geisler (2012).

107 In the winter semester 2011/12, the proportion of foreign students *(Bildungsausländer)* in Berlin was 13 percent, considerably higher than in all other federal states (average: 8 percent). In the city states of Hamburg and Bremen, the proportion of mobile foreign students was 7.5 percent and 11 percent respectively. The state with the second-highest proportion of foreign students was Saarland with just below 12 percent. Cf. *Statistisches Bundesamt* (2012b).

108 – Soundcloud
Year established: August 2007 in Berlin
Employees: 2011: approx. 70; 2012: slightly below 100
– Wooga
Year established: 2009 in Berlin
Employees: 2011: slightly below 100; 2012: 250
– 6Wunderkinder
Year established: August 2010 in Berlin
Employees: 2012: 25
– Zalando
Year established: 2008 in Berlin
Employment figures: 2008: 25; 2010: 150; 2012: 1,800
– Betterplace
Year established: 2007 in Berlin
– Rocket Internet
Year established: 2007 in Berlin
Employees: 2012: more than 700
– ResearchGate
Year established: 2008 in Hanover, relocated to Berlin in 2011
Employees: 2008: less than 10; 2011: approx. 60; 2012: approx. 100
– Visual Meta GmbH *(Ladenzeile.de)*
Year established: December 2008
Employees: end of 2011: 44; 2012: approx. 100

109 Cf. Meeker (2012).

110 Cf. Dean et al. (2012).

111 Regarding the employment development of selected successful start-up businesses, cf. endnote 108.

112 Regarding the problematic financial situation of Berlin start-up businesses, cf. Telefonica and Start-up Genome (2012).

113 Cf. EFI (2011:18ff.) and EFI (2012:p. 76ff.).

114 Cf. De Buysere et al. (2012).

115 Crowdsourcing refers to the utilisation of "swarm intelligence": crowdsourcing services are, by definition, provided outside of a company. Thus e.g. online audiences' preferences are integrated into the corporate brainstorming and decision-making process.

116 This may be done via the internet without the involvement of an intermediary, i.e. entrepreneurs directly present their business ideas to a number of individual potential investors.

117 First, the film project has created non-financial incentives in the form of investor certificates and access to the dedicated investor's lounge. Depending on the amount invested, donors will be included in the film credits and receive premiere tickets. Second, the donor directly participates in the success of the project: if the film draws an audience of one million, the donor's return on equity investment is 1:1. For an audience of two million, the rate of return is 50 percent. In the event that the film project fails in raising a total volume of EUR 1.0 million in funding, all crowdfunding donor will get their money back.

118 Had the project failed to raise crowdfunding financing of EUR 1.0 million within a predefined period of time, thereby generating a high level of public awareness and high profit expectations, the project would have been cancelled altogether.

119 http://www.mba-lyon.fr/mba/sections/fr/mecenat/mecenat-musee/donner-pour-ingres (last accessed on 11 January 2013).

120 http://crowdfunding.trampolinesystems.com/ (last accessed on 11 January 2013).

121 Cf. Crowdfunding Industry Report (2012).

122 Cf. Hemer et al. (2011).

123 Cf. Crowdfunding Industry Report (2012). The generated volume of financing through crowdfunding is not taken into account here. Germany's total volume could in fact be higher despite a more pronounced market concentration (i.e. fewer platforms). However, such figures are currently not available to the Expert Commission.

124 Cf. ZEIT online (2012).

125 Cf. De Buysere et al. (2012).

126 Scientific literature on crowdfunding is still young. Research areas here include e.g. the minor role of geographical distance between the "crowd" and the enterprise, as well as typical characteristics and motivation patterns among crowdfunders. In addition, success factors are being identified for both the selection of crowdfunding-financed enterprises and promising forms of organising and managing crowdfunding platforms (cf. Schwienbacher, 2010). From the perspective of individual venture capitalists in Germany, a crowdfunding-based financing model is largely perceived as a negative signal, suggesting that the respective company has failed to solicit funding from the usual financial intermediaries. From a contractual perspective, crowdfunding can make it more difficult to acquire subsequent venture capital financing due to the fact that crowdfunding tends to result in highly fragmented ownership structures and relatively high transaction costs.

127 Cf. BaFin (2012).

128 A first exception has recently been described in an article in the *Frankfurter Allgemeine Zeitung* (2012b). The Berlin-based platform *Bergfürst* was the first German platform to be approved as a financial services provider by the German Financial Supervisory Authority (BaFin). This means that *Bergfürst* can offer private investors equity shares that can be subsequently traded on the stock market. To accomplish this, the platform's supervisory board and management board were subjected to a compliance audit by the BaFin. Changes in this group of individuals require the consent of the BaFin. Relevant decisions must be jointly made by at least two executives, and decision-making processes must be documented and made available to the supervisory authority. The initial capital of EUR 730,000 has to be permanently available and has to be verified according to the strict standards of the accounting regulation for credit institutions and financial services institutions. In addition, the BaFin and the Bundesbank must be supplied with a monthly business performance report.

129 Cf. 2003/71/EC, annex 2010/73/EC.

130 A key measure of the JOBS Act is the abolition of the 500 shareholder regulation, which had entailed the risk of prematurely forcing founders to go public. The number of shareholders to initiate Initial Public Offering (IPO) has been increased from 500 to 2,000. The Obama administration aims to generate growth among start-ups and SMEs in the USA through the new crowdfunding regulations, and through improved incentives for equity-based crowdfunding in particular. The U.S. Securities and Exchange Commission (SEC) has been commissioned to elaborate on individual regulations and procedures, e.g. with regard to the registration requirement for crowdsourcing intermediaries.

Deregulation in this area has already resulted in efforts in the crowdfunding industry to enhance self-regulation (see e.g. http://techcrunch.com/2012/04/05/with-jobs-act-becoming-law-crowdfunding-platforms-look-to-create-self-regulatory-body/, last accessed on 11 January 2013).

131 *Frankfurter Allgemeine Zeitung* (2012a).

132 Cf. Hemer et al. (2011).

133 Cf. IAB (2011), as well as Steinke et al. (2012).

134 Cf. Wunsch and Lechner (2008:139).

135 Cf. Schlotter et al. (2009).

136 Generally speaking, not all types of R&D funding are eligible for randomised evaluations, i.e. one has to carefully consider which of the policy areas are suited and most likely to benefit from such evaluations.

137 Different options for designing randomised policy evaluations, as well as current examples in Europe have been provided by Arni (2012).

138 In the allocation of study places in Germany, the lottery system is employed only as a "secondary" selection criterion for degree courses in medicine, veterinary medicine, dentistry and pharmacy: after the candidates' average grade, waiting time and social criteria have been considered, any remaining university places will be allocated by lottery. Cf. http://www.hochschulstart.de/index.php?id=515 (last accessed on 11 January 2013).

139 Cf. *Der Tagesspiegel* (2011).

140 In legal commentaries, the legitimacy of randomised selection procedures is often considered as a permissible exercise of discretion (http://www.bfh.simons-moll.de/bfh_1989/xx890004.htm, last accessed on 11 January 2013).

141 In other policy areas in Germany, evaluations on the basis of randomised experiments are already in use. In the field of education policy, for instance, the model project Pro Kind examines the effectiveness of alternative measures to support the early development of socially disadvantaged children through an experiment with randomised control groups. A random selection is made from the target group of mothers from socially disadvantaged environments. These mothers receive regular supportive visits to their home, while the members of the control group do not receive visits. Initial results indicate that the children of supported mothers develop significantly better – e.g. in terms of weight or size – than the children of the control group members (cf. Lutz and Sandner 2010).

142 At a European level, a recent study confirms that about 3/4 of innovation policy evaluations in all EU member states are mainly based on descriptive statistics. Only 20 percent of evaluations are based on control group and econometric approaches (cf. INNO-Appraisal 2010).

143 More recent econometric procedures place a stronger focus on panel regressions, or IV regressions which use instrumental variables to identify the causal effects of measures. Cf. Woolridge (2002).

144 Cf. Moher et al. (1998).

145 Cf. Gueron (2008).

146 Innovation vouchers in the Netherlands included a programme budget of EUR 750,000 in 2004 (first round of assignments) and EUR 3 million in 2005 (second round of assignments). 100 (in 2004) and 400 (in 2005) vouchers were randomly assigned to SMEs, each to the maximum value of EUR 7,500. The vouchers had to be redeemed within a certain period of time at a selected group of Dutch research institutions.

147 Cf. Cornet et al. (2006).

148 Evaluation results of randomised procedures have played a similarly important role in US health policies, both at state and national decision making levels. Cf. Baum (1991).

149 Cf. Fitz-Gibbon (2000).

150 Cf. Word et al. (1994).

151 Cf. Grossman (1994).

152 Cf. BMWi (2012a).

153 In this regard, cf. http://www.ewe.com/de/_media/download/pdf/EWE_100201_Bullensee-Thesen_gesamt_D_2010.pdf (last accessed on11 January 2013).

154 The following expositions are largely based on a study prepared by the Ifo Institute, commissioned by the Expert Commission. Cf. Rave et al. (2013) and the literature cited therein.

155 In addition to the targets displayed in the tables, there are also existing regulations with regard to building renovation: an increase in the refurbishment rate to 2 percent of the existing building stock per year; a reduction in heat demand by 20 percent by 2020; and a reduction in primary energy demand by 80 percent by 2050.

156 A basic rule of efficient regulation dates back to Dutch economist Jan Tinbergen (1952): the number of regulatory objectives should correspond with the number of regulatory instruments.

157 This includes electricity and heat generation, iron and steel smelting, coking plants, refineries and crackers, cement and lime production, the glass, ceramic and brick industries, as well as paper and pulp production; and, since 2013, also chemical plants, other plants in the metal industry, as well as industrial plants with process heating systems.

158 Cf. in the following: Böhringer (2010).

159 The obligations of the individual member states are as follows: Belgium: –15 percent; Bulgaria: +20 percent; Denmark: –20 percent; Germany: –14 percent; Estonia: +11 percent; Finland: –16 percent; France: –14 percent; Greece: –4 percent; Great Britain: –16 percent; Ireland: –20 percent, Italy: –13 percent; Latvia: +17 percent; Lithuania: +15 percent; Luxembourg: –20 percent; Malta: +5 percent; Netherlands: –16 percent; Poland: +14 percent; Portugal: +1 percent; Austria; –16 percent; Romania: +19 percent; Sweden: –17 percent; Slovenia: +4 percent; Slovakia: +13 percent, Spain: –10 percent; Czech Republic: +9 percent; Hungary: +10 percent; Cyprus: –5 percent.

160 Cf. UBA (2007), European Commission (2008), as well as Downing et al. (2005), quoted in Rave et al. (2013).

161 Cf. Calel and Dechezlepretre (2012), Rogge et al. (2011), as well as Matthes (2010), quoted in Rave et al. (2013).

162 In specialist literature, the terms "insecurity" and "risk" are usually precisely defined and delineated. In the present context, it shall suffice to apply a more colloquial definition to both terms, i.e. a certain degree of uncertainty.

163 In this regard and in the following, cf. Böhringer (2010).

164 Cf. Battles et al. (2012), quoted in Rave et al. (2013).

165 Cf. also SRU (2011), quoted in Rave et al. (2013).

166 Cf. Duval (2008) and Neuhoff (2005), quoted in Rave et al. (2013).

167 Cf. Neuhoff (2005) und Gerlagh et al. (2008), quoted in Rave et al. (2013).

168 Cf. Requate (2009), quoted in Rave et al. (2013).

169 Economic stakeholders weigh costs and benefit to a lesser degree the further these are in the future. When assessing investments, future costs and benefits are therefore calculated with regard to the present based on an interest rate – the discount rate. Private and social discount rates may differ, and hence the assessment of investments may also vary. In addition to this, risk preferences (risk aversion, risk neutrality, risk seeking) may also vary.

170 Cf. Pollitt and Shaorshadze (2011), quoted in Rave et al. (2013).

171 To reach the optimal level of investment, relatively high transaction costs have to be incurred here.

172 Cf. § 5 Section 1 of the EEG. The costs incurred shall be borne by the plant operators (cf. § 13, Section 1 of the EEG).

173 Cf. § 9, Section 1 of the EEG. The costs incurred shall be borne by the grid system operators. (Cf. § 14 of the EEG).

174 Cf. § 8 Section 1 of the EEG.

175 Cf. § 11, Section 1 of the EEG, as well as http://www.bundesnetzagentur.de/DE/Sachgebiete/ElektrizitaetGas/ErneuerbareEnergienGesetz/LeitfadenEEGEinspeisemanagement_Basepage.html (last accessed on 11 January 2013).

176 Cf. § 12, Section 1 of the EEG.

177 Cf. § 16, Section 1 of the EEG.

178 Cf. § 16, Section 2 of the EEG.

179 Cf. §§ 23-33 (hydropower, landfill gas, sewage gas, mine gas, biomass, organic waste, anaerobic digestion of manure, gaseous fuels, geothermal energy, wind energy, wind repowering, offshore wind energy, solar radiation energy, solar radiation energy in or on buildings).
180 180 Cf. §§ 20, Section 2, 20a, Section 2–5 of the EEG.
181 Cf. §§ 20, Section 1, Clause 3, 20a, Section 7 and 21, Section 2 of the EEG.
182 Cf. § 34 of the EEG.
183 Cf. § 35, Section 1 of the EEG. Cf. § 35, Section 1 of the EEG.
184 Cf. § 36, Section 3 of the EEG.
185 In contrast to the forward market, the spot market trades at the current rate for immediate delivery.
186 In this regard and in the following, cf. http://www.bundesnetzagentur.de/SharedDocs/Downloads/DE/BNetzA/Sachgebiete/Energie/ErneuerbareEnergienGesetz/AusgleichsmechanismusAusfVerordg/HintergrundWaelzungsmechanismuspdf.pdf?__blob=publicationFile (last accessed on 11 January 2013).
187 Cf. § 37, Section 2 of the EEG.
188 Cf. § 33g, Section 1, Clause 1 of the EEG.
189 The day-ahead market trades electricity for the following day.
190 Cf. http://www.erneuerbare-energien.de/fileadmin/ee-import/files/pdfs/allgemein/application/pdf/eeg_novelle_entwurf_2011.pdf (last accessed on 11 January 2013).
191 Cf. Wissenschaftlicher Beirat beim Bundesministerium für Wirtschaft und Technologie (BMWi 2012c: 37).
192 Cf. Requate (2009).
193 In this regard and in the following, cf. Blankart et al. (2008: p. 94f.).
194 According to a study by the Lower Saxony Institute for Economic Research (NIW), import competition for solar cells and modules could still be overcompensated in the years prior to the financial and economic crisis, due to disproportionately higher foreign market shares (cf. Gehrke and Schasse, 2013). Since 2008, however, this is no longer the case, as German producers have suffered significant export trade losses.
195 In this regard and in the following, cf. Blankart et al. (2008: p. 95).
196 Cf. Frondel et al. (2011).
197 Cf. § 40, Clause 1 of the EEG.
198 Cf. Techert et al. (2012).
199 Cf. Monopolkommission (2011: p. 237).
200 Cf. in the following SVR (2011: p. 256ff.).
201 Cf. in the following SVR (2011: p. 257f.).
202 Cf. in the following SVR (2011: p. 258f.).
203 Cf. in the following SVR (2011: p. 260).
204 Cf. Buckmann (2012), quoted in Rave et al. (2013).
205 Cf. EU (2012: p. 1ff.).
206 Such measures include e.g. energy or CO2 taxes, financing systems and instruments, tax credits, standards and norms, as well as energy labeling schemes (cf. EU, 2012: p. 18).
207 Cf. in the following BMBF (2010) and EFI (2011: p. 29ff.), as well as http://www.hightech-strategie.de/index.php (last accessed on 11 January 2013).
208 Cf. BMBF (2012b) and http://www.bmbf.de/pub/HTS-Aktionsplan.pdf (last accessed on 11 January 2013).
209 The five requirement areas are: Climate/Energy, Health/Nutrition, Mobility, Security, and Communication.
210 Cf. http://www.hightech-strategie.de/de/83.php (last accessed on 11 January 2013).
211 Cf. BMBF (2010: p. 6).
212 Cf. in the following BMWi (2011a).
213 Cf. http://foerderportal.bund.de/foekat/jsp/StartAction.do (last accessed on 11 January 2013).

214 These include the Framework Programme "Research for Sustainable Developments", the Framework Programme "Bio-Economy", maintaining competences in nuclear technology, coal chemistry as a bridging technology, research and service centres for climate change and adaptive land management in Africa, climate system research, as well as earth observation from space.

215 Cf. Diekmann and Horn (2007: p. 16).

216 This has been shown by Peters et al. (2012, quoted in Rave et al. 2013) based on a case study in the area of photovoltaics.

217 This includes e.g. basic research for a more thorough understanding of the basic physical effects, the development of new cell concepts and system integration, as well as research into meteorological forecasting procedures and interactions with the grid. "Intelligent system integration" (building integration, grid integration) should also be considered to a greater extent. Long-term applied research on base materials and new cell technologies may also lead to further significant cost reductions. Various forms of thin-film cells, organic cells and concentrator systems show great promise in this regard. In addition, more attention should be given to research into the performance of photovoltaic systems under real conditions. Cf. Wietschel et al. (2010), quoted in Rave et al. (2013).

218 Cf. Wietschel et al. (2010), quoted in Rave et al. (2013).

219 Cf. Wietschel et al. (2010), quoted in Rave et al. (2013).

220 Cf. Cuntz (2011).

221 Cf. Böhringer and Rosendahl (2010).

222 Cf. Böhringer et al. (2008).

223 Cf. Lobo (2011), quoted in Rave et al. (2013).

224 Cf. Rave et al. (2013).

225 Thus, the three federal ministries jointly coordinate e.g. the funding initiative "Sustainable Power Grids", cf. BMWi, BMU and BMBF (2012).

226 Advocates of an Energy Ministry include e.g. the SPD, the CSU, the *Freie Wähler* party, as well as the federal states of Saxony-Anhalt, Bavaria, Baden-Württemberg and Lower Saxony. In the private sector, the idea of an Energy Ministry is supported e.g. by the German Association of Local Utilities (VKU) and *Die Führungskräfte* (DFK), a German confederation of executives. The Federal Chancellor has expressed the view that an Energy Ministry might be an option in the future (*Tagesschau* (2012); dapd 2012; dradio.de 2012; Reck 2012; Rothkirch 2012, quoted in Rave et al 2013.).

227 These countries have developed comprehensive measures, targets and strategies for climate protection and energy supply, which suggests that functioning internal coordination processes are in place. At the same time, it seems that horizontal coordination across administrative boundaries has also been facilitated in this context. It appears that a stronger centralisation of public relations activities also leads to enhanced transparency for citizens and greater planning security for businesses. Cf. Rave et al. (2013).

228 These two fields continue to be the BMU's areas of responsibility.

229 Cf. EFI (2008).

230 The most recent EU study (2012b) has shown that the internationalisation of production is a key driver for R&D internationalisation, cf. Europäische Kommission (2012b: p. 46 ff.).

231 Regarding the special role of international standard-setting bodies and the participation of German stakeholders, cf. Table C 3 – 9.

232 In recent years, several BRIC countries adopted the policy of systematically demanding R&D activities as part of their localisation strategy. Several emerging economies have followed suit.

233 For quite a long time, local content has played a key role in public procurement in China, especially in the field of R&D. Other countries such as Russia, India and Brazil are increasingly adopting this procurement practice.

234 Cf. Europäische Kommission (2012b: p. 24).

235 All figures in US dollar have been converted to euro based on the annual exchange rates provided by OECD, cf. http://stats.oecd.org/Index.aspx?DatasetCode=SNA_TABLE4, exchange rates tables (last accessed on 11 January 2013).

236 Cf. NSB (2012: 0-5).

237 Cf. OECD (2012a: p. 83).

238 Examples include Ireland, Portugal and Spain, where it is often feared that other locations in Eastern European or even Asia will be preferred.

239 Cf. Europäische Kommission (2012b).

240 In academic discourse, this is referred to as the hollowing-out effect. This effect could be temporarily observed in chemical research and in biotechnology. In these areas, certain fields were primarily expanded abroad.

241 The "overexpansion" of foreign R&D and resulting problems in coordinating transnational project collaboration has been described in detail by Gerybadze (2004 and 2005).

242 The importance of the manufacturing industry for export and foreign direct investment is illustrated in a study on the German innovation system (Cordes et al. 2013). A study by the Halle Institute for Economic Research (IWH) et al. (2013) confirms that R&D expenditures of German companies are focussed on a few key sectors of the manufacturing industry.

243 It is striking that Austria and Switzerland are disproportionally overrepresented as target countries for R&D of German companies.

244 The collection of foreign R&D expenditures data as part of the individual OECD countries' science statistics is not systematic enough. In collaboration with the SV Wissenschaftsstatistik, the Commission of Experts for Research and Innovation has developed a survey instrument to significantly improve the data situation in the coming years.

245 The inventor's place of residence usually allows for the conclusion that the invention activity was performed in the R&D unit in the respective country. Yet this analysis also has its shortcomings, as it does not account e.g. for an employee of a company in North Rhine-Westphalia who resides in a bordering area in the Netherlands.

246 Such estimates are flawed for a number of reasons and should be verified by means of detailed case studies. Nevertheless, such patent data analyses are an established analytical instrument in current research on the internationalisation of R&D, especially due to the unavailability of alternative data.

247 In the case of Germany, the GAFI ratio amounted to 16 percent in 2009 while the foreign R&D share was 27 percent. Thus, approximately 60 percent of R&D activities of German companies resulted in patent applications of inventors residing abroad.

248 This is a striking increase that needs to be examined in more detail through a case-related analysis. Such an analysis should also examine patent-filing procedures of selected companies; an aspect that could not be addressed in the context of the Expert Commission's work.

249 Regarding the role of BRIC countries as important R&D locations and their increase in inventor activities, cf. the analytical works of Gerybadze and Merk (2013) on host-country patenting.

250 The relevant reference value is the UAFI indicator (US-based Applications of Foreign Inventions).

251 Cf. IWH et al. (2013: p. 55), Figure III-9.

252 Cf. IWH et al. (2013: p. 53), Figure III-7.

253 Cf. Europäische Kommission (2012b: p. 35); Figure 18.

254 Cf. IWH et al. (2013: p. 30).

255 Throughout the period under examination, employment in R&D at German companies increased by only 2 percent measured in full-time equivalents (i.e. from 238,770 in 1997 to 247,516 in 2009). Within the same period, foreign MNEs increased their employment in R&D from 47,500 to 84,975 – an increase of almost 80 percent.

256 This FAGI ratio is used as an approximation that allows for an estimation of transnational R&D activities. It should be noted, however, that the estimates may be flawed. For instance, it is not always possible to clearly attribute applicants to the respective parent companies and the inventor's place of residence does not necessarily correspond with the R&D location.

257 Cf. IWH et al. (2013: p. 48), Figure III-4.

258 Cf. Ekholm and Midelfart (2004), Blonigen (2005), Jensen (2006).

259 Cf. Devereux et al. (2007), Cantwell and Piscitello (2005), Lychagin (2012).

260 Cf. Belderbos et al. (2009), Thursby and Thursby (2006), Erken and Kleijn (2010).

261 Cf. Thursby and Thursby (2006).

262 Cf. Booz Allen Hamilton and INSEAD (2006), Thursby and Thursby (2006), Kinkel and Maloca (2008), Belderbos et al. (2009), Europäische Kommission (2010).

263 Cf. Guellec and van Pottelsberghe de la Potterie (2001), Dachs and Pyka (2010).

264 Cf. IWH et al. (2013).

265 If, however, one were to conduct such analysis including country-specific fixed effects, the influence of these two factors ceases to be statistically verifiable, as these vary only little over time.

266 Yet, this result only appears in the specification that includes country-specific factors (country-specific fixed effects). In the specification without country-specific effects, to the effect of corporate income tax and R&D tax incentives is reversed.

267 Cf. Chapter B 4 of this Report.

268 Cf. information in writing by IWH.

269 Cf. IWH et al. (2013).

270 Cf. Griffith et al. (2006) for British companies and Harhoff et al. (2012) for German companies.

271 The differing results can be explained by the relatively high proportion of medium-sized enterprises in the Germany study.

272 Cf. Criscuolo (2009), Globerman et al. (2000).

273 Cf. Criscuolo (2009).

274 The German-Sino Innovation Forum held its second conference on 26 and 27 November 2012 in Berlin. The analysis of German R&D expenditure in China and Chinese R&D expenditure in Germany was the subject of a workshop.

275 The following expositions are largely based on the findings of a study commissioned by the Expert Commission. Cf. Falck and Wiederhold (2013).

276 Regarding marketable and non-marketable innovations, cf. Caloghirou et al. (2012: p. 6), as well as Crasemann (2012: p. 8).

277 2008 values. Cf. OECD (2011b). The estimated public procurement volume in 2011 could amount to approximately EUR 334 billion – provided that the proportion of public sector purchasing as a percentage of GDP continued to remain at 13 percent. In 2011, the Federal Republic of Germany's GDP amounted to EUR 2,570 billion. Cf. Destatis (2012: p. 5).

278 This line of argument is widely accepted among scholars, cf. Crasemann (2012).

279 For the collection of data at national level, the measurement, scaling and indexing of innovation-oriented procurement will have to be clearly established in advance. An ex-post analysis to assess whether a procured product or service can be deemed as innovative does not serve the purpose, since such data say nothing about the purchasing behaviour prior to the actual contract awarding. As long as a reliable national database, and, in particular, a time series of surveys on innovation-oriented procurement are lacking, it will not be possible to evaluate procurement behaviour in Germany. Cf. *Deutscher Bundestag* (2012: p. 4).

280 *Stadt München verteidigt LiMux-Projekt gegen kritische Microsoft-Studie,* http://www.zdnet.de/88140858/stadt-munchen-verteidigt-limux-projekt-gegen-kritische-microsoft-studie/ (last accessed on 28 January 2013).

281 Cf. BMI (2012), Financial Times (2009a and 2009b), quoted in Falck and Wiederhold (2013: p. 19).

282 Cf. BMWi (no year), Fraunhofer Institute for High Frequency Physics and Radar Techniques: Sensor-based landing aid for helicopters. http://www.fhr.fraunhofer.de/en/businessunits/Sensors-for-Vehicles-and-Traffic/Sensor-based-landing-aid-for-helicopters.html (last accessed on 11 January 2013), European Patent Office (2011).

283 Cf. endnote 276.

284 One of the main reasons for this may lie in the fact that public sector employees are more risk-averse than employees of private companies and tend to avoid the procurement of innovative goods. Regarding risk-aversion among public servants, cf. Buurman et al. (2009).

285 A rather sceptical assessment is presented by Falck and Wiederhold (2013), while Edler (2006) presents a more positive outlook on demand-oriented innovation policy.

286 Examples of such measures with macroeconomic benefits include the procurement of the AXE telephone exchange by the Swedish Telecommunications Authority STA (now Telia Inc.), as well as the development of the Global Positioning System (GPS) by the US Department of Defense. Cf. Edquist and Zabala-Iturriagagoitia (2012: p. 4f) and Noble (2006: p. 143).

287 In this respect, the Expert Commission largely follows the expositions of Falck and Wiederhold (2013).

288 This should not be taken as a general rejection of all demand-oriented measures. Thus, it is indisputable that the government can indeed generate benefits by providing information on innovative products and technologies. However, these measures are not at a central subject of discussion in this chapter.

289 The OECD calculates the volume of public procurement on the basis of the national economic accounts. According to the OECD definition, procurement-related expenditures comprise all public administrative costs including social security costs, while public utilities and other public sector companies are not taken into account. Due to differences in the availability of detailed national household data, international comparability is only provided to a limited extent. When analysing these data, one has to consider that the BMWi statistics underestimate the actual procurement volume, while the OECD considerably overestimates the volume of public procurement. One of the reasons for this is the fact that the OECD statistics consider all public administrative costs including social security costs, while also considering public procurement contracts that have been tendered but not procured. Regarding the problem of recording and comparing public procurement data, cf. BMWi (2011b), Falck and Wiederhold (2013: p. 39ff.), as well as Wegweiser et al. (2009: p. 55ff.).

290 The identification of business sectors in the TED database – which include research and development services (R&D services), cutting-edge technology goods and services (cutting-edge technology), defense equipment and services (military) as well as environmental goods and services (environment) – is based on the EU's Common Procurement Vocabulary sector classification system that has been established to describe the subject of procurement contracts. Thus, for instance, R&D service contracts are given the CPV code 73000000. These comprise the design of solutions, the development of prototypes and the development of test series. The classification of the cutting-edge technology sector is based on the definition given by the US Bureau of Labor Statistics. Regarding goods and services included in the cutting-edge technology sector and their CPV codes. Cf. Falck and Wiederhold (2013: p. 126). For the classification of defense equipment and services and environmental goods and services, cf. Falck and Wiederhold (2013: p. 126f.).

291 Regarding the TED database, cf. Falck and Wiederhold (2013: p. 4, as well as p. 42ff.).

292 In 2012, the threshold for European tenders for supply and service contracts at national level was EUR 130,000. For supply and service contracts at the *Länder* and municipal levels, the threshold was EUR 200,000.

293 Overview of procurement forms for contracts above the European threshold and below the European threshold

- Public call for tender (below-threshold contracts) / open procedures: Standard procedures for calls for tender: an indefinite number of companies are invited to submit a tender.
- Restricted call for tender (below threshold contracts) / restricted procedures: Applies whenever a limited circle of suppliers is eligible for the contract and/or if a public tender would be disproportionately costly, or if a public tender has failed to produce an economic outcome; with or without a prior call for competition.
- Direct award of a contract (below-threshold contracts) / negotiated procedure: The contracting authority negotiates a viable solution with several eligible companies; the subject of procurement may be modified in the course of negotiations; with or without prior call for competition.

– Competitive dialogue: A procurement form that is applied to particularly complex projects: the components of the goods/services to be supplied are only identified in the course of a prior dialogue phase with several bidders. Cf. Falck and Wiederhold (2013: p. 30)

294 Due to the general flexibility of the competitive dialogue procedure, this procurement form is often referred to as the ideal method of procuring innovative services. Cf. Falck and Wiederhold (2013: p. 32 and p. 63), Crasemann 2012, Wegweiser et al. (2009).

295 The fact that the competitive dialogue procedure is only rarely used is partially owing to the restrictive conditions for selecting this procedure, and partially owing to the procedure's high degree of complexity. In addition, competitive dialogue in particular entails risks for the suppliers as sensitive knowledge will spill over during dialogue sessions, and the public authority may intentionally or unintentionally pass this knowledge on to competing parties. The contracting authority is also exposed to risks: precisely because of the high flexibility of negotiated procedures and competitive dialogue, procurers may unintentionally deviate from procurement law, thereby evoking review procedures. Besides this, a greater leeway in designing the procurement process is generally associated with higher workloads for procurers. Cf. Falck and Wiederhold (2013: p. 33).

296 Cf. Falck and Wiederhold (2013: p. 56).

297 Cf. Falck and Wiederhold (2013: p. 58f.).

298 Cf. Falck and Wiederhold (2013: p. 58).

299 Cf. Falck and Wiederhold (2013: p. 68ff.).

300 Cf. Edler (2006: p. 143).

301 Cf. Falck and Wiederhold (2013: p. 78).

302 Public procurement initiatives have been an explicit component of innovation policy since the implementation of the *National Medium- and Long-term Program for Science and Technology Development* (MLP 2006–2020). Cf. Falck and Wiederhold (2013: p. 83).

303 For a product to be labelled as domestic, it has to be attributable to a Chinese company. Furthermore, all of the intellectual property rights for the product have to be held by Chinese parties. Cf. Falck and Wiederhold (2013: p. 93) and US-China Business Council (2011): China's Domestic Innovation and Governmental Procurement Policy. https://www.uschina.org/public/documents/2011/02/innovation_procurement_steps.pdf (last accessed on 11 January 2013).

304 Cf. Falck and Wiederhold (2013: p. 93).

305 Cf. Falck and Wiederhold (2013: p. 104).

306 While all states assert certain restrictions or exceptions to the GPA guidelines, the scope of such exceptions differs. The EU has opened more than 80 percent of its procurement market, yet other industrialised countries have opened only 20 percent of their procurement markets Cf. Opinion of the European Economic and Social Committee (2011).

307 Cf. Ahrens (2010) and Li (2011: p. 18).

308 Cf. Falck and Wiederhold (2013: p. 104).

309 WTO GPA: the Governmental Procurement Agreement (GPA) of the World Trade Organization (WTO) stipulates that public procurement procedures must be based on the awarding principles of openness, non-discrimination and transparency. Cf. WTO (2012).

310 Cf. Wegweiser et al. (2009: p. 27).

311 § 97, Section 4 of the Act against Restraints of Competition (GWB).

312 Cf. Crasemann (2012: p. 6).

313 Cf. Crasemann (2012: p. 6).

314 Cf. Falck and Wiederhold (2013: p. 29).

315 Interestingly, this cautious stance in relation to innovation cannot be applied to all of the criteria formerly deemed as "extraneous aspects". A survey among procurement officers at national level shows that environmental and social factors have become increasingly important in public procurement. The consideration of environmentally friendly components along the production and supply chain, or compliance with minimum wage standards as award criteria shows that sustainability has

already become part of the political agenda of procurement. Cf. Wegweiser et al. (2009: p. 4 and p. 54).

316 Cf. Falck and Wiederhold (2013: p. 38).

317 Public servants are more risk-averse than private sector employees. Cf. Buurman et al. (2009). Moreover, incentive systems in public authorities do not stimulate risk-seeking decision-making: achievements are not rewarded, whereas failure is indeed penalised.

318 Cf. Falck and Wiederhold (2013: p. 27f.).

319 In the event of an actual or alleged procedural error – at least for above-threshold contracts – unsuccessful bidders have the right to appeal against the decision and to seek to rescind the contract as a whole. Thus, too many public procurement agents, the procurement of conventional products appears more attractive as it prevents procedural errors from the outset; errors that would be detected in the course of review procedures.

320 Cf. Crasemann (2012: p. 6).

321 European Commission (2011): Horizon 2020 – *The Framework Programme for Research and Innovation* http://ec.europa.eu/research/horizon2020/pdf/proposals/communication_from_the_commission_-_horizon_2020_-_the_framework_programme_for_research_and_innovation.pdf#view=fit&pagemode=none (last accessed on 11 January 2013).

322 Cf. Crasemann (2013: p. 30) and BMWi (no year).

323 The European Commission's 2007 Communication (No 799) regarding Pre-Commercial Procurement (PCP) provides the basis for the PCP procedure. Cf. Crasemann (2012: p. 26).

324 Cf. Europäische Kommission (2007a).

325 Cf. Falck and Wiederhold (2013: p. 87).

326 Cf. Crasemann (2012: p. 21). Regarding WTO GPA, see B 3–2.

327 Further countries include: Denmark, Italy, Austria, Poland, the Czech Republic and Hungary. Cf. Falck and Wiederhold (2013: p. 88).

328 Cf. Falck and Wiederhold (2013: p. 88f.).

329 Cf. Crasemann (2012: p. 31).

330 Cf. Falck and Wiederhold (2013: p. 90).

331 This initiative has helped establish networks in the following areas: sustainable construction, protective textiles for fire services, and sustainable procurement in the health service. Yet these networks have been focussing their activities mainly on the procurement of existing technologies. Non-commercialised solutions, which would have required prior R&D activities, were not in demand. Pre-Commercial Procurement Procedures (PCP) were not employed either Cf. EU (2011: p. 153ff.).

332 The Innovation Union strategy is one of seven flagship initiatives of the Europe 2020 Strategy. The Innovation Union includes more than 30 action points, one of them being the European Innovation Partnership (EIP). This partnership between the EU and national governments aims to accelerate the development and market launch of new technologies. To accomplish this goal, both demand and supply-oriented support measures are being applied. Cf. Caloghirou et al. (2012).

333 Cf. Rigby et al. (2012).

334 Cf. Crasemann (2012: p. 30).

335 Cf. BME (2012).

336 BMWi (2011b: p. 4).

337 This year's Alliance report (Allianz für eine nachhaltige Beschaffung) does not make any suggestions for improving the data situation in the area of innovation-oriented procurement. BMWi (2012b).

338 Cf. Tsai et al. (2010).

339 Cf. EFI (2012: Chapter B 2).

340 Cf. EFI (2012: p. 74)

341 Cf. Eurostat, Share of women researchers 2010, http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&init=1&language=en&pcode=tsc00005&plugin=1 (last accessed on 11 January 2013).

342 However, in the natural sciences, Germany scores higher in international comparison and now even exceeds the EU average, which is attributable to a high number of female students in teaching degree courses.

343 Cf. Lörz et al. (2012: p. 46).

344 Cf. Bos et al. (2008).

345 Cf. Leszczensky et al. (2013: p. 86).

346 Cf. Prenzel et al. (2007).

347 With respect to Germany, several studies confirm this correlation, especially with regard to boys (cf. Prenzel et al. 2007 or Spangenberg et al. 2011). Yet, there is also evidence that girls with fathers in engineering professions have higher chances of studying a STEM subject (cf. GWK 2012 or Steward 2003).

348 It is important here to utilise the high potential of engineers of the parent generation in Germany. With 35 engineers per 1,000 workers, Germany ranks behind countries such as Finland (62 engineers per 1,000 workers) and Sweden (44 engineers per 1,000 workers), but ahead of Denmark (34 engineers per 1,000 workers), the UK (30 engineers per 1,000 workers), France (24 engineers per 1,000 workers) and Norway (16 engineers per 1,000 workers). Cf. VDI (2012).

349 Cf. Lörz and Schindler (2011).

350 Cf. OECD (2012b: p. 75).

351 With 40 percent each, Iceland and Greece have been recording the highest proportion of female graduates from engineering degree courses. (Cf. Leszczensky et al. 2013: p. 83).

352 The overall proportion of newly enrolled female students amounted to 46.7 percent in 2011 (Cf. Leszczensky et al. 2013: p. 78).

353 Cf. Leszczensky et al. (2013: p. 79).

354 This hypothesis is supported by empirical findings e.g. in mathematics, where a particularly high proportion of female students graduate from teaching degree courses. In 2011, teaching degree courses accounted for 40 percent of mathematics degree courses, which largely explains the doubling of the number of female graduates since 2005 (cf. Leszczensky et al 2013: p. 50). In biology, the proportion of female graduates from teaching degree courses is also very high (77 percent in 2010), albeit the total number of teachers trained is lower, suggesting that the effect on the proportion of newly enrolled students should be less pronounced here. Particularly low proportions of female first-year students have been recorded in informatics (18.9 percent) and physics (18.6 percent) (cf. Leszczensky et al 2013: p. 80), which corresponds with relatively small proportions of students following teaching degree courses. In physics for instance, the proportion of students graduating from teaching degrees is only 5 percent (cf. Leszczensky et al. 2013).

355 Studies from the United States have shown that differences in the proportion of women across various engineering disciplines significantly contribute to the fact that female engineers patent significantly less frequently than male engineers, as they are under-represented in patent-intensive fields in particular (cf. Hunt et al. 2013).

356 Overall, dropout rates in engineering sciences at universities are relatively high, amounting to 48 percent in Bachelor degree courses and 29 percent in *Diplom* degree courses. Yet, female students are doing considerably better than their male counterparts, both in *Diplom* degree courses (only 16 percent, as compared to 32 percent) and Bachelor degree courses (42 percent as compared with 49 percent). The same applies largely to universities of applied sciences, where dropout rates are also significantly lower among female students (cf. Leszczensky et al 2013: p. 87).

357 Cf. Lörz et al. (2011).

358 Cf. Leszczensky et al. (2013: p. 76f.).

359 The category of family work solely comprises individuals who are economically inactive, i.e. it does not include individuals in part-time employment.

360 Non-overlapping classificaion; family work solely refers to individuals who are parents and are not economically active or enrolled in further training.

361 Cf. von der Leyen (2011), EFI (2012).

362 Cf. thematic factsheets from the German Federal Government's First Report on Gender Equality, Factsheet V *Erwerbsunterbrechungen,* http://www.fraunhofer.de/content/dam/zv/de/ueber-fraunhofer/Gesch%C3%A4ftsstelle%20Gleichstellung/Gleichstellungsbericht_Factsheets_2011-11-02.pdf (last accessed on 11 January 2013).

363 Cf. Leszczensky et al. (2013: p. 94).

364 Cf. Eurostat, Full-time and part-time employment by sex, age and highest level of education attained, http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=lfsq_epgaed&lang=en (last accessed on 11 January 2013).

365 2010 values. Cf. http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&init=1&language=en&pcode=tsdde220&plugin=1 (last accessed on 11 January 2013).

366 Non-overlapping classification; family work solely refers to individuals who are parents and are not economically active or enrolled in further training.

367 In the school year 2011/2012, 39 percent of all professional teachers (teaching was main occupation) at general-education schools were employed on a part-time basis. Cf. Statistisches Bundesamt https://www.destatis.de/DE/ZahlenFakten/GesellschaftStaat/BildungForschungKultur/Schulen/Tabellen/AllgemeinBildendeBeruflicheSchulenLehrkraefte.html (last accessed on 11 January 2013).

368 The Toto-Lotto Niedersachsen GmbH, for instance, has launched the "Childminder on Demand" programme, a contractually bound cooperation between the company and two childminders in close proximity. The programme aims to make it easier for parents to return to work. Cf. http://www.erfolgsfaktor-familie.de/data/downloads/webseiten/080319_Handout_toto-lotto_layout.pdf (last accessed on 11 January 2013).

369 Cf. http://www.erfolgsfaktor-familie.de/default.asp?id=641&pid=291 (last accessed on 11 January 2013).

370 Cf. http://www.erfolgsfaktor-familie.de/default.asp?id=641&pid=413 (last accessed on 11 January 2013).

371 The opposite effect is achieved through childcare benefits, as has been clearly demonstrated by examples in Norway and Finland. After the introduction of childcare benefits, both countries recorded a decrease in the number of infants being cared for by publicly funded childcare facilities or childminders, and there is also evidence of a decline in the labour force participation of (child-minding) mothers: after the introduction of childcare benefits, Norway and Finland recorded a decrease in the participation rate of mothers by 4 to 8 percentage points. Ex-ante simulations suggest comparable effects in Germany. Statistical simulations on the effect of childcare benefits suggest moderate but significant negative effects on the labour supply of mothers and the demand for external childcare. Particularly mothers in part-time employment are more likely to withdraw from the labour market altogether. It is estimated that one out of two mothers working in a part-time position prior to the introduction of childcare benefits would completely withdraw from the labour market. Beyond this, great social structural differences in the use of childcare benefits are revealed: the vast majority of recipients are especially mothers with low qualifications, low incomes and from immigrant backgrounds (cf. Beninger et al. 2009, Ellingsæter 2012).

372 Figures from 2007. Cf. Duvander et al. (2010: p. 46).

373 Cf. OECD Family Database. LMF2.4: Family-Friendly Workplace Practices. http://www.oecd.org/social/familiesandchildren/43199600.pdf (last accessed on11 January 2013).

374 Cf. OECD Family Database. LMF1.2: Maternal employment rates. http://www.oecd.org/social/familiesandchildren/38752721.pdf (last accessed on 11 January 2013).

375 Cf. OECD Family Database. LMF1.2: Maternal employment rates. http://www.oecd.org/social/familiesandchildren/38752721.pdf (last accessed on11 January 2013).

376 Cf. http://www.erfolgsfaktor-familie.de/default.asp?id=348&pid=641 (last accessed on 11 January 2013).

377 Figures for the year 2007. Cf. European Commission (2009: p. 76).

378 Cf. Moss-Racusin et al. (2012).

379 Cf. Europäische Kommission (2012c).

380 Cf. http://ec.europa.eu/justice/newsroom/gender-equality/news/121114_en.htm (last accessed on 11 January 2013).

381 In 2003, Norway adopted a new law that established a 40 percent quota for women in supervisory boards. While the share of female board members was 9 percent in 2003, the share rapidly increased in the course of the following decade. However, based on a detailed empirical analysis, Ahern and Dittmar (2012) have pointed out that, as a side effect of the new quota, board members were on average younger and less experienced, which resulted in negative economic effects for companies. Detailed empirical evidence on the effects of the quota in Norway has also been provided by Matsa and Miller (2013), as well as Nygaard (2011).

382 Cf. McKinsey (2012).

383 Cf. Leszczensky et al. (2013).

384 The educational levels according to ISCED can be regarded as the UNESCO standard for international comparisons of country-specific education systems. The OECD also adopts the ISCED classification system.

Based on the ISCED system, education (in Germany) can be divided into the following education levels:

ISCED 0 Pre-primary education

– Nursery school

ISCED 1 Primary education

– Primary school

ISCED 2 Lower secondary education

– *Hauptschule, Realschule, Gymnasium* (grade 5 to grade 10)

ISCED 3 Upper secondary education

– Qualification to study at a university or university of applied sciences *(Fachhochschulreife/Hochschulreife)*; without formal vocational qualification or completion of an apprenticeship.

– Qualification to practise an occupation, earned at a vocational school *(Berufsfachschule or Kollegschule)*.

– Graduation from a one-year school in the health care sector.

ISCED 4 Post-secondary non-tertiary education

– Qualification to study at a university or university of applied sciences *(Fachhochschulreife/Hochschulreife)* plus completion of an apprenticeship.

– *Fachhochschulreife/Hochschulreife* plus qualification to practise an occupation, earned at a vocational school *(Berufsfachschule or Kollegschule)*.

– Graduation from a one-year school in the health care sector.

ISCED 5B First stage of tertiary education B

– Master craftsman/tradesman or technician training *(Meister/Techniker)* or equivalent degree from an advanced trade and technical school *(Fachschule)*.

– Graduation from a two-year or three-year school in the health care sector.

– Graduation from a specialised academy *(Fachakademie)* or a college of advanced vocational studies *(Berufsakademie)*.

– Graduation from a public administration university of applied sciences *(Verwaltungsfachhochschule)*.

– Graduation from a university of applied sciences of the former GDR *(Fachschule)*.

ISCED 5A First stage of tertiary education A

– Degree from a university of applied sciences *(Fachhochschule),* including a degree from a school of engineering, a Bachelor's or Master's degree from a university of applied sciences, excluding final qualification earned at a public administration university of applied sciences.

– Degree from a tertiary education institution (*Diplom* certificate, university) and respective final examinations).

ISCED 6 Completion of doctoral degree.

Cf. Müller (2009: 43), OECD (2011c: p. 31).

385 Cf. Gehrke, Schasse et al. (2013).

386 The Mannheim Innovation Panel (MIP) surveys the innovation activities of legally independent enterprises with five or more employees in industry and selected services sectors. The MIP constitutes the German contribution to the European Commission's Community Innovation Survey (CIS). In the course of adopting the most recent economic sector classification scheme (WZ 2008; Cf. Statistisches Bundesamt 2008), the MIP survey wave of 2009 was adjusted in several respects. Furthermore, 2009 was also the first year in which the business register of the statistical offices could be used as the basis of extrapolation. Both factors have led to a revision of data leading back to the reporting period of 2006, as well as a break in the time series between 2005 and 2006. Cf. in the following Rammer and Hünermund (2013).

387 According to the definition provided by the OECD's Frascati Manual (2002), research and development comprises creative work undertaken on a systematic basis in order to increase the stock of knowledge; including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications. According to the Frascati Manual, the term R&D covers three activities: basic research, applied research, and experimental development.

388 The European BACH database (Bank for the Accounts of Companies Harmonised) is hosted at the *Banque de France*. The database allows for determining the equity ratios of non-financial enterprises for a number of European countries. Cf. http://www.bachesd.banque-france.fr/?lang=en (last accessed on 11 January 2013).

389 Cf. EVCA (2012).

390 Cf. Blind (2002).

391 Data are based on non-representative samples that are confined to public limited companies. Samples are identical only in two successive years *(two-year sliding samples)*.

392 The Mannheim Enterprise Panel (MUP), which also includes the former ZEW Start-up Panel, is a ZEW panel data set of businesses located in Germany. It is maintained in cooperation with Creditreform, the largest credit information bureau in Germany. The term enterprise, as employed by the MUP, refers to economically active enterprises only, while the term start-up refers to original newly formed companies only. This is the case provided that economic activities are taken up that have not been previously carried out, and provided the activities are the main source of income of at least one person. The closure of a company occurs when a company is not economically active anymore and ceases to offer products on the market. Sectoral evaluations on business dynamics were conducted on the basis of the new economic sector classification scheme (WZ 2008, cf. Statistisches Bundesamt 2008). The procedure for documenting company closures is continuously being developed. Due to this, values relating to closures and values relating to the stock of companies have been revised retrospectively back to 1995. The classification of R&D-intensive industries is based on the revised list of research-intensive sectors (cf. Gehrke et al. 2010). Cf. in the following, Müller et al. (2013).

393 The GEM is a project that has been running since the late 1990s. In 2011, the GEM compared entrepreneurial activities in 55 countries regarding their scope, development, framework conditions and motives. The GEM surveys are based on data from interviews with a representative sample of citizens and experts. Cf. in the following, Brixy et al. (2012).

394 Cf. Brixy et al. (2012: p. 13ff.).

395 A patent family is a group of patents or patent applications that are directly or indirectly linked via a priority, that have at least one common priority, exactly the same priority or a combination of priorities. Cf. http://www.epo.org/searching/essentials/patent-families/definitions.html (last accessed on 11 January 2013).

396 The Patent Cooperation Treaty (PCT) is a contract between more than 140 countries regarding international cooperation in the field of patents. It is administered by the World Intellectual Property Organization (WIPO). Inventors from PCT contracting states can file for patent protection in various countries at the same time. For this purpose, the inventor files a single patent application with the WIPO's International Bureau or another approved office (e.g. the German Patent Office or European Patent Office) instead of filing several individual national or regional applications. The granting

of patents in the true sense remains in the area of responsibility of the national or regional patent offices. Cf. http://www.wipo.int/export/sites/www/pct/en/texts/pdf/pct.pdf (last accessed on 11 January 2013).

397 Cf. Neuhäusler et al. (2013: p. 5).

398 Cf. Neuhäusler et al. (2013).

399 On the financial crisis's effects on patent applications, cf. Frietsch et al. (2011).

400 Cf. Legler and Frietsch (2007).

401 Cf. e.g. Corrado et al. (2007).

402 Cf. Michels et al. (2013).

403 Although this indicator accounts for the continuous expansion of the database, it disregards the relative size of the countries and the size of their respective science and research systems.

404 Cf. Cordes et al. (2013).

405 Cf. Gehrke et al. (2010).

406 Cf. BMWi (2009).

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Published by
Commission of Experts for Research
and Innovation (EFI), Berlin

Translation
Michael O'Sullivan, Ingrun Wenge, Berlin

Cite as
Commission of Experts for Research and Innovation (EFI)
(ed.) (2013): Research, innovation and technological
performance in Germany – EFI Report 2013, EFI, Berlin.

Design
Kognito Gestaltung, Berlin

Production
Buch- und Offsetdruckerei H. Heenemann
GmbH & Co. KG, Berlin

ISBN 978-3-00-041794-8

Editorial deadline: 11 January 2013

ISBN 978-3-00-041794-8