RESEARCH, INNOVATION
AND TECHNOLOGICAL
PERFORMANCE IN GERMANY

EXPERTENKOMMISSION
FORSCHUNG
UND INNOVATION

EFI

REPORT

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

ISBN 978-3-00-038185-0

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We wish to thank
Dr. Hendrik Brandis, Prof. Dr. Hans-Jörg Bullinger, Dr. Sigurd Dahrendorf, Prof. Dr. Karl Max Einhäupl, Dr. Christiane Gaehtgens, Prof. Dr.-Ing. Peter Gutzmer, Dörte Höppner, Prof. Dr. Matthias Kleiner, Gerd Koslowsky, Dr. Thomas Pattloch, Dr. Christian Rammer, Dr. Jürgen Steiger, Dr. Michael Stückradt, Prof. Dr. Ulrike Tagscherer and Prof. Dr. Margret Wintermantel, all of whom contributed expertise to the report. In addition, we wish to thank all those persons who helped prepare the studies on the German innovation system.

In September 2011, the Expert Commission travelled to Shanghai, Changzhou and Beijing in preparation of the 2012 annual report. We would like to thank all those persons we spoke to: Christoph Angerbauer, Kang Bingjian, Prof. Gao Changlin, John C. Chiang, Ph.D., Prof. Bai Chunli, Ph.D., Martin Daffner, Dr. Wen Danyi, Jeffrey Fan, Prof. Dr. Sun Fengchung, Ruan Gao Feng, Prof. Zhao Gang, Ph.D., Jifan Gao, Song Gelong, Dr. Jari Grosse-Ruyken, Christian Hochfeld, Dr. Jennifer Hu, John Q. Huang, Ph.D., Prof. Dr. Huo Jiazhen, Dr. Zhang Jie, Prof. Dr.-Ing. Zhang Jun, Prof. Dr. Zhang Junzhi, Holly Lei, Dr. Ma Lian, Yu Liang, Ph.D., Shih-Ping Liou, Ph.D., Dr. Ulrich Liman, Jeff Lindsay, Dr. Oliver Lutze, Sandra Retzer, Prof. Dr. Mu Rongping, Dr. Klaus Schäfer, Dr. Sylvia Schwaag Serger, Zhao Shaoqin, Prof. Chen Song, Qu Wan, Ph.D., Dr. Julian Weber, Wang Wenwei, Ph.D., Jörg Wuttke, Liu Xiang, Colin Yang, Ying Ying, Ph.D., Fan Yonggang, Ph.D., Meng Yuhuan and Prof. Dr. Max von Zedtwitz.
The Expert Commission would like to thank Shen Lei and Christine Müller for their support in organising the visit to China.

The Expert Commission wishes to emphasise that the positions expressed in the report do not necessarily represent the opinions 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 Commission of Experts – and of the staff of the individual Commission members.

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FOREWORD

In their Annual Report 2012, the Commission of Experts for Research and Innovation once again addresses current developments in Germany and presents detailed analyses of core topics relating to research and innovation policies.

Although Germany fell short of the three-percent target, the country's research and development (R&D) intensity has systematically increased over the last years. Yet, in the long term, the Federal Government should aim at thinking beyond the three-percent target. For the year 2020, it should strive for more ambitious goals than it has previously. On a European scale, a considerable gap in productivity can be observed. The present crisis of the European Union (EU) provides a perfect illustration of this fact. In collaboration with its European partners, the Federal Government should be committed to strengthen the innovative power of the entire European region. At the same time, the attractiveness of Germany as an R&D location should be further improved. R&D tax credits are, and will continue to be, a useful measure for achieving this. The Energy Transition that was launched by the Federal Government in the early summer of 2011 poses new challenges to Germany, but it also offers interesting economic perspectives. Yet, at this point in time the Expert Commission can only see reserved reactions within the German research system.

In this report, the Expert Commission further presents an in-depth discussion of the following five core topics: in Chapter B1, the role of university-based research within the German innovation system is analysed. In Chapter B2, Germany's future skills shortage, an issue that is becoming ever more pressing, is discussed, and measures to tackle the issue are presented. The Annual Report 2012 also addresses conditions of growth and constraints on growth for start-up businesses (Chapter B3) and points to the necessity to improve framework conditions for new enterprises. In Chapter B4, the Expert Commission addresses the need for progress in terms of documenting and assessing the impact of public R&D funding: a suitable data infrastructure is needed that will provide policy-makers in the field of research and innovation (R&I) with more precise information on the results of their measures. In the Annual Report 2012, special attention is paid to China's sustained efforts to become one of the world's leading locations for innovation within the course of this decade. While China's ambition gives rise to major challenges for Germany's research and development system, it also creates interesting opportunities for scientific-technical collaboration (Chapter B5).

The Federal Government should continue to attach particularly high priority to introducing tax credits for R&D, improved framework conditions for business angels and venture capital, and a systematic approach to improving the German education and research system. Measures to overcome the emerging skills shortage should be adopted now as only immediate action will make it possible to prevent adverse developments within the German economy. The Federal Government's financial and economic policies are characterised by the current critical developments in Europe. While these require special attention, the Commission of Experts for Research and Innovation still emphasises the urgent need for action in the field of R&I policies. These should not be neglected when dealing with the larger European issue. Germany can only maintain its economic strength if it manages to achieve continuous progress regarding the research and innovation location of Germany.

Berlin, 29 February 2012

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SUMMARY

SUMMARY

CURRENT DEVELOPMENTS AND CHALLENGES

A 1 RESEARCH AND DEVELOPMENT – THINKING BEYOND THE THREE-PERCENT TARGET

Germany's research and development (R&D) intensity, i.e. the proportion of R&D expenditures of the gross domestic product (GDP), amounted to 2.82 percent in 2010. This is a solid interim result on the way to the three-percent target specified by the European Council in Barcelona, even though Germany failed to reach the target by EUR 4.7 billion. Yet, other leading economies and innovation countries have long exceeded the three-percent target. In the future, Germany should orient itself towards the R&D intensity of these global leaders and not focus on the three-percent target alone. On a global scale, Germany can only reach or maintain a competitive edge if the German innovation system continually generates new knowledge and flexibly adopts fresh impetus while transforming it into innovation on the market. With regard to research and innovation policies, it makes sense to refer to the national R&D intensity as an orientation mark. In the view of the Expert Commission, this is not a perfect means of measuring an economy's knowledge intensity, it is however a useful means.

A 2 ENHANCING INNOVATION AND PRODUCTIVITY IN ALL EU MEMBER STATES

On average, EU member states are less productive and considerably more heterogeneous than the US states – in spite of extensive use of resources from EU Structural Funds. While the Scandinavian countries are at the higher end of the productivity scale and surpass the three-percent target, the R&D intensity of the less productive Southern European countries amounts to less than half of this value. The main reason for this is the low level of private sector investment in R&D. Considering the heterogeneous nature of the EU member states it seems that a universally applicable three-percent target does not lead to the desired results. Instead, those countries that fall behind should specify targets that can be duly implemented and measured within the framework of a national innovation strategy. In addition to that, these countries should expand the differentiation of their educational systems, strengthen collaboration between research organisations and businesses, develop more efficient administrative structures and improve institutional framework conditions. These measures would improve their competitiveness and attract foreign investment. The targeted use of EU Structural Funds should be reviewed on a regular basis.

CONTINUALLY IMPROVING THE ATTRACTIVENESS OF GERMANY AS AN R&D LOCATION

A 3

Germany has developed successful modernisation strategies for the manufacturing sector. At the same time, the country exhibits deficits in cutting-edge technologies, a field that is becoming increasingly relevant on an international scale. In fact Germany is currently caught in a difficult position between emerging countries and classical cutting-edge technology producers. In the context of an ongoing globalisation process in the field of R&D, attractive framework conditions for R&D are becoming ever more important – not only as an incentive for R&D investments, but also as a means of preventing a brain drain. In the past, foreign businesses have been making significant R&D investments in Germany. Yet, Germany as a location for research and innovation should be strengthened by further improving framework conditions for research and innovation. R&D tax credits, as has been strongly recommended in the previous reports, will have to be implemented as soon as possible. Furthermore, it should be ensured that research activities conducted abroad by publicly funded research bodies create a suitable backflow of knowledge.

THE ENERGY TRANSITION AS AN INNOVATION OPPORTUNITY

A 4

Germany's *Energiewende* (Energy Transition), which was adopted in the early summer of 2011, does not only provide for nuclear phase-out but also for a reduction in the use of fossil fuels and a reinforced expansion of renewable energy sources. This Energy Transition offers interesting economic perspectives for a high-tech location such as Germany, as the world market currently offers excellent opportunities for German businesses to position themselves in the field of sustainable power supply technologies. In order to transform this potential into real innovation leadership, all the stakeholders involved will have to commit themselves to take co-ordinated action. The Expert Commission has identified a quick response to the Energy Transition in some parts of the non-university research system. The Federal Ministries are now obligated to provide an allocation of funding for energy research that is transparent and systematically adapts to the challenges ahead. The main task for the years to come will be to considerably enhance co-ordination between energy, environmental and innovation policies. This will help to make the most of the positive effects derived from the Energy Transition, while at the same time avoiding welfare losses.

CORE TOPICS

B 1 UNIVERSITY-BASED RESEARCH

Universities and universities of applies sciences are an important pillar of the German R&I system. Over the last years, the introduction of numerous reforms and new programmes has created major challenges for German higher education institutions – not least since these challenges had to be faced against the background of dwindling funds. An upward trend can only be observed since 2006, and this is largely caused by a significant increase in third-party funding.

The Excellence Initiative by the German federal and state governments to promote top-level research at German universities has intensified a differentiation process in the German academic landscape: not only did the funded universities improve their international visibility, but the Excellence Initiative also provoked and enhanced a thematic differentiation within the higher education sector.
In spite of various positive developments, e.g. in terms of university autonomy and remuneration law, the Expert Commission still sees considerable need for action:

- The Expert Commission emphasises the necessity to correct the reform of the federal system (Federalism Reform I): the Federal Government should be allowed to fund universities institutionally, i.e. as organisations. This would require amendments to Article 91b of the Basic Law.
- The provisions of the "Freedom of Science Act" initiative should also be extended to universities and universities of applies sciences, so as to strengthen their autonomy. This should be conducted in close collaboration with the federal states *(Länder)*. By extending the initiative to the higher education sector, universities and universities of applied sciences would also establish an important prerequisite for advancing horizontal and vertical differentiation within the academic system.
- Although the availability of third-party funding has led to positive results, the Expert Commission sees an imbalance in the current funding structure of universities. Basic funding of universities should be increased, and financing by foundations should be further facilitated through German legislation.
- Higher education institutions have an obligation to make use of their autonomy and financial scope. The professionalisation of universities and the reduction of administrative activities carried out by academic staff in favour of research should be advanced.
- In Germany, it is difficult to plan a career in public research, particularly in university-based research. To complement existing junior professorships, tenure track models should be applied to a larger extent. In order to create opportunities for young academics, the number of W2 and W3 professorships should be increased.
- Basic research at universities should not be streamlined to the demands of application-related usage. Yet, whenever application possibilities occur, these should be consistently promoted on the part of the university.
- Important research initiatives and academic bodies that have been launched within the framework of the Excellence Initiative should be pursued so as to ensure the success of the measures in the long term. To achieve this, a suitable policy approach is required. New types of collaboration between universities and non-university research institutions should be continually examined. In the event that institutional funding of universities by the Federal Government will be reintroduced, serious consideration should also be given to the idea of establishing federal universities.

SKILL SHORTAGES AND INNOVATION

Germany is facing major challenges as a result of demographic change and the economy's ever-increasing orientation towards knowledge intensity. These two factors are profoundly changing the economy's skill requirements and lead to structural changes in the labour market. Skill shortages in growth-oriented occupations must be expected along with an oversupply in other occupations. At the same time, guaranteeing a sufficiently qualified workforce that matches the economy's skill requirements is a necessary prerequisite to protect Germany's innovative power and competitiveness in the long term. Challenges are large and need to be tackled quickly and energetically. There are several policy areas that will help to solve the problems: Education and training to adjust the skill structure of the workforce, company-internal measures for retaining older employees' valuable skills, measures to increase the participation of the non-working but highly skilled (mostly female) employment population, and immigration policies that take account of the extensive reserves of skills available internationally. The Expert Commission thus offers the following recommendations to the relevant stakeholders:

- Germany's education policies must increasingly be oriented towards enhancing vertical and horizontal permeability in the educational system.
- Germany's vocational education and training system needs to be strengthened as youth cohorts are expected to decrease substantially over the coming years. To increase the attractiveness of the vocational education and training system, vertical mobility also has to be improved. The latter requires that higher education institutions sharpen their profiles and that some of them put more emphasis on improving vertical mobility options.
- Higher education institutions should in the future highlight more clearly their individual comparative advantages and position themselves based on individually defined "roles and missions". Horizontal differentiation will become more and more important. A broad spectrum of options is available, and universities have to adjust these options to the different funding opportunities available.
- Educational policy-makers should support the development and implementation of bold new profiles by providing suitable financial incentives and regulatory clauses allowing for experimentation.
- In addition, all stakeholders in the educational system and the labour market must seek to improve the attractiveness of study programmes that are ultimately conducive to innovation and economic growth – engineering sciences in particular. Special efforts should be made to increase female participation in the respective degree programmes. Higher education institutions have to make their study programmes more attractive for female students, and companies have to adjust their workplace structures and working time conditions to make them more attractive for female graduates.
- The continuing vocational education and training system needs to be further developed with a focus on increasing the participation of groups that have always been underrepresented in the past.
- In the labour market, efforts have to be intensified to enhance integration of foreign employees on all qualification levels. The Expert Commission welcomes the improvements enacted in immigration regulations for well-qualified foreigners and for foreigners in the education and training system. Particular focus should also be given to attract the best foreign graduates for the German labour market. Such activities must be flanked by measures aimed at fostering public awareness of the need for immigration and at promoting public support for the integration of foreigners.

- Concerted efforts must be taken to make better use of the non- or underemployed but highly skilled female employment population. Women must be given a clearer message that they are needed and welcome in the workplace even with children. And men must be given a clearer message that they have to take on more responsibility in raising children and doing housework. Institutional regulations that provide incentives for women to work only part-time or not to work at all have a detrimental effect on Germany's innovative strength. These include e.g. the tax regulation that provides for splitting income taxation between married couples, which creates a disincentive to work mostly for females, and social benefits such as the planned childcare supplement for parents staying at home.

B 3 CONDITIONS FOR GROWTH AND CONSTRAINTS ON GROWTH FOR START-UP BUSINESSES

The number of business start-ups in Germany is relatively low by international standards. This is also true for start-ups in knowledge-based fields of business. Overall, many young businesses in Germany are not sufficiently funded. Often enough, attempts to financially restructure young businesses that have a workable business model but are facing temporary liquidity problems caused by external factors are not successful. Therefore the Expert Commission recommends the following:

- The legal form of a European limited liability company should be introduced as soon as possible. This would enable companies from all member states to act within the same legal framework regarding the launch and the operation of a business. This would considerably decrease the administrative effort of setting up an international business.
- German insolvency law should have a stronger focus on restructuring and maintaining businesses.
- The current legal uncertainty regarding the classification of the activities of venture capital companies must come to an end. A binding legal framework should be established that would define venture capital companies as asset management companies.
- Tax incentives to promote private investments in venture capital funds should be introduced.
- The restrictive treatment of carried-over losses should be abolished so as to increase the willingness of venture capital providers to invest in German technology-based business start-ups.
- The recent suggestion of the European Commission to introduce a regulation that would provide Europe-wide specifications for marketing risk capital funds would give German policy-makers the opportunity to restructure the framework conditions for venture capital. After ten years of hesitation and failures in this policy area, consistent action is now required.

ECONOMIC ASSESSMENT OF PUBLIC R&D FUNDING

B 4

Long-term growth and a sustainable increase in productivity can only be achieved through a high level of R&D investment. Over the last ten years, many countries have been employing specific state support measures to achieve a particularly expansive R&D dynamic in their economy. In Germany however, the largest part of public R&D funds is still being allocated to public research, while the proportion of government funds for privately implemented R&D activities remains comparatively low.

One method of public R&D funding that is employed by the majority of OECD and EU member states consists in R&D tax credits. Various evaluation studies have confirmed that R&D tax credits result in an increase in private R&D expenditures. Yet Germany has not made use of this method of funding to date. Scarce public resources should be used effectively and efficiently. Since innovation research is still lacking a systematic impact analysis, the question arises of how public funding measures can be monitored effectively. Thus the Expert Commission recommends the following:

- It is time for the government to introduce R&D tax credits, a measure that is long overdue. R&D tax credits will facilitate R&D projects for small and medium-sized businesses and further improve the international attractiveness of Germany as an R&D location.
- Funding measures in the field of R&I should be generally evaluated according to academic standards. A reliable, coherent data infrastructure for documenting the impact of public research should be introduced and advanced as soon as possible.

THE CHALLENGE OF CHINA

B 5

Over a period of a few years, China has risen to become one of the world's major economies and scientific locations. The Chinese government is pursuing an offensive innovation strategy that aims at turning China into one of the world's leading innovation locations before the year 2020. The rise of China poses major challenges to the economic and research system of Germany. Due to state-controlled influence on businesses and research organisations in particular, China is conquering more and more fields of expertise that have always been highly relevant to Germany. Among other things, the situation is aggravated by the fact that the Chinese government makes market access of foreign businesses dependent on their readiness to relocate their manufacturing and R&D activities to China. At the same time, foreign businesses are subjected to disadvantages due to the weak Chinese patent jurisdiction and the existing practice of standard setting. Based on this, the Chinese government has managed to significantly decrease the country's technological deficit. Yet, in order to reach a more balanced collaboration, framework conditions should be reorganised so as to be more reliable and beneficial for China and Germany alike.

Against this background, the Expert Commission recommends the following:

- A decisive factor for advancing the Chinese innovation system and the quality of collaboration between China and its foreign partners lies in the development of the Chinese patent system and a functioning system for the protection of intellectual property.

The Federal Government should monitor China's progress in the field of intellectual property and report on their findings on a regular basis.
- The Expert Commission considers the development of norms and standards an important starting point for advancing innovative projects in both countries on equal terms.
- The Federal Chancellery, the heads of the respective Federal Ministries and the academic bodies, as well as the Federal Government's advisory committees should, on a regular basis, announce co-ordinated strategies for suitably dealing with the challenge of China.
- When training future management personnel in the field of engineering, natural sciences, law and economics, more attention should be paid to building up expert knowledge on Asia – and China in particular – at an early stage.
- The Expert Commission recommends strengthening the co-ordination of the foreign science policy with regard to China in order to improve visibility of German research organisations. However, too generous a transfer of academic results into application-oriented areas should be avoided.
- In the view of the Expert Commission, China, and not Germany, is emerging as a leading market in the field of electromobility. Germany still has the chance to establish itself as a major technology provider in this market. In order to achieve this, it is crucial to develop a co-ordinated strategy between German industry, government bodies and research organisations, e.g. by means of the National Platform for Electromobility.

CURRENT DEVELOPMENTS AND CHALLENGES

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A CURRENT DEVELOPMENTS AND CHALLENGES

A 1 RESEARCH AND DEVELOPMENT – THINKING BEYOND THE THREE-PERCENT TARGET

In 2010, investments in research and development (R&D) in Germany reached a new high. With expenditures amounting to EUR 69.7 billion, the German economy increased its investments in R&D by 4.3 percent compared with the preceding year. Germany's R&D intensity, i.e. the proportion of R&D expenditures of the gross domestic product (GDP), has thus risen to 2.82 percent. This is one step further on the way to the three-percent target as defined by the European Council in Barcelona.[1]

In the year 2010, the business sector spent a total of EUR 46.9 billion on R&D – compared with 2009, this is a rise of 3.7 percent. The different industries showed quite heterogeneous developments: in automotive engineering for instance, R&D expenditures increased by 7.2 percent, and R&D expenditures in air and spacecraft manufacturing even rose by 22 percent. The pharmaceutical and chemical industries however displayed a decrease of 4.1 and 2.3 percent respectively.[2]

The current R&D figures are a solid interim result on the way to the three-percent target that was specified in Barcelona for 2010 – despite the fact that Germany failed to reach the target by EUR 4.7 billion. This gap is not inconsiderable, and yet the figures represent a significant, positive trend, considering the increase in public and private R&D expenditures over the last few years. Thus Germany's research slowdown that began in the 1990s and lasted approximately until 2005 has been replaced by a multiannual growth in R&D expenditures.

Other countries such as Finland, Sweden, Japan and Korea have long exceeded the three-percent target.[3] Since Germany considers itself as one of the leading economies and innovation countries, it should orient itself towards the R&D figures of these global leaders rather than focussing on the three-percent target or the average R&D expenditures of all OECD countries. Against this background, the Federal Government's current objective to invest 3 percent of the GDP in R&D[4] until the year 2015 seems to be lacking in ambition. If Germany fails to catch up with these global leaders, it may be subjected to substantial economic risks in the future.

Even though not all of Germany's economic achievements can be attributed to R&D activities and innovations resulting from this, it is still the R&D activities that have played a major role in securing Germany's competitive edge as a leading international business location. To a large extent, the success of Germany's export industries is determined by capital goods (machinery and plant), motor vehicles, chemical products, as well as associated services. Ever since the 1990s, this pattern of specialisation has proven to be particularly successful as it allows German companies to benefit from the growing demand for high-quality industrial and consumer goods in aspiring emerging economies worldwide.[5]

At the same time, competitors are emerging from these very countries. It is yet unclear how competition and international specialisation patterns will evolve in the future. Some of the emerging countries, China in particular, can offer not only low labour costs and innovative enterprises, but also high-performing scientific institutions. Similar developments in the past, e.g. in the context of Korea's and Japan's rise in the 1960s and 1970s, had prompted fears that Germany's competitive position might weaken. Overall, the increase in the international division of labour and the expansion of trade led to an improved level of prosperity for all countries involved.[6] Yet, there is no such thing as an automatism for a positive trend; in these new global settings, Germany can only reach or maintain a competitive edge if its innovation system continually generates new knowledge and flexibly adopts fresh impetus while transforming it into innovation on the market.

The German industries that perform best in terms of exports are those that are innovative and research-intensive.[7] In the view of the Expert Commission, national R&D intensity is not a perfect means of measuring an economy's knowledge intensity; it is however a useful means. From an academic point of view, there is no reason for questioning the indicator of R&D expenditures as an important benchmark for policy, and this is in spite of remarkable innovations in sectors with a low R&D intensity. Hence, the three-percent target for 2015 and a new target for the consecutive years can be significant milestones for assessing Germany's political and economic performance.

A 2 ENHANCING INNOVATION AND PRODUCTIVITY IN ALL EU MEMBER STATES

The current debt crisis clearly illustrates that the member states of the European Union display extremely divergent levels of economic power. The EU member states as a whole are less productive than the US federal states, and the productivity level of the EU-27 currently lies at less than 80 percent of the United States' productivity level. Compared with the US, the EU member states are also much more heterogeneous than the US states.[8] The EU is faced with significant challenges, which, in the medium term, cannot be overcome on the basis of monetary and fiscal measures alone.

The last few decades have been characterised by a convergence process between Europe and the United States. Since the 1990s, this process has slowed down and has at least partially reversed. Back in the 1970s, the productivity level of the continental European countries was still 30 percent lower than that of the US. In the years that followed, they managed to continuously narrow this gap, and in the mid-1990s they even surpassed the United States in productivity. Since then, productivity growth in Europe has slowed down again, with a current productivity level falling behind that of the US by 10 percent. While the Scandinavian countries underwent a comparable development, the Southern European countries also narrowed the gap but experienced another significant downturn in productivity from the mid-1990s. Today, the productivity level of these countries amounts to a mere two thirds of the productivity level of the US. Finally, the new EU member states, starting at a relatively low level in the early 1990s, managed to improve their performance and currently have a productivity level that amounts to a good 40 percent of the US' productivity level.[9]

Above all, the disparity in economic strength between individual EU member states is of particular concern since it proves to be a very persistent pattern. In 1975, the European Union established its European Regional Development Fund, and 1994 saw the launch of the Cohesion Fund for the promotion of structurally weak regions ("convergence regions"). In spite of considerable funding allocations of more than EUR 800 billion since 1994, income disparities between member states – an additional means of measuring differences in productivity – have not significantly decreased in the course of the last 15 years.[10] A commonly used measure for assessing income heterogeneity has shown that the EU-27 countries display three times the value than that of the United States. For Europe and the US alike, heterogeneity[11] within the respective region has remained largely unchanged over the last 15 years. In short, Europe as a whole did not manage to catch up with the US, and neither did it succeed in sustainably reducing inner-European differences in economic development.

This heterogeneous pattern is also reflected in the innovation-related activities of the individual countries. The EU aims at an R&D intensity of 3 percent of GDP for each member state, with the aim of increasing the innovative power of the EU as a whole. Two thirds of this is due to be financed by the private sector and one third by the public sector. Currently the average R&D expenditures within the EU are below 2 percent. This average however covers up vast disparities in terms of individual R&D efforts: thus the Scandinavian countries, Germany and Austria are leading with more than 3 percent and slightly less than 3 percent respectively. These are followed by France, Slovenia, Belgium, the Netherlands, Ireland, Great Britain, Luxembourg and Estonia, with slightly over 2 percent on average. With an average of 1 percent, the Southern and Eastern European countries can be considered mildly innovative, while Lithuania, Poland, Malta, Slovakia, Bulgaria, Latvia, Cyprus and Romania are at the bottom of the innovation list with less than 1 percent.[12] This means that, on average, Southern and Eastern European countries invest less than half of what the leading R&D countries invest. A similar trend can be observed when comparing the number of researchers and R&D personnel, or the number of patent applications.[13]

Effectively, on an EU average, one third of R&D expenditures are covered by public funding, and two thirds are covered by the private sector, as specified in the objective. It is striking however that the countries with the highest R&D proportion of GDP in fact finance the smallest part via public funds. In the Scandinavian countries and Germany for instance, the proportion of publicly funded R&D expenditures amounts to a good quarter.[14] A particularly high proportion of public funding however can be found in countries that display very low R&D figures – among them the new member states and Greece; countries in which public R&D expenditures make up a good half and even more of the overall R&D expenditures. This goes to show that these countries have deficits particularly in the field of private R&D investments. Those few private investments that can be observed are largely attributable to multinational foreign enterprises. Notably in the new member states, multinational corporations are, on average, responsible for 50 percent of private R&D expenditure.[15] Against this background, it is hardly surprising that the new member states are characterised by a significant productivity gap between foreign-owned companies and private domestic businesses.[16]

In the current situation, currency adjustments as a means of increasing international competitiveness of the less productive European countries are not a given option anymore. Therefore, the focus should be increasingly placed on non-monetary measures that aim at improving productivity.[17] These measures however will have to be enforced in the very countries that are at the low end of the productivity scale. So far, European policy-makers have failed in addressing this issue. In the Southern European regions, it is still the industries with a low added value that are most dominant. With the current rate of exchange, these countries are not able to compete on a global scale, given the increase in unit labour costs in these regions. What is more, businesses in these regions are usually less innovative than comparable businesses in other European countries.

Based on what can be observed in the new member states, one could conclude that foreign direct investment plays a major role in boosting the innovative power of the respective region. Innovation would be enhanced directly via the transfer of capital and know-how, but also indirectly as foreign investment will generate competitive pressure for domestic companies. However, a certain amount of skepticism is advised as it is yet unclear if this path can also be successfully applied to Southern European countries such as Greece. Over the last few years, wage increases in Southern European countries have exceeded productivity growth. This obviously has a discouraging effect on direct investments.[18] The issue is even more pressing for countries that are lacking qualified skilled workers and attractive co-operation partners from local research institutions, which would allow companies to develop new technologies in collaboration with domestic partners. Finally, recent cutbacks that have become necessary, and the decline in consumption that accompanies them, make investments in many of the Southern European countries an unattractive scenario for those who want to invest with a view to opening up new markets.

Against this background, infrastructural measures in the educational sector play a major role in increasing innovative power. The innovation environment of the Southern European countries would greatly benefit from a broader differentiation in their education and training system and a stronger focus on universities of applied sciences and vocational training centres. It is also essential that educational and research organisations on the one hand and private companies on the other hand intensify co-operation, which would strengthen weak innovation-related activities in the private sector. Yet, as a prerequisite for successfully promoting knowledge and technology transfer on both a national and international level, a strong national science system is required. The ultimate aim is to develop a national innovation strategy that defines targets that can be duly implemented and measured. Standards such as the three-percent target for R&D expenditures of EU countries, as discussed above, are of little use to countries that so far have fallen short of the specified target by more than half. For these countries, the three-percent target should be replaced by more realistic objectives.

Improved efficiency in administrative structures and simplified bureaucratic structures, e.g. with regard to planning and permission procedures, could help to successfully commercialise innovations. What is more, they are also a prerequisite for applying resources provided by the EU Structural Funds in a sustainable, efficient way. From the outset of allocating funds to structurally weak regions, it is vital to ensure that the resources allocated contribute to an increase in productivity. On the part of the EU, it is imperative to introduce a suitable monitoring system that will safeguard the designated utilisation of funds.

Finally, the institutional environment in these countries will have to be improved. Transparency International's corruption indicator suggests that for some of the Southern European countries corruption continues to be a massive problem.[19] Other indicators, which aim at assessing the overall institutional environment for companies, also testify to a poor track record for some of these regions.[20] Without the necessary legal certainty and institutional framework conditions, it will not be possible to attract foreign investors, and neither will it be possible to persuade domestic investors to invest in regional enterprises.

CONTINUALLY IMPROVING THE ATTRACTIVENESS OF GERMANY AS AN R&D LOCATION — A 3

Over the last decade, the economies of all OECD countries have undergone a development towards a knowledge-based economy. As regards value added, export and employment, there is a continuous increase in the proportion of industries and service areas that are characterised by a high degree of knowledge intensity. This process is accompanied by a structural shift towards research-intensive goods, a growing proportion of highly qualified personnel, and an increasing relevance of patents and other forms of securing intellectual property.

The individual OECD countries pursue different strategies for growth and specialisation. The United States, Great Britain and Canada, as well as several Scandinavian countries, are focussing on cutting-edge technologies and on continuously developing their services sector. In some cases – in the US and Great Britain for example – this also implied that national governments knowingly accepted redundancies in the industrial sector. Other countries decided to maintain and modernise their traditional industrial structures. Germany in particular, but also Japan, thus embarked on modernisation strategies in their manufacturing industries. Since 1990, and even more so since 2000, Germany has been attaching great importance to high-value technologies, and this has lead to significant improvements in its competitive position. However, in cutting-edge technology fields with particularly strong international growth, Germany continues to display deficiencies.[21]

Challenges posed by new producer countries for cutting-edge technology

For R&D-intensive goods and cutting-edge technologies in particular, global competition has intensified considerably. Not only do the leading industrialised countries compete with each other – they are also increasingly exposed to competition from emerging economies that have for the last few years been pursuing offensive innovation strategies. Notably in the area of cutting-edge technology more and more Asian countries are positioning themselves on the market. In fact 35 percent of the worldwide value added in this highly competitive segment of manufacturing can be attributed to Asian countries, and this trend is due to continue. China has managed to outperform Japan and is now, after the US, ranked second place in the leading list of cutting-edge technology goods producers. Other emerging countries from Asia are pushing themselves up in the global ranking: thus South Korea has surpassed countries such as France and Great Britain as a cutting-edge technology goods production location. Taiwan, Singapore, India and other aspiring economies are also pursuing ambitious development strategies that are directed at innovation and cutting-edge technology.[22]

In the international race for innovation, the European countries have been consistently falling behind. In 2007, European countries held a mere 25 percent share in worldwide value added in the market for cutting-edge technology. The US managed to maintain their share of 31 percent despite the fact that they, too, are subjected to major challenges brought about by Asian countries. Germany is currently caught in a difficult position between ambitious emerging countries and classical producers of cutting-edge technology such as the US and Japan. Germany's industrial innovation strategy, characterised by strong high-value technology and the skillful adaptation of cutting-edge technologies, has proved successful over the last few years. Considering the massive innovation efforts made by other countries as well as Germany's own structural deficiencies in critical cutting-edge technologies, it seems questionable whether this strategy will continue to be successful in the future.[23]

Globalisation of research and development

The worldwide relocation of production sites is accompanied by the globalisation of R&D. Multinational companies conduct their R&D activities in various locations around the world, often seeking the proximity of highly dynamic markets. For many host countries, R&D investments by foreign multinational corporations have a major impact on the domestic economy and innovation system. To safeguard a country's competitive edge, it is crucial to launch new R&D centres whilst also securing existing business locations of foreign enterprises. This is especially true for countries in which foreign R&D expenditures account for a particularly high proportion of national R&D expenditures. In Great Britain, the proportion of industrial R&D expenditures attributable to foreign enterprises has gone up from 30 percent in the 1990s to nearly 40 percent in the last decade. A similar trend can be observed in Canada (35 percent) and Sweden (36 percent).

In the United States, R&D expenditures of foreign enterprises have also increased continuously, with figures currently ranging between 14 and 15 percent.[24] Several European countries – primarily small, export-oriented economies – specifically target foreign multinational companies to invest in R&D. Among these countries are Ireland (72 percent), Belgium (59 percent) and Austria (53 percent). New EU member states such as Hungary (67 percent) and the Czech Republic (55 percent) are also gaining a profile as locations for R&D centres (see Chapter A2). A similar policy is pursued by China (see Chapter B5), as well as Brazil, India, Singapore and, more recently, Russia. All of these countries are successfully competing for foreign enterprises to establish new R&D centres in their respective countries.[25]

Foreign enterprises have also come to play an essential part within Germany's R&D system. The proportion of the national economy's total R&D expenditures that is attributable to foreign enterprises has gone up from a good 17 percent in the 1990s to currently more than 27 percent (see Table 1). This upturn was particularly significant between the years 1993 and 2001. Since 2001, foreign enterprises have increased their R&D expenditures in Germany by nearly the same growth rate as that of domestic businesses.[26] In terms of employment of highly skilled personnel[27] and collaboration with other companies and research organisations in Germany, R&D branches of foreign enterprises are becoming ever more important. In 2009, R&D employment and expenditures of foreign enterprises in Germany totalled EUR 12.3 billion. Here, the most important industries included other transport equipment (with a proportion of 85.9 percent of foreign enterprises), pharmaceutical industry (52.5 percent), as well as computers, electronics and optics (31.7 percent).[28]

In the course of the last few years, German companies have increasingly undertaken to relocate production sites to international locations. As a result, certain R&D activities have also been shifted.[29] This applies to development activities – especially in cases where a company produces for the host

R&D expenditures of foreign multinational enterprises in Germany

TAB 01

	Internal R&D expenditures			R&D personnel		
	in million euro	sectoral structure in percent	pro-portion in percent	number (FTE)	sectoral structure in percent	proportion
Industry (WZ 2008)						
Manufacturing	**10,685**	**87.1**	**27.6**	**73,546**	**86.6**	**26.8**
Chemical industry	440	3.6	13.8	3,800	4.5	17.6
Pharmaceutical industry	2,044	16.7	52.5	8,329	9.8	44.0
Computers, electrical engineering, optics	1,843	15.0	31.7	14,763	17.4	29.5
Electric equipment	382	3.1	28.7	3,484	4.1	26.6
Mechanical engineering	932	7.6	20.7	7,878	9.3	20.8
Automotive engineering	2,030	16.5	14.7	16,885	19.9	19.2
Other transport equipment	1,766	14.4	85.9	8,980	10.6	80.7
Information and communication	**534**	**4.4**	**20.9**	**4,986**	**5.9**	**22.7**
Scientific and technical services	**715**	**5.8**	**27.2**	**4,288**	**5.0**	**18.0**
Economy in total	**12,273**	**100.0**	**27.3**	**84,975**	**100.0**	**25.9**

Source: *SV Wissenschaftsstatistik*. Calculations of DIW Berlin (German Institute for Economic Research). Cf. Belitz (2012).

Proportion of German companies' foreign R&D expenditures of overall R&D expenditures

TAB 02

Year	**1995**	**2003**	**2005**	**2007**	**2009**
	Foreign R&D expenditures in billion euro				
Industry (WZ 2008)					
Manufacturing	**4.9**	**10.2**	**11.3**	**8.8**	**10.7**
Chemical industry	2.5	1.6	1.2	1.6	0.7
Pharmaceutical industry	–	1.7	2.1	2.1	3.7
Mechanical engineering	–	0.6	0.7	0.8	0.5
Computers, electrical engineering, optics	–	2.5	2.3	1.2	1.8
Automotive engineering	–	3.5	4.8	3.0	3.6
Other industries	**–**	**0.7**	**0.2**	**0.6**	**0.6**
Economy in total	**5.1**	**10.9**	**11.4**	**9.4**	**11.3**
	Proportion of foreign R&D expenditures, in percent				
Manufacturing	**23.1**	**30.0**	**30.7**	**24.2**	**27.4**
Chemical industry	35.6	34.4	29.7	29.9	25.4
Pharmaceutical industry	–	50.1	51.8	69.2	54.0
Mechanical engineering	–	32.2	27.2	29.4	19.5
Computers, electrical engineering, optics	–	36.5	31.6	20.2	33.2
Automotive engineering	–	21.3	26.5	15.6	18.3
Other industries	**–**	**30.8**	**10.1**	**27.3**	**25.7**
Economy in total	**23.1**	**30.0**	**29.9**	**24.4**	**27.3**

Source: *SV Wissenschaftsstatistik*. Estimates of DIW Berlin (German Institute for Economic Research). Cf. Belitz (2012: Table 2–3).

country's local market and has to adapt its products to local demands. But it also applies to a company's actual research activities; provided that the relocation leads to cost savings and that access to local know-how and research organisations is available. Between 1995 and 2005, R&D expenditures of German companies abroad steadily increased from EUR 5.1 billion to EUR 11.4 billion. Within this period, the proportion of foreign R&D expenditures of the overall R&D expenditures of German companies rose from 23 percent to 30 percent. Table 2 illustrates that German companies only briefly decreased their R&D activities abroad[30]; this was the case between 2005 and 2007, following a phase of strong internationalisation. Since 2008, German R&D activities abroad have been re-intensified considerably. By 2009, R&D expenditures of German companies abroad had gone up to EUR 11.3 billion, which equals 27 percent of total R&D expenditures.[31] German businesses primarily conduct their R&D activities in the United States and in Germany's neighbouring countries. More and more, the new Asian research locations and the new EU member states also serve as R&D locations for German companies.[32]

Political framework conditions increasingly important for securing locations

Multinational enterprises choose their business locations based on economic criteria such as access to attractive markets and technologies and the availability of skilled personnel and researchers. Germany, being a highly developed research location and Europe's largest market, is well positioned in this regard and has an overall positive R&D track record. Since 2007, foreign enterprises have invested approximately EUR 4 billion more in R&D in Germany each year than German companies have invested abroad.[33] Yet, today's companies' location decisions are more and more influenced by innovation-related political conditions in the target country. Here, strategic measures to attract industrial settlement and promote R&D, as well as tax regulations and patent policies are becoming increasingly relevant. In this respect, Germany fares relatively poorly in international comparison, which is largely given to the fact that Germany does not offer tax credits for R&D – a measure that has been increased in many other countries.[34] In their previous reports, the Expert Commission has repeatedly stressed the importance of R&D tax credits. So far, the Federal Government has not implemented this measure – despite their declaration in the 2009 coalition agreement.

A further factor that influences multinational companies' location decisions are national regulations for patent protection and the tax treatment of income from licensing. In terms of establishing R&D centres and allocating patents to locations, tax arbitrage considerations are also important: patent portfolios and related research are preferably concentrated in regions that offer particularly favourable taxation on licensing revenue. In this regard, Germany is behind in the game, which is resulting in an increasing distortion of competition.

In view of this, the Expert Commission expresses its concern that a race for the most favourable taxation conditions for licensing revenue in Europe is currently in full swing. In 2007, the Netherlands and Belgium were the first to introduce "patent box regulations", followed in 2008 by Luxembourg and Spain. For 2013, Great Britain, too, is planning to introduce this measure.[35] Patent box regulations permit companies in certain circumstances to apply a reduced tax rate of up to 10 percent on their licensing revenue. Governments that promote such regulations are hoping to improve both the attractiveness of the location for foreign enterprises and the framework conditions for research and development. The latter remains dubious however, as it is not the R&D activities as such but only the exploitation of patents that is being rewarded through tax regulations. Instead, there are grounds for suspecting that measures like these will lead only to the tax-induced shifting of patent portfolios – at the expense of other countries that do not offer comparable tax benefits. As the Expert Commission already pointed out in their Annual Report 2011, this causes serious threats for Germany as an R&D location. In the meantime, the subsidy race is further accelerating in several European countries.

The impact of R&D internationalisation on Germany as a location

In order to assess the impact of R&D internationalisation on Germany as a location, it is necessary to find out whether German companies' R&D activities abroad actually supersede domestic R&D – or whether R&D abroad in fact complements domestic R&D. Although at this stage a definite answer to this question cannot be provided, recent scientific studies suggest that they largely complement each other.[36]

Surveys on company acquisitions by foreign enterprises also suggest that such acquisitions do not necessarily lead to a shifting of R&D activities to the home country of the new parent company. In Sweden for instance it has been observed that, following the acquisition of Swedish companies by foreign enterprises, Swedish R&D activities indeed remained in the country. Similarly, a survey on company acquisitions in Spain shows that a relocation of R&D into the home country of the acquiring company is likely to happen only if the purchasing party comes from a country with a much higher degree of technological development, such as the United States.[37]

Even if R&D activities of German companies abroad at least partially replace their domestic R&D activities, questions concerning the macroeconomic impact of this development remain. It would be worrying to find that such shiftings are profitable for the companies involved but unfavourable for the whole economy because positive R&D repercussions (externalities) in the home country have been disregarded. Smaller companies in particular might have to bear the negative effects of this if they cease to benefit from new business and impulses attributable to those larger companies. In fact, a company's geographical proximity to the R&D activities of other enterprises plays a key role in creating such positive spillover effects.[38] But of course it is also true that German companies conducting R&D abroad do also benefit from spillover effects from local companies; Silicon Valley may serve as a prime example for this.[39] Numerous German companies, among them Bayer AG, Robert Bosch GmbH, Daimler AG and Siemens AG, are conducting R&D activities in close proximity to Stanford and Berkeley, thereby receiving vital stimulus for innovation projects within the global parent corporation.

While the positive externalities of business ventures abroad are clearly factored in by companies, their corporate perspective does not allow for considering the macroeconomic consequences. Companies have to follow a business rationale, and this perspective makes them neglect the negative social and economic consequences that such relocation may have on Germany as a location. This can however lead to imbalances on the labour market for highly qualified personnel. For instance, in the context of the migration of the microelectronics industry, graduates from the respective fields were unable to find suitable employment options in Germany. What is more, Germany's domestic research organisations have had to go without the application-related stimulus and co-operation opportunities that would otherwise be available. Thus it has been the case that specialised public research organisations were lacking collaboration partners at home – and more often than not, this resulted in research organisations increasingly seeking fields of activity abroad.

Foreign and domestic skills as mutually enhancing factors

Industrial R&D clusters that are effectively integrated into the economic, research and educational sectors can only be secured in the long term if unique skills are available on a national level. In fact a worldwide thematic clustering as described above is an unavoidable and necessary development. In the international competition for R&D activities, Germany has a location advantage in the automotive, mechanical engineering and chemical industries – a competitive edge that needs to be maintained. In other sectors, such as the information and communication industry, the pharmaceutical industry and biotechnology, Germany will be able to succeed if German companies also conduct their R&D in international locations. This would enable them to reap the benefits of spillover effects from local companies in the target country. Examples include the Silicon Valley for network technologies and the east coast of the United States for pharmaceutical and biotech clusters. Yet, for such a strategy to lead to the desired results it must be actively reinforced by a reverse technology transfer from German ventures abroad to competence centres in Germany. It is the responsibility of businesses to implement suitable organisational models of international collaboration.[40] Policy-makers can pave the way by developing new structures for international collaboration between students and scientists and by offering binational platforms for innovation.[41]

To complement these efforts, Germany will have to ensure that it remains attractive, and further improves its attractiveness, as an R&D location for foreign enterprises. Germany can position itself by providing a highly-developed R&D environment, e.g. by means of collaborations with German research organisations. How to excel in this regard has been demonstrated in Switzerland. Here, examples include the long-standing collaboration between the IBM research centre and the ETH Zurich, and the development of joint research centres by universities and foreign enterprises such as the SAP research centre in St Gallen. Intensive institutional collaboration between German research organisations and higher education institutions on the one hand, and foreign enterprises on the other hand, should be systematically targeted and fostered. This would lead to the launch of new domestic research centres and, as a result, to increased value added and employment in Germany.

As regards German research organisations that are publicly funded, intensified commitments abroad will only lead to the desired results if they succeed in benefitting both parties, i.e. Germany and the target country. Over the last decade, numerous initiatives have been launched. Here, it is essential to critically assess if the knowledge flows resulting from this are bidirectional and mutually enhance each other. This aspect will be further dealt with in Chapter B5, on the example of China.

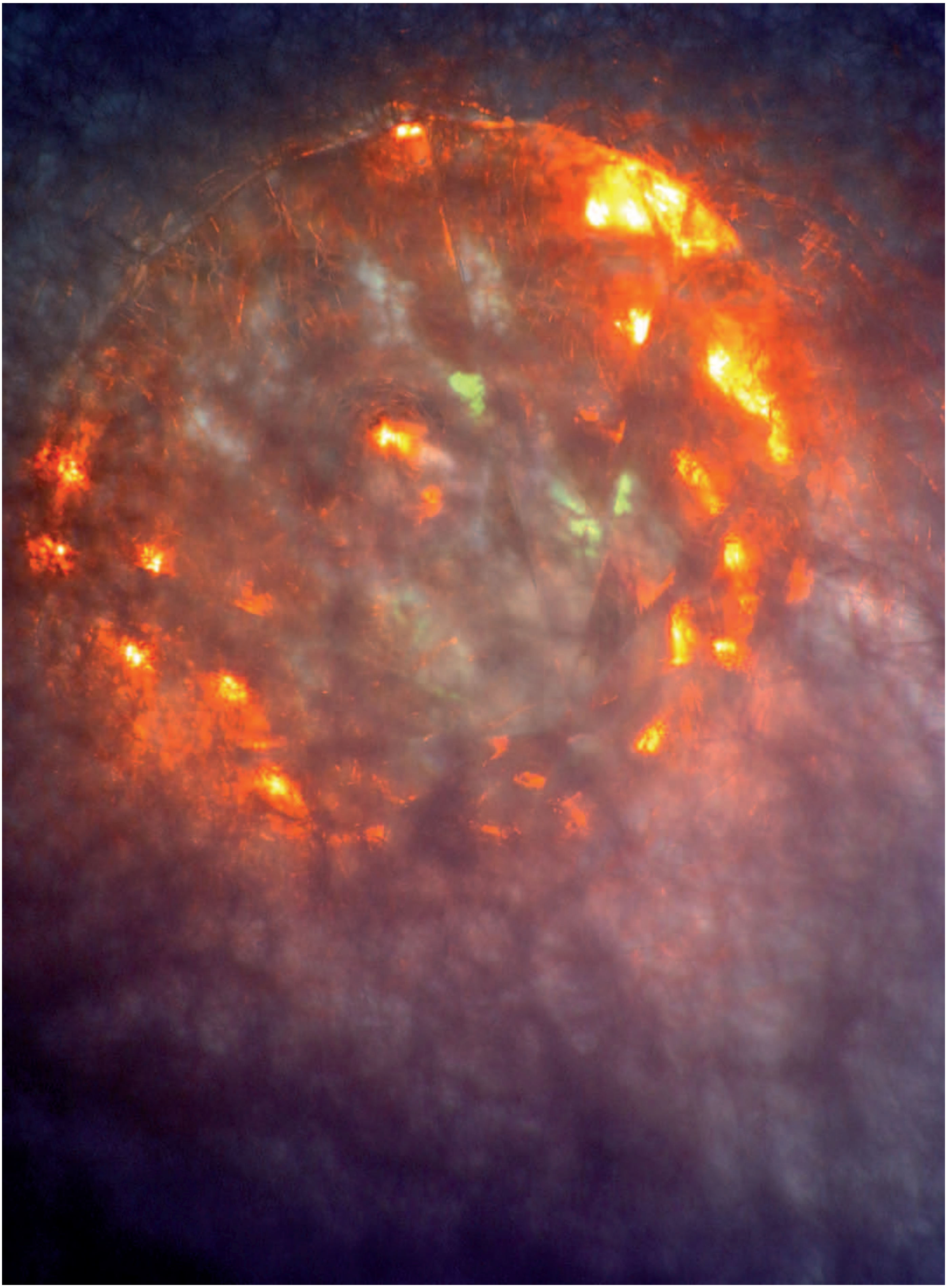
A 4 THE ENERGY TRANSITION AS AN INNOVATION OPPORTUNITY

The disasters at several nuclear power reactors in Fukushima in the spring of 2011 triggered a broad, intensive social and political debate about the future of energy supply in Germany. This was followed by a legislative package that was adopted by the German parliament on 30 June 2011. Among other things, it provides for a step-by-step decommissioning of all German nuclear power reactors by the year 2022.[42] To complement this nuclear phase-out, it is also planned to significantly reduce the use of fossil fuels as a means of climate protection. This "Energy Transition" *(Energiewende)* shall be facilitated not only by a considerable improvement in the production, transport and application of energy that is technically usable, but also by a significant increase in the use of renewable energy sources generated from e.g. the sun, wind, biomass, and geothermal sources. In implementing this energy shift, Germany aims to phase out nuclear energy, while at the same time achieving their self-defined objectives in terms of climate protection.[43]

The Expert Commission would like to comment on three dimensions of the Energy Transition: (1) responses from the German innovation system in the field of non-university research institutions,[44] (2) changes in the Federal Government's research and energy policy, and (3) the relevance of the Energy Transition for innovations in Germany as an industrial location. The Expert Commission is aware of the fact that substantial strategic adjustments in the area of research and innovation require a sufficiently long preliminary phase. Hence, the current status should be considered as no more than a provisional snapshot.

The Fraunhofer-Gesellschaft (FhG) has dealt with nuclear energy and fossil energy conversion only to a limited extent in the past.[45] Their focal points in the field of energy have been, and still are, renewable energy (solar, wind, biomass), energy efficiency technologies, energy-efficient buildings and building components, intelligent electricity networks, as well as energy storage and electromobility. The Fraunhofer-Gesellschaft also comprises an Energy Alliance, a co-operation in which 15 out of the 60 existing Fraunhofer institutes participate.[46] The Fraunhofer-Gesellschaft does not see the necessity to make major adjustments to their R&D focal areas as a result of the Federal Government's energy shift. The reason for this is that the FhG portfolio planning is already directed at further expanding and complementing its strengths in the key fields mentioned above.

The Helmholtz Association (HGF) focuses its activities on renewable energy, efficient energy conversion, nuclear fusion, as well as the "technology, innovation, society". As a response to the new energy legislation, several new strategic "Helmholtz Energy Activities" *(Helmholtz Energieaktivitäten)* have been launched within the HGF,[47] and some of these promise to take effect in the near future. For the 2015-2019 funding period, HGF is also planning to further advance its efforts in the area of renewable



1/10 Transilluminated fibrous tissue
© Bildlabor 2012

2/10 Liquid at rest
©Bildlabor 2012

energy and efficiency technologies. This will be complemented by enhanced efforts in the fields of energy storage technologies, grid issues and system solutions. In the current funding period (2010-2014), 42 percent (EUR 562 million) of the Helmholtz Association's basic funding resources allocated to energy-related research will be granted to activities in the field of nuclear fusion.[48]

For many years now, the Max Planck Society (MPG) has been attaching special attention to sustainable energy supply as a strategically important field of work.[49] Since the MPG's scope of implementation usually extends to a decade or more, Germany's accelerated phase-out of nuclear energy does not affect MPG's long-term objectives. MPG's research activities in the field of future energy supply are focussed on nuclear fusion (in close co-operation with HGF[50]) and chemical energy conversion. As regards chemical energy conversion, the Max Planck Society is currently launching an MPG institute for basic research in (bio-) chemical energy research.

The research facilities of the Leibniz Association (WGL) are primarily engaged in energy-related research into materials and technologies.[51] In addition to that, economic, societal, ecological and environmental issues are being analysed with regard to current and future power supply systems. In order to further consolidate these research activities, WGL has initialised first steps towards the launch of a research association on energy issues.

The Expert Commission welcomes these diverse activities that contribute to the Energy Transition through scientific and technological advancements. Yet, it seems that a comprehensive/all-encompassing co-ordination of all of these non-university research institutions currently exists only in rudimentary form. Moreover, the Expert Commission sees the need for additional debates and adjustments. In view of the Energy Transition, the Expert Commission also recommends reconsidering the nuclear fusion.[52] In particular, it seems questionable whether Germany should maintain to simultaneously pursue two different technological concepts, i.e. Tokamak and Stellarator. The Expert Commission further suggests reassessing the relevance of nuclear transmutation research[53] for Germany.

On 3 August 2011, the Federal Government adopted their 6th Energy Research Programme for Germany *(6. Energieforschungsprogramm für Deutschland)*.[54] This programme already responds to the government's nuclear phase-out policy that was adopted in June 2011. The 6th Energy Research Programme is the result of an extensive consultation process: although drawn up under the aegis of the Federal Ministry of Economics and Technology (BMWi), the programme is in fact the product of a close collaboration between the BMWi, the Federal Ministry for Environment, Nature Conservation and Nuclear Safety (BMU), the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) and the Federal Ministry of Education and Research (BMBF). All measures suggested in the Energy Research Programme are part of the Federal Government's dedicated Hightech Strategy. While the Expert Commission welcomes the Ministries' increasingly collaborative approach to energy-related R&D policies, it is calling for further steps towards an effective co-ordination of energy research activities. Moreover, it does not suffice to merely co-ordinate publicly funded research – the economic players have to be integrated through a pre-competitive co-ordination process.[55]

In the context of the 6th Energy Research Programme, the following cumulative sub-budgets are earmarked for the years 2011 to 2014: EUR 1.2 billion for efficient energy conversion and usage as well as energy efficiency; EUR 1.4 billion for renewable energy; EUR 0.3 billion for nuclear safety and disposal; and EUR 0.6 billion for nuclear fusion. The funding volume of the efficient energy conversion and renewable energy budget shall be increased by approximately 40 percent between 2012 and 2013. Given the objectives of the Energy Transition, these budgetary developments appear to be coherent.

The Expert Commission understands that the resources designated for nuclear safety and disposal according to the 6th Energy Research Programme will be used for research and development purposes only. In the view of the Expert Commission, any resources that are made available to nuclear fission and nuclear fusion technologies in the context of the Euratom agreement should be reported in conjunction with the Energy Research Programme, a measure that would further enhance transparency. Considering the strained national budgets in Europe, the Expert Commission would like to reiterate its earlier critical comments on the management of the nuclear fusion programme ITER.[56]

The Expert Commission expressly welcomes the fact that the Energy Research Programme, in addition to sustainable power supply, strongly addresses issues regarding efficient energy usage, energy supply for buildings, and sustainable transport technologies. It is striking, however, to see that the report on the 6th Energy Research Programme only briefly describes and discusses the research areas of "Nuclear safety and disposal research and radiation research" as well as "Fusion research".[57] Such scarce documentation appears to be disproportionate in comparison to the resources that are channelled into these areas.

From among the leading economies worldwide, Germany assumes a leading role in transforming energy systems towards sustainability. The Energy Transition offers Germany the chance to position itself as a high-tech location on the global market e.g. in the following fields: (1) technologies for efficient energy use, (2) use of renewable energy sources, (3) energy-efficient building technologies, (4) energy storage technologies, (5) efficient and intelligent power networks, and (6) sustainable transport technologies. With its excellent R&I infrastructure, Germany has very good prospects of maintaining, extending or acquiring a global leading role in most areas of sustainable energy supply technologies – as a system provider, manufacturing equipment supplier and service provider. In order to transform this potential into real innovation leadership, a concerted commitment of all stakeholders is now required. Moreover, energy, environmental and innovation policies will have to be co-ordinated to a much higher degree than has been the case in the past. This will prevent welfare losses in the context of the nuclear phase-out and let the positive impact of the Energy Transition come into full effect.

CORE TOPICS 2012

B

B CORE TOPICS 2012

B 1 UNIVERSITY-BASED RESEARCH – CURRENT STATUS AND DEVELOPMENT PROSPECTS

B 1–1 RELEVANCE OF UNIVERSITY-BASED RESEARCH

Research is a key element in innovation processes.[58] In Germany, research is largely conducted by three groups of stakeholders: companies, non-university research institutions, and higher education institutions, i.e. universities and universities of applied sciences. The Expert Commission regularly reports on company-based research activities. In its 2010 Annual Report, the Expert Commission also provided in-depth coverage of the role of non-university research. In the 2011 Annual Report, new potentials for collaboration between non-university institutions and higher education institutions were discussed. In this current report, university-based research shall be analysed in more detail.[59] Not only the current status, but also development prospects for research in the higher education sector will be discussed.[60] One major aspect to be discussed will be the special role that university-based research takes in contributing to knowledge and technology transfer.[61]

Throughout 2010, Germany invested a total of EUR 69.8 billion in R&D. The majority of R&D expenditures – EUR 46.9 billion – is attributable to the private sector (67 percent). Higher education institutes spent EUR 12.6 billion on R&D activities (18 percent), and the R&D expenditures of non-university institutions and the federal department research institutions[62] amounted to EUR 10.2 billion (15 percent). Thus, in terms of quantitative importance, the higher education sector exceeds both the non-university sector and the federal department research institutions.

B 1–2 FEDERAL FRAMEWORK CONDITIONS

With only a few exceptions, Germany's public higher education institutions are subjected to the rights of legislative initiative and executive power of the *Länder*, i.e. Germany's federal states. In terms of education policies, the Federalism Reform I *(Föderalismusreform I)*, which was enforced in September 2006, strengthened the education-related responsibilities of the *Länder* and weakened those of the Federal Government.[63] The reform provided for an abolition of the joint tasks of "construction in the higher education sector" and "education planning", both of which had been anchored in the German Basic Law (GG).[64] Prior to the Federalism Reform I, the Federal Government had co-financed building projects in the higher education sector by covering 50 percent of construction expenses. To compensate for the increased burden on the *Länder* caused by the cancellation of these joint tasks, the Federal Government's share of contributions stipulated for university construction has been made available to the *Länder* until and including 2019, while funding is earmarked until 2013. Only construction of tertiary education research facilities and large-scale equipment are eligible for financing through the joint task of "promotion of research" which is still in place. A means of collaboration between Federal Government and *Länder* in the educational field is provided by the joint task of "promotion of research". It enables policy-makers from the federal and national levels to co-operate in financing science and research ventures of transregional importance. However, such collaboration is only possible provided that all of the federal states have given their consent. So far, only few collaboration agreements

BOX 01

Federalism Reform 2006, Amendment of Article 91a, Paragraph 1 and Article 91b of the German Basic Law (GG)

Article 91a (1) of the Basic Law[65]

Old version
The Federal Government participates in the performance of *Länder* tasks if these tasks are relevant to the public and if participation of the Federal Government is necessary for improving living conditions (joint tasks):
1. Expansion and construction of higher education institutions, including university hospitals
2. Improvement of regional economic structures
3. Improvement of agricultural structures and coastal protection.

New version
The Federal Government participates in the performance of *Länder* tasks in the following areas if these tasks are relevant to the public and if participation of the Federal Government is necessary for improving living conditions (joint tasks):
1. Improvement of regional economic structures
2. Improvement of agricultural structures and coastal protection.

Article 91b of the Basic Law GG[66]

Old version
In instances of transregional importance, the Federal and *Länder* governments may co-operate, on the basis of agreements, in education planning and the promotion of facilities and ventures of scientific research. The sharing of costs shall be specified in the agreement.

New version
(1) In instances of transregional importance, the Federal and *Länder* governments may co-operate in promoting:
   1. Facilities and ventures in scientific research outside of the higher education sector
   2. Science and research ventures in the higher education sector
   3. Research buildings at higher education institutions, including large-scale equipment.

   Agreements according to Clause 1, No. 2 require the consent of all *Länder*.
(2) Federal and *Länder* governments may co-operate, based on agreements, in monitoring the performance of education in international comparison and in preparing reports and recommendations relating to this.
(3) The bearing of costs shall be specified in the agreement.

between the Federal and *Länder* governments have been achieved, and all of these were in fact preceded by lengthy negotiations.

The Federalism Reform 2006 contributed to aggravating existing imbalances in the development prospects of higher education institutions on the one hand and non-university research institutions on the other hand. In the 1960s and 1970s, Germany's higher education institutions and non-university research institutions were still being developed in equal measures (Article 91b, Paragraph 1 (1) GG).[67] In the course of the Federalism Reform 2006, framework conditions were modified in favour of the non-university research organisations and to the significant expense of the higher education institutions. With the passing of the law on 28 August 2006, Article 91a, Paragraph 1 (1) of the Basic Law was abolished. In addition to that, Article 91b of the Basic Law was revised, which had an even greater impact on research funding.[68] Due to these new regulations, framework conditions for advancing research at higher education institutions have deteriorated considerably. According to the new regulations, the Federal Government can still use its vast financial resources to fund facilities and ventures (basic funds, infrastructure and projects) of non-university research institutions. For the higher education sector however, public funding is limited to ventures (projects) alone. This however requires the consent of each of the federal states, which is extraordinarily hard to achieve. In political practice, this may lead to flawed quid pro quo deals as in the case of the University Hospital Lübeck.[69] Since then, a number of voices from the fields of science and politics have been pleading for the necessity to further adjust Germany's federal structure,[70] arguing that the Federal Government should be re-enabled to provide long-term institutional funding for universities. The Expert Commission strongly agrees with this plea.

B 1–3 IMPORTANT REFORMS AND PROGRAMMES OF THE LAST DECADE

The last few years have seen the launch of important reforms and programmes affecting the higher education sector. Not only did this have an immediate impact on the higher education sector's contributions to knowledge and technology transfer, it also meant that Germany's higher education institutions had to cope with extensive change processes that demanded capacities in all levels of staff.

- **Bologna process:** The signing of the Bologna Declaration by the 29 European ministers of higher education marked the beginning of the Bologna process, in which 47 countries currently participate.[71] The Bologna process aims to create a European Higher Education Area that is characterised by unlimited mobility for students, graduates and lecturers. The European Higher Education Area shall be achieved on the grounds of a mutual recognition of academic achievements and degrees as well as transparency and comparability of degrees using a three-cycle degree system (Bachelor's – Master's – doctorate degree). In the history of the Federal Republic of Germany, the Bologna process is arguably the most comprehensive reform of the academic system. In the winter semester of 2009/2010, 79 percent of available study programmes had been adapted to the Bachelor's and Master's scheme. The transformation of study programmes is not yet completed in the state-regulated curricula (teacher training, law, medical), and neither is it completed in the field of fine arts and specific theological fields of study.[72]

- **G8:** In nearly all of the German federal states the mandatory period for upper secondary school has been reduced from nine to eight years (commonly referred to as G8). As a result, a double intake of drop-outs will be entering higher education in the very year the first of the G8 students have completed upper secondary school. Thus, German higher education institutions are subjected to an increase in students in the respective year and consecutive years. In the case of Bavaria, twice the amount of pupils completed their upper secondary school-leaving certificate in 2011; the same is due to happen in 2012 in Baden-Württemberg, and in North Rhine-Westphalia in 2013.[73] This reduction in the upper secondary school term, combined with a slightly earlier school enrollment and the suspension of mandatory military services, has led to the fact that today's first-year students are, on average, noticeably younger than first-year students ten years ago.

- **Abolition of the "university teachers' privilege":** For a long time, tertiary education lecturers at public universities and universities of applied sciences were entitled to freely utilise their inventions – unlike researchers in the private sector and the non-university research sector (cf. university teachers' privilege, § 42 of the Act on Employees Invention (ArbnErfG), old version). Since 7 February 2002, the university teachers' privilege has been removed from the Act on Employees Invention, which means that inventors employed in the public higher education sector have to report their job-related inventions to the respective higher education institution, which is then entitled to exploit the invention. While the higher education institution has to bear any costs involved, the inventor gets a share of the gross revenue. The aim of the abolition of the university teachers' privilege was to promote knowledge and technology transfer at universities and universities of applied sciences and strengthen innovation.[74] To achieve a more active role for higher education institutions in the field of patent application, a suitable infrastructural environment is needed.[75] In the framework of the SIGNO programme for the higher education sector, patent exploitation agencies have been established with the support of the Federal Government. The main objective of these agencies is to assess inventions in terms of their market potential and patentability and, if necessary, to provide advice and funding for the process of property right application.[76]

- **Excellence Initiative by the German federal and state governments to promote top-level research at German universities:** Launched in 2005 by the Federal and *Länder* governments, the Excellence Initiative aims to promote science and research at German higher education institutions. The initiative shall "initialise a competitive spiral that aims to promote top-level performance and to improve the overall quality of Germany as a higher education and science location".[77] Funding is allocated based on three

BOX 02

The three funding lines of the Excellence Initiative

Graduate Schools:[78] Research schools serve the purpose of promoting young academics and providing optimal conditions for doctorate research within a broad, interdisciplinary field of study. At the same time they are expected to contribute to the respective university's development of core scientific areas. During the first programme phase, the promotion of 39 research schools has been approved in the context of the Excellence Initiative.

Clusters of Excellence:[79] The aim of Clusters of Excellence is to consolidate existing research potential at German university locations. The focus is on networking and co-operations between different university facilities, and also between universities and non-university research institutions and the private sector respectively. This should result in the sharpening of university profiles and create excellent funding and career structures for young academics. In this funding line, 37 applications have been approved within the first programme phase.

Institutional strategies to promote top-level research:[80] Future concepts aim to strengthen universities institutionally and establish them in the top group in international competition. Each of the institutional strategies of those nine universities that have been funded in the first programme phase ("Elite Universities") entails a long-term strategy for sustainably developing and enhancing top-class research and for promoting young scientists. To be eligible for this funding line, a university has to have at least one research school and one Cluster of Excellence.

different funding lines: Graduate Schools, Clusters of Excellence, and institutional strategies to promote top-level research (cf. Box 2). The Excellence Initiative is divided into two programme phases that are implemented by the German Research Foundation (*Deutsche Forschungsgemeinschaft,* DFG) and the German Council of Science and Humanities *(Wissenschaftsrat)*. A total of 39 Graduate Schools, 37 Clusters of Excellence and nine institutional strategies ("Elite Universities") have been funded since 2006. 37 higher education institutions are receiving approximately EUR 1.9 billion for their projects.

In 2009, the Federal and *Länder* governments signed an agreement on the launch of the second programme phase of the Excellence Initiative, which provides for a five-year extension and a funding volume of more than EUR 2.5 billion. Funding decisions are due to be announced in June 2012.[81]

– **EU state aid framework:** The "Community framework for state aid for research, development and innovation", which came into effect on 1 January 2007, abolished the aid-related privileged treatment of not-for-profit universities that had previously been in place.[82] This resulted in the fact that, as of 2009, universities are required to provide separate costing and funding for economic and non-economic activities, i.e. costs and funding have to be reported separately, and the full costs for projects of an economic nature (e.g. R&D commissions to the business sector) have to be invoiced.

– **Higher Education Pact 2020:** In July 2007, the Federal and *Länder* governments agreed on the Higher Education Pact 2020.[83] This agreement aims to ensure the availability of study programmes corresponding with demand. In addition to that, it aims to stimulate competition for research funding via the introduction of programme allowances in the form of one-off payments. Prior to the launch of the Higher Education Pact, higher education institutions themselves had to bear the overhead costs for project implementation.

About 91,000 new places in higher education were scheduled to be created in the first programme phase of the Higher Education Pact, implemented between 2007 and 2010. To these ends, the Federal Government provided EUR 566 million, while the *Länder* committed themselves to secure the general funding. In the years leading up to 2010, an additional 182,000 new students enrolled in study programmes compared with 2005.[84] In June 2009, the Federal and *Länder* governments decided to extend the Higher Education Pact until 2015. A key objective of the second programme phase is to create 275,000 additional study places, to be funded by the Federal and *Länder* governments at an average of EUR 26,000 per place. In March 2011, it was decided to provide additional resources so as to meet the short-term increase in demand for study places caused by the suspension of mandatory military service and civilian service. In addition to that, the Federal Government doubled their financing for students who had enrolled between 2007 and 2010. In the second phase of the programme, the Federal Government allocated a total of EUR 4.7 billion to advancing study opportunities in Germany.

The second component of the Higher Education Pact 2020 is the granting of programme allowances, i.e. one-off payments. Prior to the introduction of the Higher Education Pact it had been the responsibility of the higher education institutions themselves to bear the overhead costs of a project. Since the launch of the Pact, applicants of a research venture funded by the German Research Foundation (DFG) receive a programme allowance to cover indirect additional expenditures and variable expenditures relating to the funded project. This one-off payment serves as a lump sum compensation for infrastructure used in the context of the funded project (such as expenses for premises, maintenance costs, software costs or energy costs) and for individuals who are not on the project staff's payroll. The programme allowance amounts to 20 percent of direct project expenditures that are chargeable. Until December 2015, the programme allowance will be financed solely by the Federal Government. The future design of financing shall be decided on at a later stage, on the basis of a progress report to be submitted by the German Research Foundation by October 2013. The overall objective is to consolidate the funding scheme in the long term and have the federal states participate in the financing of the programme allowance.

– **Teaching Quality Pact:** In June 2010, the Federal and the *Länder* governments launched their "Programme for better study conditions and better quality in teaching".[85] The Higher Education Pact 2020 has thus been provided with a third component, in the context of which the Federal Government will grant approximately EUR 2 billion in total. The Teaching Quality Pact does not aim to enhance capacities of higher education institutions; the aim is to improve student assistance and the quality of teaching within the entire academic landscape.[86] One of the main objectives here is to improve staffing levels for teaching, student assistance and supervision and to continuously qualify existing academic personnel in higher education institutions. To a certain extent, this initiative can be regarded as a response to earlier criticism according to which the Higher Education Pact solely addresses quantitative measures caused by growing numbers of tertiary students, but does adequately account for the issue of teaching quality.

Within the course of only ten years, Germany's higher education institutions had to face the challenges associated with these reforms. Generally speaking, the extent of resources that have been made available for these purposes is insufficient. In the case of the Bologna reform, the transition process itself consumed working time of lecturers and academic staff that could otherwise have been dedicated to research and other specific tasks. Even more, the transformation of study programmes into Bachelor's and Master's programmes resulted in increased efforts in student assistance. Moreover, the Bologna process has also been characterised by a failure to systematically adapt existing academic structures to the requirements of the now relatively young first-year students, e.g. by means of introducing an orientation phase.[87]

FINANCIAL RESOURCES AND STAFFING IN THE GERMAN HIGHER EDUCATION SECTOR

B 1–4

More academic and artistic staff employed at higher education institutions

In 2010, German higher education institutions provided employment for 324,400 individuals from the group of academic and artistic staff. This group comprised 210,600 full-time employees and 113,800 part-time employees.[88] Compared with figures from 2000, the number of academic and artistic staff had increased by 105,100 persons; albeit 84 percent of this increase was attributable to part-time positions. In only 36.4 percent of cases, financing of these additional jobs was covered by basic funds – the majority of jobs were financed via public and private third-party funding as well as tuition fees. It is for these reasons that the increase in staffing levels within this group of employees was considerably higher than that of the group of professors.

BOX 03

Empirical surveys commissioned by the Commission of Experts for Research and Innovation

Qualitative survey "Heads of Universities":[89] In 2011, the Social Science Research Center Berlin (WZB) was commissioned by the Expert Commission to conduct eight interviews with research vice presidents and vice chancellors of research. Four of these interviews were conducted at higher education institutions that had succeeded in the third funding line of the Excellence Initiative (i.e. institutional strategies), and four interviews were conducted at universities that did not have an awarded institutional strategy. The aim of the survey was to find out if the current structural and organisational framework conditions facilitate or hamper the capacity of heads of universities to influence the research-related services portfolio via structures, processes, incentive systems and priority setting as part of their research strategy.

Quantitative survey "Heads of Universities":[90] In 2011, the Donors' Association for the Promotion of Sciences and Humanities in Germany *(Stifterverband für die Deutsche Wissenschaft)* conducted a full survey in the German higher education sector *("Hochschulbarometer")*. With the exception of public administration universities of applied sciences, the presidents and rectors of all of Germany's public higher education institutions were surveyed. The gross return rate for this survey was 56 percent (n=199).

Quantitative survey "Academic Research Staff":[91] In 2011, the Centre for European Economic Research (ZEW) was commissioned by the Expert Commission to conduct a quantitative survey among university professors in order to document in detail the current research situation for academic research staff. A total of 9,400 individuals were asked to participate; the return rate was 27 percent.

Quantitative survey "Non-university Research Institutions":[92] Already in 2009, the ZEW was commissioned by the Expert Commission to interview personnel at 430 non-university research organisations by means of a written survey. The aim was to collect data for analysing the tasks and structures as well as the performance and the governance of non-university research institutions.

The results of this survey have been integrated into this chapter. A more detailed analysis of the respective data is presented in the Expert Commission's studies on the German innovation system.[93]

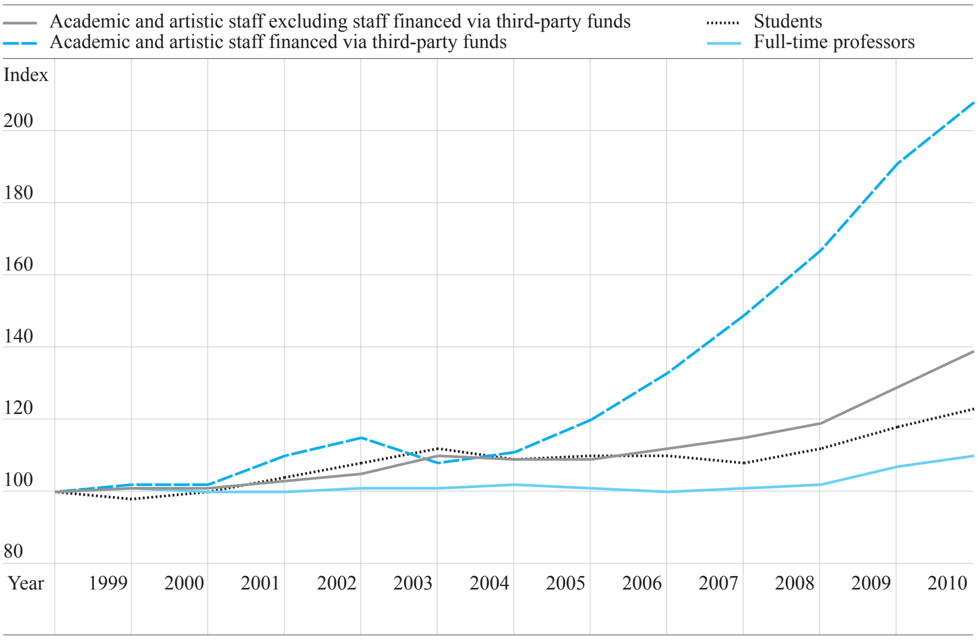
In the second half of the last decade, the increase in academic and artistic staff was significantly higher than that of the increase in student numbers. From a purely numeric point of view, the student/teacher ratio recorded by the Federal Statistical Office – i.e. the relation between the number of students and the number of academic and artistic staff – improved from 8.2 in 2000 to 6.8 in 2010. Yet, these results are misleading as improvements in staffing levels were primarily achieved via an increase in employees who were financed by third-party funding. While these employees take on research tasks, they usually refrain from teaching assignments. When deducting the personnel financed by third-party funding, it turns out that the student/teacher ratio only improved from 9.8 to 8.8 between 2000 and 2010. What is more, the student/full-time professor ratio deteriorated from 47.6 to 53.5 since the number of professors increased at a lower rate than the number of students (cf. Figure 1).

Basic funds for 2009 back to 2002 levels

In 2009, the revenue of German higher education institutions amounted to a total of EUR 38.9 billion. Of this amount, EUR 12 billion are attributable to administrative revenue from the higher education sector's medical facilities.[94] When deducting this administrative revenue derived from medical facilities, financing of higher education institutions for 2009 was composed of 73 percent basic funds, 20 percent third-party funds, and 7 percent administrative revenue.

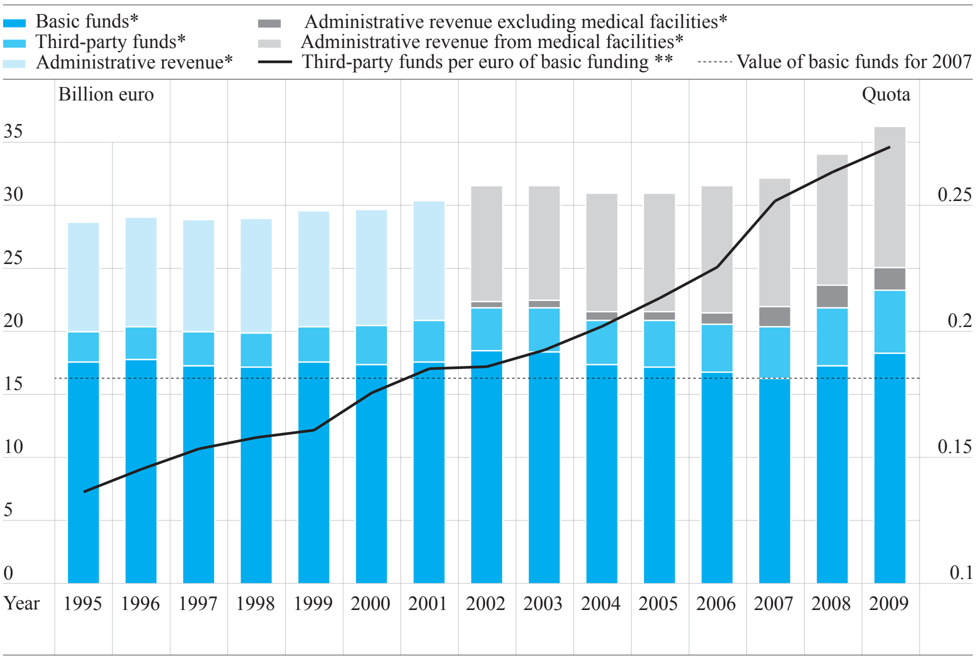
Over the last decade, the amount of basic funds was subjected to considerable fluctuations (cf. Figure 2). In 2002 for instance, extra funds from the proceeds of the sale of UMTS mobile phone licences had been made available. In the consecutive years, basic funds decreased, and in 2007 they reached their lowest point of the entire recorded period. It was only in 2009 that the level of 2002 and 2003 was reached again. The increase that has been recorded

FIG 01 **Development in the number of academic and artistic staff and students at German higher education institutions**

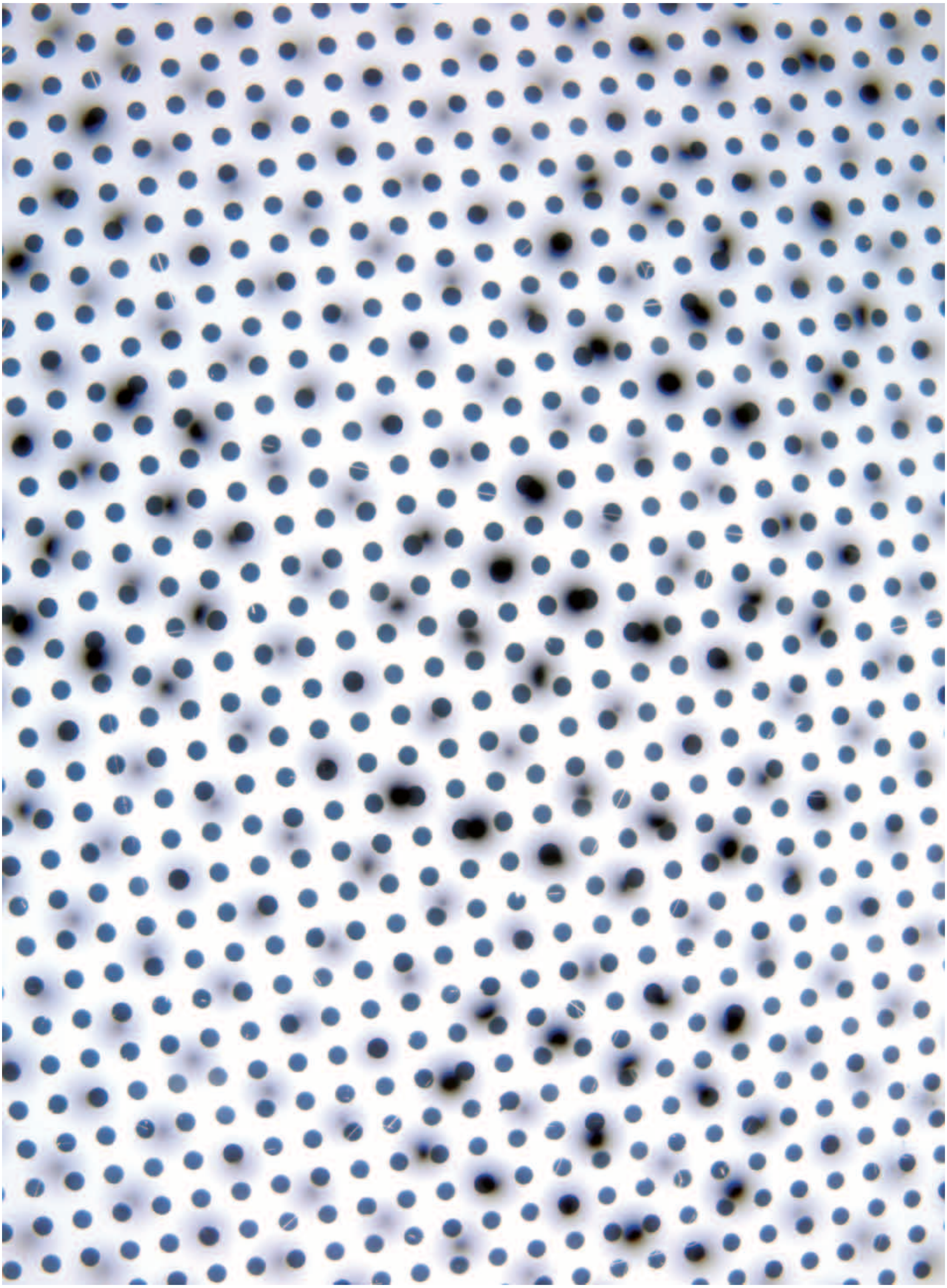


Index: 1998 = 100.
Source: Federal Statistical Office *(Statistisches Bundesamt, Fachserie 11, Reihe 4.4 und 4.1)*. Own calculations.

FIG 02 **Financing of higher education institutions in Germany**



* in billion euro at 2005 prices (left scale); ** quota (right scale).
Up until 2002, administrative revenue could not be broken down into revenue from medical facilities and revenue from other academic facilities. Revenue figures are deflated using the consumer price index. Revenue includes income from tuition fees.
Source: Federal Statistical Office *(Statistisches Bundesamt, Fachserie 11, Reihe 4.5.)* Calculations by ZEW and own calculations.



3/10 Moiré effect: dot pattern
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4/10 Moiré effect: dot and line pattern
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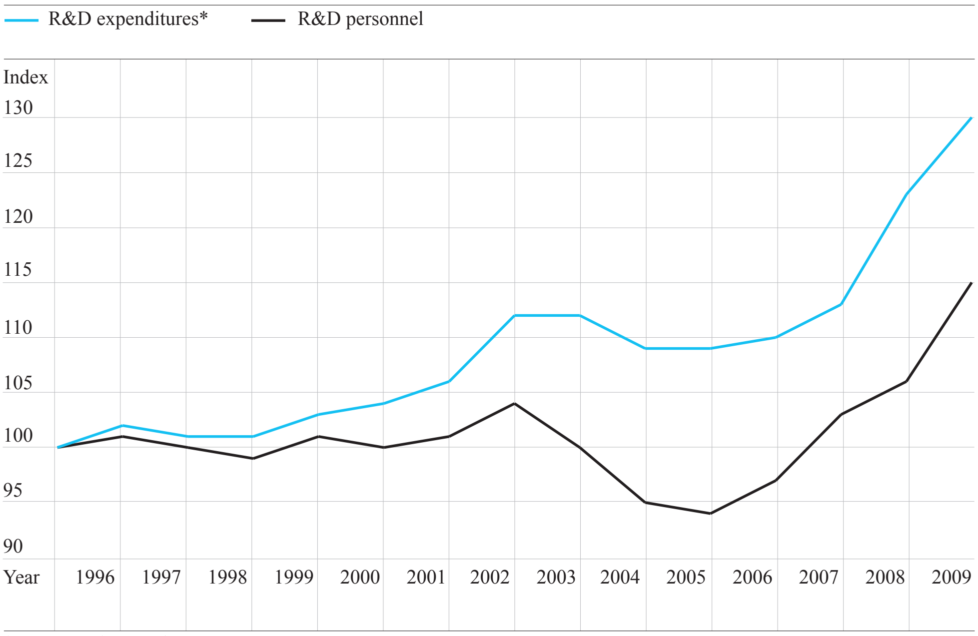
Development of R&D expenditures and R&D personnel (full-time equivalents) at higher education institutions in Germany

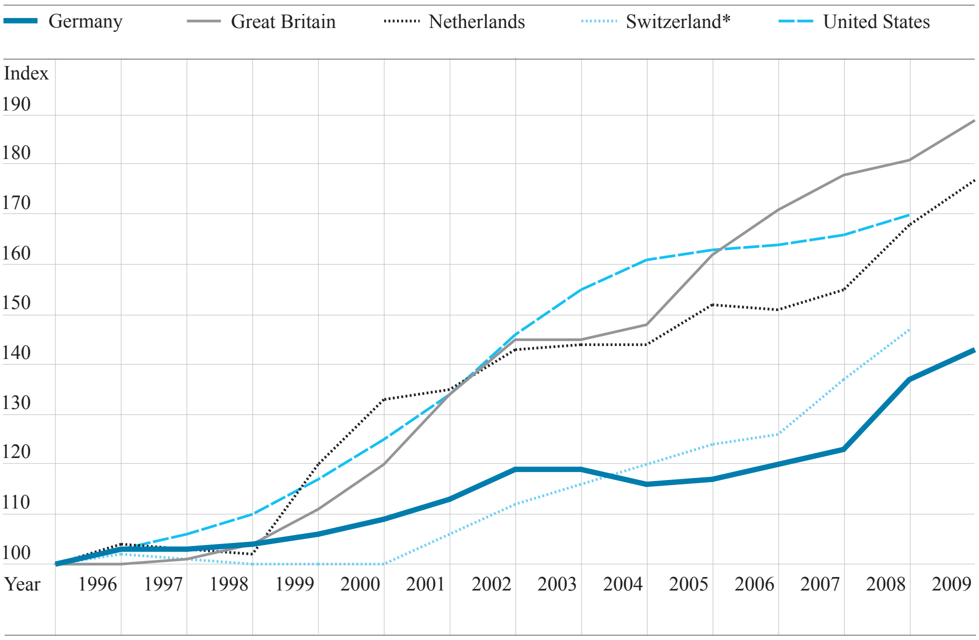
FIG 03



* at 2005 prices. Index: 1995 = 100.
Source: Federal Statistical Office *(Statistisches Bundesamt, Fachserie 11, Reihe 4.3.2.)* Calculations by ZEW.

Development of R&D expenditures (at 2000 prices) of higher education institutions 1995–2009 in international comparison

FIG 04



* Values are interpolated for odd years. R&D expenditures are deflated by applying the implicit price index of GDP (at 2000 prices). Index: 1995 = 100.
Source: OECD – MSTI 1/2011.

since 2007 is largely attributable to the launch of the Higher Education Pact in 2007.[95] At the same time, the number of students enrolled in the winter semester of 2009/2010 was 14 percent higher than in the winter semester of 2002/2003.

Overall, third-party funding has become more and more relevant when compared with basic funding. In 1995, German higher education institutions received EUR 0.14 of third-party funds per euro of basic funds. In 2009, third-party funds increased to EUR 0.27 per euro of basic funds. It is worth considering here that third-party funds can be used for financing research but not for financing teaching assignments; teaching assignments still have to be financed through the higher education institutions' basic funds.

University-based research increasingly financed via third-party funds

In 2009, German universities and universities of applied sciences invested EUR 11.8 billion in R&D and had a staffing level of 115,400 in full-time equivalents. Following a decrease between 2003 and 2005 in R&D expenditures and R&D personnel at higher education institutions, an upward trend could only be observed since 2006. This progress accelerated in 2008 and 2009: thus, in 2008 and 2009 the real growth rate for R&D expenditures of the higher education sector amounted to 9 and 6 percent respectively. Based on full-time equivalents, the higher education sector's R&D staffing level increased by 2.7 percent in 2008, and it even increased by 8.2 percent in 2009.

The proportion of third-party funded personnel of the total R&D personnel increased from 50.2 percent in 2005 to 59.2 percent in 2009. Over the same period, the proportion of third-party funded R&D expenditures increased from 41.6 percent to 46.2 percent. This increase in external funding was derived from several sources. Within this specified period, third-party funding from the Federal Government and the German Research Foundation (DFG) increased by 60 and 71 percent respectively.[96] Two factors in particular are worth mentioning here: first, the Federal Government's increase in project funding within the framework of its High-Tech Strategy, and second the Central Innovation Programme *Mittelstand* (ZIM) that was launched as part of the Federal Government's 2009 stimulus package *(Konjunkturpaket II)*. The ZIM programme aimed to promote co-operation projects between R&D facilities and the private sector. Another aspect to be taken into account was the launch of the Excellence Initiative in 2007. Between 2006 and 2009, the amount of third-party funds acquired via EU programmes increased by 29 percent.[97]

The increase in third-party funding of research has the advantage of allowing for an expansion of university-based research activities. What is more, the allocation of research funds in the context of application or competition procedures can focus to a higher degree on current quality criteria[98] – which is not necessarily the case when basic funds are allocated. Yet, the increase in third-party funding also bears risks as it limits the freedom of the researcher to a considerable extent; both in terms of time and in terms of research contents. The preparation of research proposals is very time-consuming, and proposals are reviewed by other academic staff, which means that even more time is taken up. Moreover, third-party funding is not always open to all research topics, which means that researchers have an incentive to adapt their research topics according to the funding opportunities available. As a result, research programmes with relatively low external funding prospects may not be pursued. This means that unconventional ideas may lose out, and the higher education sector is being deprived of range and diversity. These are risks that should be taken into account by political decision-makers involved. Research and teaching in the higher education sector are in need of sustainable financing structures; in the long run, too high a proportion of third-party funding will jeopardise the contributions of higher education institutions to basic research.

Progress in financing of university-based research only since 2008

Research funding at German tertiary institutions can be assessed by comparing it with the current status and development of countries that are in the forefront of higher education performance (e.g. Great Britain, the Netherlands, Switzerland, and the United States). In 2009, Germany spent 0.49 percent of GDP on university-based R&D. This value is much lower than that of the Netherlands (0.73 percent) and that of Switzerland (0.72 percent in 2008), at approximately the same level as that of Great Britain (0.52 percent) and higher than that of the United States (0.36 percent in 2008).

Between 1995 and 2009, Germany's average annual growth rate for R&D expenditures was 2.6 percent. This is lower than that of Switzerland (3 percent), the Netherlands (4.1 percent), the United States (4.2 percent) and Great Britain (4.7 percent). While higher education institutions in the compared countries further increased their R&D expenditures in the middle of the last decade, real R&D expenditures in the German higher education sector stagnated (2003, 2005) and decreased (2004). This resulted in a relative deterioration of Germany's position. It is only since 2008 that the real R&D expenditures of German higher education institutions have increased markedly.

In terms of the public financing of university-based research, Continental Europe and the Anglo-Saxon countries display different levels of participation. In Germany, the Netherlands and Switzerland the public sector provided for approximately 80 percent of research expenditures in 2008. In Great Britain and the United States, only two thirds of research activities were financed by the public sector.

Between 2001 and 2008, the proportion of publicly funded research in the higher education sector in Great Britain, Switzerland and the United States remained largely unchanged, while in Germany and the Netherlands the proportion in fact decreased. In numerous countries – Great Britain and the United States in particular – a considerable part of funding is provided by foundations, which is notably the case with the countries' leading private universities. In Germany, this funding model is also gaining more relevance, although it applies to non-university research institutions rather than higher education institutions. Compared with higher education institutions in other countries, many of the institutions in Germany are lagging behind considerably when it comes to professionalising this funding approach.[99] In Germany, there are indeed individuals with substantial private assets; assets which could be used to support science and research. Yet, the use of this source of financing is hampered by unfavourable legal framework conditions and an insufficient degree of professional fundraising structures in the German higher education sector.

SCOPE OF RESEARCH SERVICES AT UNIVERSITIES AND NON-UNIVERSITY RESEARCH INSTITUTIONS

To record the scope of research activities in the higher education sector, data relating to university[100] publication and patent activities have been compared with corresponding data from the four main non-university research institutions. These non-university research institutions are: the Helmholtz Association of German Research Centres (HGF), the Max Planck Society (MPG), the Gottfried Wilhelm Leibniz Science Association (WGL), and the Fraunhofer-Gesellschaft (FhG).[101] For certain subject domains, publication performance can only be quantified with a high degree of difficulty. Hence, the current analysis shall only integrate data from natural sciences, engineering sciences, medical sciences and agricultural sciences. The findings are as follows:

- The Max Planck (MPG) institutes are well positioned in the field of basic research. This is reflected in extensive publication activities and a relatively low level of patent activities.

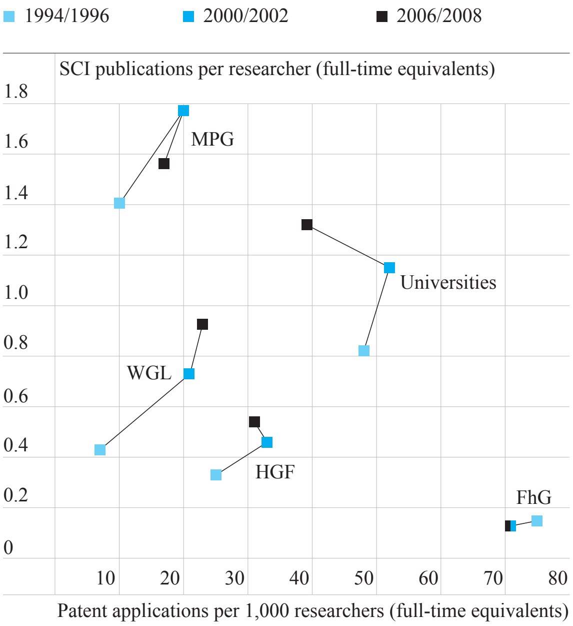
- The universities managed to significantly increase their publication activities over the last few years. In terms of publication intensity they have currently reached a level that almost corresponds with that of the MPG. Taking into account the limited resources available at universities, this is an impressive result.

- The Fraunhofer-Gesellschaft is primarily dedicated to applied research and technology transfer. This is reflected in a relatively high level of patent intensity and a relatively low level of publication intensity.

- Facilities of the Helmholtz Association (HGF) have the task of bridging the gap between basic research and applied research. Moreover, the original HGF mission is directed at research on systems based on large-scale facilities and comprehensive scientific infrastructure. In the surveyed subject domains, HGF institutes display a slightly lower publication and patent intensity than the surveyed universities.

- The Leibniz Association (WGL) is an umbrella organisation that comprises legally independent facilities. In addition to basic research and applied research, WGL facilities are active in the

FIG 05 **Patent and publications intensity of German higher education institutions and non-university research institutions in natural sciences, engineering, medical sciences and agriculture**



Figures on publications and researchers are each relating to natural sciences, engineering, medical sciences and agriculture; figures on patent applications at universities, including academic inventors of private and corporate patents, are based on estimates.
Sources: EPA: Patstat; Thomson Reuters: SCIE; Federal Statistical Office *(Statistisches Bundesamt: Fachserie 11, Reihe 4.3.2, Fachserie 14, Reihe 6)*. Calculations and estimates by ISI and ZEW.

field of information and documentation, knowledge transfer, training and continuing education, as well as advisory services to the public sector. In the surveyed subject domains, both the universities' publication intensity and the universities' patent intensity are higher than that of WGL facilities. At the same time, both the surveyed universities and the WGL facilities displayed a significant increase in publication intensity over the last 15 years.

The Expert Commission is aware of several weaknesses associated with the measures employed to assess performance.[102] Moreover, the average view provided in this analysis may serve to identify tendencies but does not allow for an assessment of individual research facilities. Thus there are indeed Fraunhofer institutes that are active in the field of basic research.[103] Similarly, the Max Planck Society has over the last few years undertaken important initiatives for the transfer of results from basic research.[104] In spite of the weaknesses of the metrics employed, Figure 5 still illustrates quite clearly the distinct profiles of non-university research institutions and universities. Moreover, it also provides evidence for the significant improvement of the universities' position.

Regardless of these positive tendencies, it is still obvious that German universities are not yet among the world's leading research universities. In terms of the number and quality of publications, German universities are still lagging behind when compared on an international scale. Thus, according to OECD, the ranking of the top 50 universities with the largest scholarly impact does not include any of the German facilities.[105] German universities have been listed in only six out of 17 academic subject domains in the respective top 50 ranking. Similarly, the Times Ranking and the Shanghai Ranking have included only one German university in their ranking of the 50 leading universities.[106] Although there are good reasons for questioning the value of such rankings, they still display a high degree of international visibility, and talented young academics and eminent scientists alike use these rankings as orientation marks. In the long term, German higher education institutions cannot afford to linger in mediocrity. In view of these considerations, the positive trend that was triggered by the launch of the Excellence Initiative should be actively continued.

AUTONOMY, GOVERNANCE AND PROFILE-BUILDING

B 1–6

Increased autonomy of higher education institutions – strengthened position of heads of universities

Since the 1990s, the co-ordination of higher education institutions has been increasingly shifted from the respective federal ministries to the head offices of the higher education institutions. By and large, the hierarchical governance and the co-ordination structures of ministerial bureaucracy have been replaced by contractual agreements. Yet, depending on the respective federal state, there continue to be differences regarding the extent to which objectives are developed in collaboration with the Federal Government or indeed pre-established by state regulations.

A survey among heads of universities and universities of applied sciences, conducted by the

Stifterverband für die Deutsche Wissenschaft[107], shows that more than half of the respondents (55 percent) would regard the degree of autonomy of German higher education institutions as "high" or "rather high". Only 5 percent of respondents felt that the degree of autonomy was "rather low". About three quarters of respondents felt that the higher education institutions' autonomy was higher today than it had been five years ago. The degree of autonomy as perceived by the interviewees varies depending on the federal state, which corresponds with earlier studies on the same topic.[108]

The implementation of new models of governance has led to major changes not only in the relationship between higher education institutions and the responsible federal ministries; it has also affected decision-making processes within the higher education sector. With respect to internal governance of higher education institutions, two distinct changes have become evident. First, the legal status of presidents and rectors as opposed to academic senates and faculties has been strengthened over the last decade; the power of governing bodies has been enhanced while academic self-government has lost some of its influence.

BOX 04

Types of governance in the higher education sector[109]

- **Hierarchical model** (Hessen and Saarland): The university management possesses at least veto rights regarding essential personnel and policy decisions; in most cases the final decision is theirs.
- **Hierarchical/council model** (Bavaria and North Rhine-Westphalia): The university management is provided with a university council as the decision-making entity.
- **Hierarchical/council/collegiate model** (Baden-Württemberg, Hamburg and Thuringia): Overall, academic self-government has the same or comparable influence as the university management and the university council.
- **Hierarchical/collegiate model** (Brandenburg, Lower Saxony and Schleswig-Holstein): The university council has only marginal powers compared with that of the university management and academic self-government. The academic senate has a considerable say in decision-making.
- **Collegiate model** (Berlin, Bremen, Mecklenburg-Western Pomerania, Rhineland-Palatinate, and Saxony-Anhalt): Governance is largely dominated by university committee structures. The academic senate has a considerable say in decision-making.

Second, heads of higher education institutions in nearly all of the *Länder* have been provided with university councils that take the role of supervisory and advisory bodies. Yet, in terms of decision-making structures, there are vast differences between the individual federal states (cf. Box 4): the extent to which major staffing and policy decisions are made by heads of universities, academic self-governments or ministries varies considerably as the federal states have each established different forms of academic governance.

In the higher education sector, structure and development plans are employed to establish an organisational framework and to map out the future shape of research. At those federal states that follow a hierarchical model, a hierarchical/council model or a hierarchical/council/collegiate model of governance, the heads of universities have substantial leeway in designing these structure and development plans. Interviews with heads of universities suggest that these seek collaboration with and the consent of academic staff in order to support their decisions.[110] In this respect, respondents regarded the respective dean of the university as their most important partner. In those federal states that have embarked on the hierarchical/collegiate model or the collegiate model, the academic senate has, with few exceptions, significant participation rights. At the same time, the interviews with heads of more hierarchical universities have shown that they, too, integrate the faculties into their decision-making processes so as to make use of expert knowledge and achieve consent among staff.[111] In addition to this, some of the higher education institutions are also establishing strategic advisory boards that comprise selected and often eminent academics. These committees are designed to consolidate specialist knowledge while at the same time legitimising management decisions within the larger institution.[112]

These new models of governance have led to major changes in the relationship between higher education institutions and the respective federal ministries, and also in the field of internal decision-making. The functioning and impact of the different models will now have to be assessed on the basis of a comparative evaluation. Ideally, such a survey should be co-ordinated on a national level; it should be based on internationally recognised criteria, and, finally, it should allow for both international and cross-regional comparison.

Enhancing profile-building and competition via the Excellence Initiative[113]

The Excellence Initiative has triggered and enhanced profile-building processes in the higher education sector. Those heads of universities who had been successful in the context of the Excellence Initiative stressed that the initiative had caused a debate on the strengths and weaknesses of the respective institution. They further stated that the initiative had led to attempts to strengthen individual faculties in the course of their application.[114] Yet, also structural strains could be observed since universities had to enter into long-term financial commitments that took up resources beyond the funding period, thereby limiting their future scope for action. For instance, this is the case if new academic staff of a Cluster of Excellence or members of a new administrative unit have been hired on the basis of open-ended contracts.[115] In the context of the Excellence Initiative, the funded Graduate Schools have also sharpened their profiles. Thus the thematic priorities of these schools have been integrated into existing research areas, or indeed serve as a solid basis for the development of a research focus.

Heads of universities of institutions that did not, or only partially, succeed within the Excellence Initiative often stated that they would motivate the academic staff that had been involved in the application to further pursue the planned ventures. Often it is the case that new funding opportunities are jointly sought, and in some of these cases the application for the Excellence Initiative even provided for a "plan B". Thus the impact of the Excellence Initiative is not limited to those universities that have succeeded in the competition; the consequences of the initiative reach far beyond the scope of participating universities.

The critical debate on excellence and competition, which has been triggered by the Excellence Initiative, has multiple effects on the character of research. In the view of the professors who were interviewed in the course of the survey commissioned by the Expert Commission, the most crucial consequences of the Excellence Initiative are as follows: research is more and more oriented towards its potential for third-party funding; interdisciplinary research topics are gaining more relevance; and, finally, there is a recent tendency for large-scale research projects.

The Excellence Initiative has forced vertical and horizontal differentiation of the German academic landscape.[116] The awarding of "seals of excellence" has led to an increased visibility of selected universities, which has a positive effect e.g. on attracting prominent scholars. But the Excellence Initiative has also initiated thematic specialisation and horizontal differentiation among universities by promoting Graduate Schools and Clusters of Excellence. In the view of the Expert Commission, both developments are crucial steps on the way to a higher education system that is internationally competitive.

Profile-building through institutional metastructures

According to the respondents, profile-building and profile-enhancing processes have been initiated in the course of the last few years. This has been done with a view to increasing the prospects for acquiring funds within the framework of the Excellence Initiative and other promotional schemes. According to the interviewed heads of universities, another reason for profile-building measures has been the need to adapt to upcoming budgetary constraints.[117] The ultimate aim of profile-building is to identify the unique characteristics and specialisations of research topics and approaches, thereby positioning oneself within the research landscape.[118] The surveys commissioned by the Expert Commission (cf. Box 3) provide an interesting insight into the ways in which profile building works. In the majority of cases, these processes are initiated by the heads of universities.[119] At the core of any profile-building process lies an analysis of the strengths and weaknesses of the respective institution. Yet, bottom-up processes have also been put in place e.g. by inviting academic staff to contribute their own ideas. The surveys also revealed that, besides health sciences, it is primarily the MINT subjects group that is gaining more and more relevance in establishing an academic profile.[120] The reason for this may be a priority treatment of this subjects group on the part of education policy-makers, but also incentive structures in third-party funding.

Profile building usually manifests itself in the identification of research focuses. This is followed by the process of defining thematic specifications that are thought to represent the individual research and competence portfolio. This means that research focuses can be regarded as institutional metastructures which span across faculties and departments and are designed in an interdisciplinary way. The university's underlying organisational structure, i.e. its division into academic disciplines, remains unaffected by this; a clear division into academic disciplines is still regarded as a necessary prerequisite for successful interdisciplinary work.[122] Irrespective of an institution's thematic focus, basic research is an extraordinarily important factor in profile-building processes.

BOX 05

Institutional metastructures: an example

The Centre for Renewable Energy (ZEE) at the Albert Ludwigs University of Freiburg:[121] The ZEE is a key research institute of the University of Freiburg that brings together all those academic entities that conduct research and teaching on issues relating to renewable energy; with a special focus on solar technologies, biomass production, biomass utilisation, geothermal energy, energy systems, and energy efficiency. The aim is to illuminate the technological, economic and social implications of renewable energy. To date, seven out of eleven faculties are participating in ZEE activities. On the basis of co-operation agreements, the ZEE closely collaborates with non-university research institutions. ZEE partners are the *Forstliche Versuchs- und Forschungsanstalt Baden-Württemberg* (FVA), the Fraunhofer Institute for Solar Energy Systems (ISE), the Offenburg University of Applied Sciences, and the *Öko-Institut e.V.*

The winter semester of 2008/2009 saw the launch of the new international Master's programme "Renewable Energy Management", in collaboration with the Faculty of Forest and Environmental Sciences of the University of Freiburg. In addition to that, "Photovoltaics", a Master's programme for working professionals, was introduced in co-operation with the Faculty of Engineering of the University of Freiburg and the Fraunhofer Institute for Solar Energy Systems.

Often enough, the defined research focuses are allocated with additional financial resources that serve as a type of "initial funding", both for internal use (development of new research topics within the research focus) and external use (development of research focuses within the higher education institution). Once this consolidation period has been completed, in many cases the aim is to finance the research focus via third-party sources alone. Some of the higher education institutions have already evaluated their research focuses on an internal basis; others have not been active in this regard yet. Preliminary findings suggest that the development of research focuses as a means of profile building and attracting eminent researchers is showing its effect even at this stage. In many cases research focuses have only been defined in the course of the last few years. Hence, it remains to be seen if the newly created structures can stand the test of time and sustainably shape the profile of the higher education institutions involved.

APPOINTMENT POLICIES, REMUNERATION AND RESEARCH CAREERS

B 1–7

Enhancing flexibility in appointment policies

In 2009, a total of 22,109 university professors were employed in the German higher education sector, while the number of published vacancies amounted to 1,856 positions. The average annual renewal rate for 2009 was thus 8.4 percent.[123] The appointment of professors can have a major impact on a university's profile building in research and teaching. Meanwhile, in eleven of the German federal states, the right to appoint professors has been transferred from the respective *Länder* authorities to the heads of the higher education institutions; this was achieved by amending the state laws for higher education. Only in Baden-Württemberg, Bavaria, Berlin, Bremen and Rhineland-Palatinate are professors still largely appointed by the respective federal ministry. Heads of higher education institutions who are entitled to appoint professors can sharpen the profile of their institution via strategic appointment policies. Only occasionally do heads of universities make use of this right in order to strategically strengthen certain departments through their appointment decisions, sometimes at the expense of other departments. Some of Germany's higher education institutions feed a fixed quota of vacant professorship positions into a university-wide pool of vacancies, which are then redistributed via an internal competition as a means of strengthening their profile.[124]

Appointment procedures in the German higher education sector can develop into rather lengthy procedures that are often perceived as non-transparent. One distinct feature of universities that are particularly successful on an international scale is their more centralised, professionalised approach to appointment procedures. Nowadays, the German higher education sector also provides for more active approaches to appointing professors.[125] These are search processes that are employed to identify and address individuals that seem suitable for the position. The Expert Commission is generally in favour of applying such search processes. However, when attempting to shorten these processes, suitable methods should be employed to avoid that an accelerated process results in a further decrease in transparency or jeopardises international academic quality standards.

Remuneration and performance-related benefits

In the past, university professors in Germany had been paid according to the "C remuneration" scheme, a model that provides for different salaries depending on a person's years of service to the state. In 2005, this model was replaced by the "W remuneration" scheme, a system that allows for variable performance-related benefits for W2 and W3 professors, in addition to their fixed basic salary.[126] In North Rhine-Westphalia for example, the monthly basic salary of a professor amounts to EUR 5,279.[127] Among the different federal states, vast differences can be observed: thus a W3 professor in Baden-Württemberg receives a monthly basic salary of EUR 5,529, while a W3 professor in Berlin receives EUR 4,890.[128]

Performance-related benefits according to the W3 scheme can be divided into three categories: recruitment and retention awards, special performance-based benefits, and additional service compensation.

– Recruitment and retention awards can be used by higher education institutions as a means of attracting exceptional scientists and artists, or, respectively, as an incentive for them to remain at the university. Higher education institutions are thus provided with a tool that enables them to force appointments that are regarded as particularly valuable in terms of profile building.

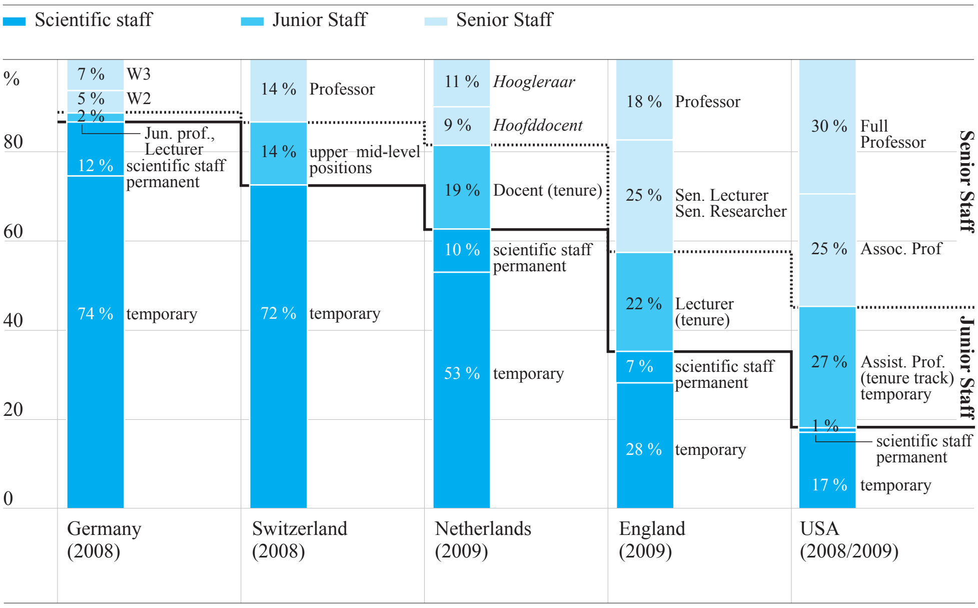
– Special performance-based benefits and additional service compensation provide incentives for professors to excel in the fields of research, teaching, further training, arts, and the recruitment of young academics, and to take on roles in academic self-government.

The criteria according to which performance-related benefits are granted are at the discretion of the federal states and the higher education institutions. In many cases, a phased model has been put in place.

The W remuneration model cannot compete on an international level.[129] The annual basic salary of a W3 professor in North Rhine-Westphalia is EUR 68,627 (based on a 13 month salary, excluding performance-related benefits). In the United States, a university professor receives an average annual salary of USD 110,488 (approx. EUR 84,200). At private higher education institutions, the average salary even amounts to USD 131,589 (approx. EUR 100,300), and professors employed at high-ranking universities such as Harvard or Stanford can earn as much as USD 240,000 (approx. EUR 182,800).[130] This goes to show that universities can only attract internationally renowned academics and artists if they are able to grant them substantial bonuses. The basic salary in combination with performance-related benefits will have to compete with salaries granted at world-class universities – and not with average salaries. In Germany, the Federal Pay Act (BBesG) specifies an upper limit for performance-related benefits. This ceiling is defined by the difference in basic salary between the W3 remuneration group and the B10 remuneration group. In North Rhine-Westphalia, this difference amounts to approximately EUR 6,246 per month.[131] Performance-related benefits may exceed this amount particularly in cases where this is deemed necessary for attracting a professor from outside the German higher education system, or for the purpose of averting the outmigration of a professor from the German higher education sector.[132] Yet, due to the requirement of budget neutrality,[133] higher education institutions may grant high

Full-time academic personnel in universities
(figures in percent)

FIG 06



Rounding errors Netherlands
Source: Kreckel (2008; revised); Kreckel (2010): 38 f.

Relevance of different modes of collaboration according to university professors and heads of non-university research institutions
(multiple answers were allowed; figures in percent)

TAB 03

	Higher education institutions	**Non-university research institutions**
Joint research	43	66
Staff from non-university research institutions holding a professorship	17	41
Joint academic events	16	23
Joint student mentoring	15	44
Staff from non-university research institutions holding academic events	15	37
Joint doctoral programmes	14	32
Participation in committees of non-university research institutions	9	–

Proportion of interviewees who allocated highest relevance to the respective modes of collaboration
Sources: *ZEW-Hochschulforscherbefragung 2011; ZEW-AUF-Befragung 2009.*

BOX 06

Junior professorships and tenure track careers

2002 saw the launch of junior professorships in Germany, a title that can be granted provided that a doctoral thesis has been completed. The aim is to provide young academic talents with more flexibility and responsibility at an earlier stage in their career as this would be the case when pursuing the regular path of a post-doctoral academic career. At this stage in time, both models, i.e. junior professorships and W professorships, are still applied in parallel.

Tenure track refers to academic careers that are offered to young scholars following successful evaluation. The candidate is then supplied with a permanent position at the respective higher education institution. As part of the tenure track model, academic achievements of the candidate are evaluated twice. The first evaluation usually takes place after approximately three years into the person's tenure track career, and the second after approximately six years, i.e. at the end of the temporary contract.

performance-related benefits only within the limits of the resources at their disposal: if a professor is granted a particularly high remuneration, this will narrow the scope of action regarding further appointments and the granting of performance-related benefits to other academic staff.

Obviously an international comparison of the remuneration of professors is not without problems. Factors such as differences in the social system – particularly with regard to health insurance and old age pensions – as well as differences in tax levels and income-related purchasing power have to be taken into account. Yet, when refining the method of comparison, it still leads to the result that salaries of professors in Germany are lower than those of analogue countries such as the Netherlands, Switzerland, the United States or Great Britain.[134]

Limited career options for young academics

In the German higher education sector, only a small part of the academic mid-level positions can be attributed to junior staff, i.e. full-time professional teaching staff situated below the peak group of professors. Only 2 percent of personnel in the German higher education sector are junior professors or lecturers, while the proportion of junior staff in the United States' higher education sector amounts to 27 percent. While these positions in the United States are temporary posts, continued career options are made available in the form of tenure track careers (cf. Box 6), provided that the candidate has proven successful in his or her job. In Germany, the tenure track model has only been rarely applied to date.[135]

Over the last few years, the number of temporary mid-level positions in the German higher education sector has been increased – this however was done without increasing the number of W3 and C4 professorships to the same extent. This means that, from the perspective of young academics, the prospects of getting a permanent position in Germany are rather low. In international comparison, German universities have only insufficient means of attracting and keeping young academic talents as tenure track models are not widely offered in Germany. As a prerequisite for establishing a broad-based tenure track system in Germany, a sufficient number of vacancies have to be available; this is currently not the case. Furthermore, academic labour markets would have to develop in order to cater for post-doctoral candidates who have entered tenure procedures, and for those who did not succeed in the tenure procedures. In Germany, such labour markets still only exist in underdeveloped form.

CO-OPERATION AND COMPETITION WITH NON-UNIVERSITY RESEARCH INSTITUTIONS

B 1–8

Co-operation with non-university institutions are becoming more and more important

In the view of the heads of universities surveyed, collaborations between higher education institutions and other stakeholders have become more important over the last few years. Particularly relevant in this regard are collaborations with non-university research institutions.[136] Heads of universities feel that co-operations with Max Planck institutes and Leibniz institutes are especially important. The reason for this is that the universities' research programmes are primarily focussed on basic research, a field that is highly compatible with those of the institutes mentioned above. According to the interviewees,

BOX 07

Institutionalised forms of collaboration between higher education institutions and non-university research institutions

Göttingen Research Council (GRC): By launching the GRC in 2006, the University of Göttingen and seven non-university research institutions – the Göttingen Academy of Sciences and Humanities, five Max Planck institutes and one Leibniz institute – institutionalised their history of collaboration. GRC is a co-ordinating body and a platform for achieving decisions by consensus. On central issues with transorganisational relevance, the different facilities co-operate while maintaining their institutional independence and internal governance structures.

Karlsruhe Institute of Technology (KIT): The KIT is a merger of the University of Karlsruhe and the Karlsruhe Research Centre (FZK), a research body that is a member of the Helmholtz Association. In July 2009, the state parliament of Baden-Württemberg passed the "KIT Merger Act", thereby sealing Germany's first institutional merger of a university and a non-university research institution. On the basis of an elaborate legal framework, the formerly independent entities are now part of joint governance structures. The funding structures of these two former entities had been very different; not least due to the fact that the Karlsruhe Research Centre had been receiving considerable funding from the Federal Government. The KIT will be maintaining its internal division between a university sector a nd a large-scale research sector. These two areas are closely linked via joint fields of expertise, joint centres and thematic focal points.

Jülich-Aachen Research Alliance (JARA): JARA is a joint venture between RWTH Aachen University and the Jülich Research Centre, which is a member of the Helmholtz Association. In JARA, no attempts were made to fully merge the university and the non-university research institution. The "JARA agreement" merely provides a formal framework for establishing joint topic-related sections. Each of these "JARA sections" is jointly managed by a director from the Aachen side and a director from the Jülich side. The four research areas that are currently in place within this framework represent the heart of the co-operation between the two institutions. In addition, the management levels of the RWTH Aachen and the Jülich Research Centre have also been integrated further.

The Charité University Hospital Berlin and the Max Delbrück Center for Molecular Medicine (MDC): The Charité and the MDC at Berlin-Buch, a research centre belonging to the Helmholtz Association, are planning to expand their collaboration, which includes, among other things, a closer organisational integration. In their coalition agreement for the federal state of Berlin, the Social Democrats (SPD) and the Christian Democrats (CDU) state the following: "The coalition intends to enter negotiations with the Federal Government, based on exploratory talks between the Berlin Senate and the Federal Government, with the aim of launching a pilot project before the year 2018. This pilot project comprises the merging of the research areas of the Charité University Hospital and the Max Delbrück Center for Molecular Medicine Berlin-Buch (MDC) under the umbrella of the Helmholtz Association."[137]

co-operations with Helmholtz institutes primarily enable higher education institutions to make use of costly research infrastructures. With the exception of the universities of applied sciences, collaboration with Fraunhofer institutes seems to be considered less relevant for the strategic focus of the higher education institutions.

For the higher education institutions, the key rationale for collaborating with non-university research institutions lies in the research itself and in the opportunity to obtain reputable third-party funding. In addition to that, close collaboration with regional facilities is regarded as crucial for reaching a critical mass in the context of the Excellence Initiative.[138] Thus, collaboration at a regional level leads to an expansion of research fields, creates opportunities for recruiting top scientists, improves a university's research infrastructure through the use of non-university facilities, and, finally, provides a basis for improved teaching and theses supervision.

When engaging in collaborations, the primary focus for both university professors and heads of non-university research institutions are joint research ventures (cf. Table 3).[139] For the heads of

BOX 08

Freedom of Science Act[140]

Key improvements brought about by the Freedom of Science Act comprise the following:

1. The introduction of global budgets and more flexible budgetary framework conditions: e.g. abolition of staff plans, the expansion of defined areas to which the organisations may allocate funding (staffing, material, and investment), as well as a substantial expansion of the proportion of funding amounts that the organisations manage under their own responsibility, with the aim of carrying over budgets into the consecutive year.
2. Improved conditions for attracting the best minds: a step-by-step abolition of the assignment framework *("Vergaberahmen")*, abolition of approval requirements for W professorship positions, as well as further developments in the terms of employment.
3. Simplified conditions regarding stakes in undertakings, collaborative projects and the launch of spin-offs in Germany and abroad.
4. Simplified construction of facilities for the science sector; science organisations have been given more responsibility in the field of construction. Regulations for simplified, modernised construction procedures for FhG and HGF will be adapted to the regulations that apply to MPG building procedures.
5. Facilitation in the regulation for procurement of goods and services: removal of administrative barriers; free choice in terms of procurement procedures for all suppliers and service providers.

non-university research institutions, other aspects are also highly relevant: these include the joint mentoring of students and doctoral candidates as well as joint appointment procedures and co-operations in the area of lectures and seminars. Thus it appears that for scientists at non-university research institutions there are more incentives to co-operate than for academic staff at higher education institutions.

In its Annual Report 2011, the Expert Commission expressed the view that a stronger integration of university-based and non-university research could improve Germany's competitive edge as a science location. Over the last few years, a number of promising types of institutionalised collaboration between higher education institutions and non-university research institutions have been established (cf. Box 7). Yet, the development of efficient co-operation models is currently being hampered by differences in funding formulas employed by non-university research institutions.[141]

The Expert Commission expressly welcomes these forms of collaboration as they can be regarded as promising experiments for integrating complementary elements of university-based and non-university research. At the same time, one might assume that in some cases these models are used as vehicles for bypassing restrictions for Federal/*Länder* joint research funding; restrictions that had been established by the Federalism Reform I. To achieve sustainable solutions, comprehensive policy measures are needed. Therefore the Expert Commission reiterates that the Federal Government should be re-enabled to engage in regular institutional funding of higher education institutions.

Creating comparable conditions for higher education institutions and non-university research institutions

Germany's higher education institutions do not solely engage in collaborations with non-university research institutions; in some cases, these two types of research entities do in fact compete with each other. However, this competition is characterised by distorted competitive conditions. The Federal Government has initiated the "Freedom of Science Act" initiative, a scheme that seeks to improve the framework conditions of the science system while also improving Germany's attractiveness in the international competition for science and innovation locations (cf. Box 8). The Expert Commission is very much in favour of this initiative. Currently, the "Freedom of Science Act" only applies to non-university research institutions (FhG, MPG, HGF, and WGL) as well as the German Research Foundation (DFG).[142] Due to the fact that the federal states are largely responsible for research in the higher education sector, university-based research has been virtually exempted from these improvements. In the view of the Expert Commission, these limitations should be lifted as soon as possible.

B 1–9 KNOWLEDGE AND TECHNOLOGY TRANSFER; PATENTING IN THE HIGHER EDUCATION SECTOR

Minor role of knowledge and technology transfer to date

In its earlier reports, the Expert Commission already stressed that the transfer of findings plays an increasingly important role in knowledge-based economies. The transfer to relevant groups of society and the transfer to companies are particularly relevant here. Yet, only a small proportion of interviewed university professors perceived the transfer of knowledge to the private sector as a substantial part of their academic work.[143] According to the interviewees, scholarly research is primarily directed at the respective academic community of the researcher. Scientific publications, academic lectures and collaborative projects are regarded as the key transfer channels to the private sector. Other forms of transfer such as advanced training, advisory services or the launch of spin-offs are regarded as key channels by only a small number of interviewees. The findings of the survey confirm the notion that university professors regard transfer activities as very important only if they are accompanied by research activities. Yet, there is a notable exception to this pattern: academic staff from universities of applied sciences frequently stated that companies were indeed important addressees of their research findings.[144] The surveyed heads of selected higher education institutions largely confirmed the views expressed by the interviewed university professors. Nonetheless, higher education institutions with a technical focus regard technology transfer and collaborations with the private sector as relatively important.[145]

Mixed results for the work of patent exploitation agencies

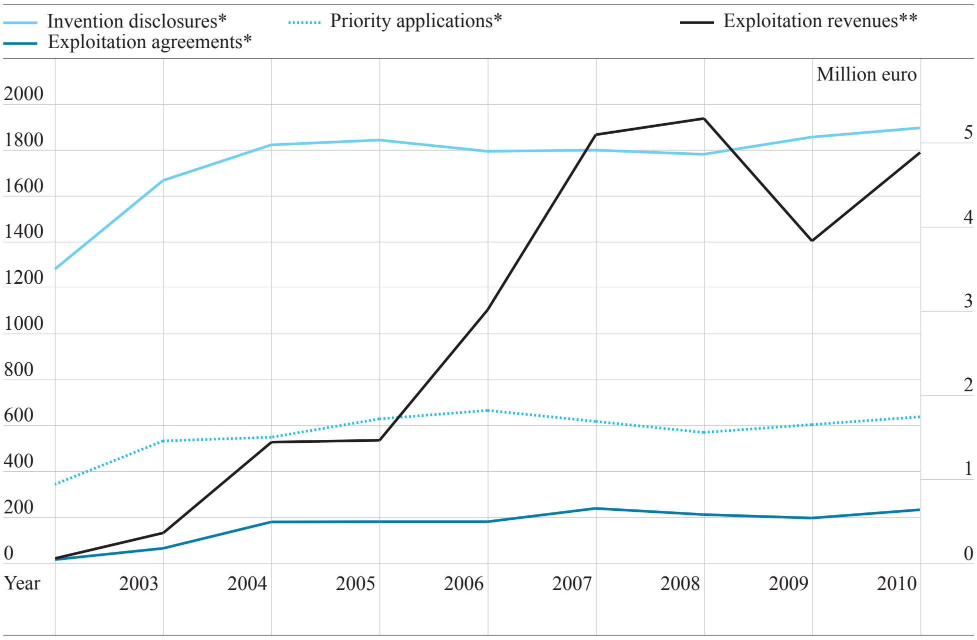
Following the abolition of the university teachers' privilege, agencies for patent exploitation were established in Germany's federal states. These patent exploitation agencies operate as external, largely independent service providers and usually work for only one regional higher education network *(Hochschulverbund)*, without any overlapping. Due to this, agencies have adapted their thematic specialisation to the services portfolio of the higher education institutions they are in charge of. Given these organisational structures, there is no direct competition between the individual patent exploitation agencies.[146]

Whether or not Germany's patent exploitation agencies have a positive impact on the higher education sector's overall exploitation activities is yet unclear. Figure 7 shows the development of inventions documented by the agencies and patent applications and exploitation cases managed by the agencies. About one out of three registered inventions documented by an agency leads to a patent application. Unsurprisingly, the number of invention disclosures and patent applications by higher education institutions has substantially increased since 2002, while the first three years after the abolition of the university teachers' privilege were especially dynamic. Since 2005, the number of patent applications has largely consolidated, having reached a consistent level of approximately 600 priority applications per year. A similar trend could be observed for the number of exploitation agreements, albeit with more fluctuations over the years when compared with the development of patent applications. Following a moderate increase in the starting phase, the patent exploitation agencies managed to significantly increase their exploitation revenues after 2005. In 2010, exploitation revenues amounted to EUR 4.9 million.

In spite of this increase, Germany's patent exploitation agencies do by no means operate on a cost-covering basis; and it is highly likely that also in the future they will still be dependent on public basic funding.[148] When looking at comparable models in other countries, it appears that even long-established exploitation systems such as those that can be found in Great Britain or the United States are still making a loss after 15 or even 30 years. Nevertheless, both countries still hold on to their systems as the long-term macroeconomic welfare effects are perceived as higher than the costs incurred by the transfer agencies.[149]

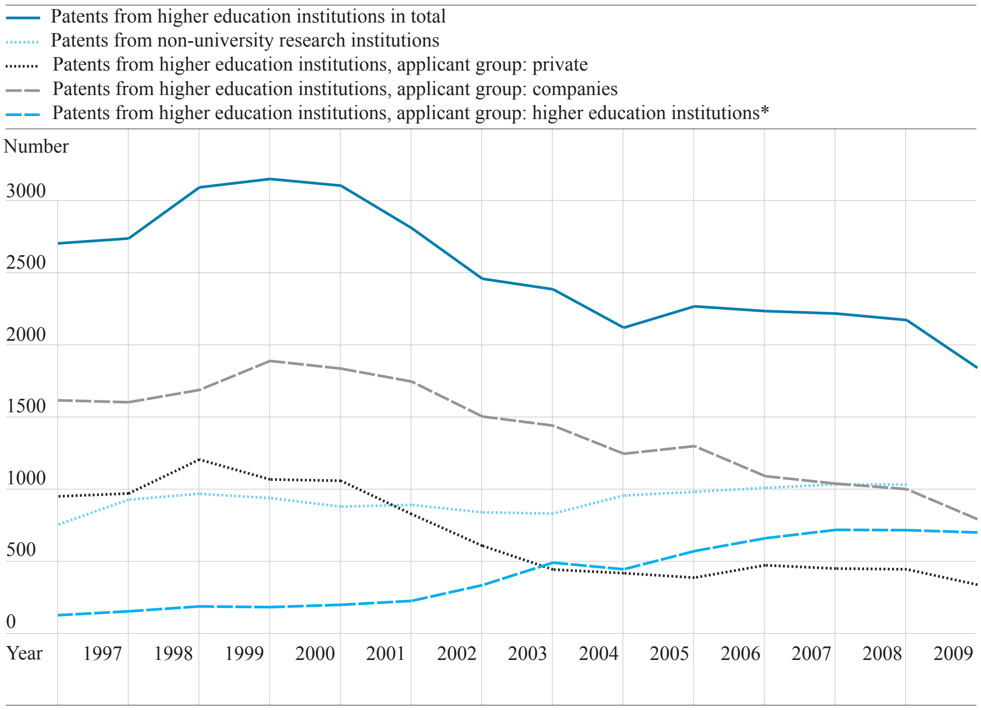
But not only the patent agency system as a whole is difficult to assess; a comparative assessment of German patent exploitation agencies is also difficult to conduct per se. This is due to the fact that (regional) higher education networks have different organisational structures, which is partly owing to their individual thematic specialisation. What is more, there are also substantial differences in terms of an agency's geographical and thematic proximity

FIG 07 **Invention disclosures, priority applications and exploitation relating to patent exploitation agencies**



* Number (left scale); ** in million euro (right scale).
Source: Project Management Jülich (PTJ). Own calculations.

FIG 08 **Published patent applications from higher education institutions in total and according to applicant groups; patent applications from non-university research institutions[147]**



Assumptions: 40 percent of inventors of patents within applicant group "private" or "company" are higher education staff other than professors; 20 percent withdrawal rate before disclosure.
* Due to differences in parent populations, annual figures slightly deviate from the values displayed in Figure 7.
Source: PATDPA. Research, calculations and estimates by Fraunhofer ISI.

to the higher education institution it is in charge of. Finally, the financial returns from patent exploitation are often only partially attributable to the agency's work and that of the inventor; they are also resulting from market developments, a factor that is generally difficult to predict.

Decreasing number of patent applications from university-based inventions

Not all of the patents that inventors from the higher education sector participate in are filed by the higher education institution itself.[150] Depending on circumstances, the patent may also be filed by the inventor or by a collaborating company. The inventor is entitled to file a patent in their own name provided that the higher education institution has released the employee's invention.[151]

Patents from the higher education sector that are filed by companies may emerge from different types of collaboration between a higher education institution and a company:

- The company has commissioned the higher education institution with an R&D project. In such a case, the company has borne all the costs associated with the development of the invention and is the owner of the intellectual property rights.
- The higher education institution has transferred their rights in the invention to the company, against payment of a fee (at the market rate).[152]
- The inventor is a full-time employee at the company that filed the patent and at the same time an honorary professor at a higher education institution.[153]

To monitor the frequency of these different scenarios, several assumptions and estimations will have to be made first. The results of these estimations are shown in Figure 8.[154] Following the abolition of the university teachers' privilege, the annual number of filed patents increased. However, during the same period, the number of patents filed by private persons or companies but originating in the higher education sector decreased. The university professors now had to report their inventions to their higher education institution and could not file a patent individually, as had been the case prior to the new legislation. Hence, a decrease in patents filed by private persons was to be expected; potential patent applications would now be filed by the university or the respective patent exploitation agency. Still, the decrease in applications of higher education patents by companies should be investigated in more detail. The question is whether a causal link exists between said decrease and the abolition of the university teachers' privilege and the establishment of patent exploitation agencies; or indeed, if other factors appear to be relevant here.

Overall, the number of patent applications from higher education institutions has decreased after the abolition of the university teachers' privilege. Yet, it should be noted that the decrease in applications had started much earlier than 2002. This does not apply to the four large non-university research institutions, which have been recording relatively stable numbers since the mid-1990s. Based on this observation, it could be presumed that the exploitation of inventions from the higher education sector is based on mechanisms that fail to lead to optimum results. In any event, it seems obvious that to date the 2002 reform has not resulted in increased patent activities in the higher education sector. Neither has the qualitative progress of patents been investigated – an aspect that is quite important as the commercial and technical relevance of intellectual property rights may vary significantly.

RECOMMENDATIONS OF THE EXPERT COMMISSION

The Federal Government should re-enable institutional funding of higher education institutions

The expansion of Germany's innovation system is largely dependent on a highly developed academic research landscape. While important progress has been achieved, Germany's higher education institutions are still disadvantaged – not only compared with leading international competitors, but also compared with German non-university research institutions. These impediments to the higher education sector will have to be overcome as soon as possible. Considerable improvements could be achieved by amending and simplifying Article 91b (1) of the German Basic Law, which should stipulate the option of funding "facilities and ventures".[155] In the history of the Federal Republic of Germany, a total of

58 amending statutes to the Basic Law have been adopted to date. The proposed modification of Article 91b would be an extremely useful measure that would lead to substantial improvements for Germany as a science location. Against this background, the Expert Commission is in favour of modifying the Basic Law and re-introducing regular institutional funding in the higher education sector.

Expanding the "Freedom of Science Act" initiative to the higher education sector

The Federal Government has launched the "Freedom of Science Act" initiative, and the Expert Commission welcomes this move. To strengthen university-based research in international competition and to avoid higher education institutions being disadvantaged compared with non-university research institutions, the Expert Commission recommends expanding the provisions of the "Freedom of Science Act" to the higher education sector. The initiative should be adopted step by step and in close collaboration with the federal states.

Scopes for development within the science sector should be expanded continuously, and the deregulation process that has been put in motion should be continued in all relevant fields of higher education. The long-term objective should be to create full financial autonomy for higher education institutions, with follow-up accountability. Global budgets should become the norm.

Strengthening autonomy in the higher education sector while advancing competition and differentiation

In spite of considerable progress, higher education planning in Germany is still based on a largely hierarchical pattern. For many years, competition and differentiation had played only a marginal role in this. The Excellence Initiative and other political reforms have guided the higher education sector towards a more competitive, profile-oriented system. These adjustments deserve continuous support from the political stakeholders. There is still a long way to go to achieve a diverse, heterogeneous academic landscape. Besides, Germany's higher education institutions will have to take on a more active role in the field of further training (cf. Chapter B2), an important new area of responsibility for higher education institutions.

Strengthening basic funding of the higher education sector

The Expert Commission welcomes the improvements that have been achieved in the financing basis of Germany's higher education institutions since 2006. However, the fact that these improvements are largely based on an increase in third-party funding entails certain threats to the system. University-based research should be enabled to regain its long-term orientation. This is one of the main reasons why institutional funding by Federal and *Länder* governments should be re-introduced as this would provide for a balance between project-based and institutional research. Furthermore, foundations could take on a more prominent role for the higher education sector than has been the case in the past. Here, the Federal Government should strengthen the legal position of foundations and introduce tax concessions for foundations. This would include improved options for ploughing foundation assets back into the higher education sector, and improved tax credits for endowments.[156]

Enhancing professionalisation of research organisations

Higher education institutions have an obligation to make use of their autonomy and financial scope. The German higher education sector is still characterised by a high degree of bureaucracy and a lack in professionalised administrative structures. The results of the surveys clearly demonstrate that a surplus of administrative activities undermines the advance of research. A stronger professionalisation of the higher education sector is currently being hampered by a faulty salary scheme for administrative staff and leading university management. Furthermore, the extent of available training for careers in higher education management is still insufficient.[157]

In this context it is also worth discussing the internal organisational structure of the higher education institutions' faculties. If one disregards the exception of Switzerland, it can be observed that none of the compared countries, i.e. the Netherlands, the United States and Great Britain, have embarked on the chair principle. Instead, the higher education sectors of these countries are based on a departmental structure. As a result, research teams are not centred on chairs but are assembled especially for academic research projects (often with a long-term outlook). Due to this, the creation of new professorships is usually less expensive than it is in Germany, and the creation of tenure track positions is also associated with smaller follow-up costs. German higher education institutions should enhance their efforts in testing models like these. This does not mean however that organisational structures should be prescribed – instead, independent higher education institutions should be given the opportunity to find organisational structures that best fit their scope of services.

Improving the attractiveness of research careers in German higher education

The growth pattern of Germany's higher education institutions is lacking in balance and sustainability. From a careers perspective, financing of higher education institutions must be reconsidered: any university that is competing for the best talents has to be able to offer attractive research careers. The Excellence Initiative has indeed managed to advance Germany's position in direct competition with universities in other countries. Despite this progress, Germany is still lagging behind: research careers at German higher education institutions are difficult to plan, and opportunities for permanent employment in research are lower than in international comparison. In many other countries, the prospects of obtaining an open-ended contract that entails a high degree of research autonomy are better than those in Germany. To complement the junior professorship model, Germany should test tenure track models to a much larger extent. In addition to this, the number of W2 and W3 professorships should be increased as this would make it more realistic for talented academics to obtain an attractive position in an ever more competitive environment.

The Expert Commission believes that academic careers should not be planned around one and the same higher education institution, from the doctoral phase to professorship. Yet, a strict ban on internal appointments of post-doctoral candidates who completed their doctoral thesis at another institution does not seem to lead to the desired results, and it also hampers the introduction of tenure track models. It would make sense indeed to require at least one change of institution on the way from doctoral thesis to post-doctoral thesis; yet the actual time of transfer should be kept flexible.

Increasing the higher education sector's contributions to innovation

Higher education institutions can provide important contributions to the transfer of findings. The transfer of knowledge and technology, which is particularly relevant for innovations, can be achieved in different ways, e.g. via spin-offs, via the licencing of patents, or via private-public research partnerships. At the moment, all of these three options remain somewhat underused. Regardless of its positive impact, the Excellence Initiative has in fact led to a reverse development: instead of integrating aspects of knowledge and technology transfer into their scheme, Germany's policy-makers have launched parallel promotional tools such as the "leading-edge clusters" and the "research campus" programmes.

Universities have the privilege and the task to engage in research that is unrelated to concrete practical application. Yet, as soon as opportunities for practical application emerge, higher education institutions should make an effort to strategically promote these opportunities. This may require elaborate political skills on the part of the university management – in some fields of research more than in others. While scientists in engineering consider knowledge transfer as an almost natural aspect of their research activities, other fields of study are characterised by a more reluctant attitude. In some of the academic fields, the idea of closely collaborating with external partners and businesses in particular is often met with strong concerns. These reservations will have to be overcome.

The German legislator has the responsibility to promote the innovative impact of findings derived from basic research. The Federal Ministry of Education and Research (BMBF) and the German Research Foundation (DFG) have created instruments to achieve this. Thus, the BMBF "research campus" programme has received numerous applications, a fact that is welcomed. On the part of the DFG, funding opportunities for information transfer have also been established, and the Federal Ministry of Economics and Technology (BMWi) has created incentives for supporting the launch of spin-offs via its promotional programme “EXIST”. These measures demonstrate that Germany is moving in the right direction. Taking into account the diversity of instruments available, it now seems necessary to conduct a system evaluation of this area. In the context of such assessment, it should also be investigated why the abolition of the university teachers’ privilege has yet failed to produce the positive impact envisaged by the political stakeholders involved.

Swiftly paving the way beyond the Excellence Initiative

The expiry of the Excellence Initiative is due to create major challenges for Germany’s higher education institutions. Major research programmes and newly established research bodies should be maintained to guarantee the long-term success of measures. That said, political concepts that would cater for the period following the termination of the Excellence Initiative are not in place. The emergence of several new types of co-operation (e.g. in Karlsruhe, Aachen, Göttingen, and, more recently, in Berlin) should be generally appreciated. Yet, it seems that these have been established against the background of historical co-locations of higher education institutions and (mostly) Helmholtz facilities, or on the basis of rather coincidental political constellations.

In the medium term, the Federal Government will have to go back to systematically and sustainably supporting research in the higher education sector. While support can be granted via several different channels, one crucial point of departure would be to further strengthen higher education institutions in implementing research projects. The programme allowance that is currently in place does not suffice to cover the indirect costs incurred by DFG-funded research projects. Increasing the allowance appears to be a useful measure that could be financed by the Federal Government. Still, an increased programme allowance alone does not provide a solution to the problem of an overly strong focus on third-party funding for research in the higher education sector. To overcome this issue, the Federal Government itself will have to provide funding for research facilities.

Provided that the political stakeholders manage to facilitate co-operation between the Federal and *Länder* governments in the field of higher education, the actual structure of such extended collaboration will have to be decided on. Recent tentative approaches to discussing the idea of federal universities have not led very far. The notion of the Federal Government “taking on” individual higher education institutions and positioning them as high-level institutions for research and teaching is often regarded as a utopian vision or even a threat. Regardless of these reservations, the idea of federal universities should be taken into account as a serious policy option that should be given due consideration. The federal states however should not withdraw from financing as soon as the Federal Government extends its supportive measures.

B 2 SKILL SHORTAGES AND INNOVATION

In the decades to come, Germany's potential labour supply will be subjected to systematic, long-term transformations caused by demographic change. Both the number of persons who enter the job market and the number of young employees are decreasing in relation to the number of older employees. This will lead to an ageing, or rather, a lack of rejuvenation, of businesses.[158] At that point in time, it will not be possible anymore to meet new qualification requirements by hiring young persons who newly enter the labour market.

In addition to this, the structure of demand for goods and services is also subjected to change. One of the reasons for this is the ageing of society as a whole; another reason is an increase in the economy's knowledge intensity. As a result of these structural changes, demand for certain qualifications will increase disproportionately while others will somewhat decrease. Those occupational fields that are growth-oriented can be expected to display a shortage, while other vocational fields will be characterised by an oversupply. This will lead to the necessity to shift qualified personnel between different occupational fields and groups of products. According to recent estimates,[159] it is to be expected that by 2050 more than one sixth of jobs will have to be restructured, i.e. shifted.

A sufficiently large pool of suitably qualified, highly skilled labour is a crucial prerequisite for maintaining the innovative strength and competitive edge of German businesses and Germany as a location. This, in turn, will be a crucial prerequisite for securing sustainable financing for maintaining Germany's social insurance system.[160] Against this background, the process of demographic change poses a major challenge that has to be addressed swiftly and sternly. To address these issues, the Expert Commission suggests the following approaches in particular:

- Education and training policies for adjusting the qualifications structure of the workforce
- Operational measures for utilising and maintaining the valuable qualification of older employees
- A more efficient use of the so-called "hidden labour market reserve", i.e. a skilled female workforce that is not active in the labour market, and its underlying qualification potential
- A migration policy that allows to tap on international qualification reserves.[161]

Developing education and training policies

Policies for vocational education and training are particularly important factors in dealing with Germany's skill shortages. While the public sector is certainly called upon here, businesses and individuals, too, will have to engage in further training so as to contribute to providing Germany with a suitable qualification structure.

Unlike many other countries, Germany has two main pillars that provide for a solid qualification for those entering the job market: the dual vocational training system, and the higher education system. Whenever Germany's training system is being discussed, the dual vocational training system is often somewhat forgotten. Given the relevance of the dual system, it should be ensured that, despite the decrease in school-leaving cohorts, sufficient numbers of well-qualified school leavers will be attracted to entering dual vocational training.

As regards developments in the higher education system, the Expert Commission expresses its concern about the fact that the proportion of graduates with engineering degrees has been continuously decreasing when compared with the total number of graduates.[162] In 1998, the proportion of graduates with an engineering degree was still above 20 percent and thus higher than the OECD average. By 2007, this number had decreased to 12 percent, a value that is just about within the OECD average (cf. Table 4).

The proportion of graduates from the fields of life sciences, physics and agricultural sciences has also decreased over time, while the proportion of graduates from mathematics and computer sciences has increased slightly, albeit at a low level, thus mildly exceeding the current OECD average. Due to a continuous increase in new enrollments, the absolute number of students in MINT subjects has increased, yet engineering programmes in particular have benefitted less from this increase than other fields of study. (cf. Figures 9, 10)

TAB 04 **Proportion of tertiary graduates in engineering and natural sciences subjects of all graduates in 1998, 2000, and 2005 to 2007 in international comparison** (figures in percent)

	1998	2000	2002	2005	2006	2007
Engineering, manufacturing, civil engineering						
OECD average	14	13	13	12	12	12
Germany	20	19	18	16	13	12
Life sciences, physics, agricultural sciences						
OECD average	9	9	8	7	7	7
Germany	12	11	10	10	9	9
Mathematics, computer sciences						
OECD average	4	4	5	5	5	5
Germany	5	5	5	8	8	8
Technical/natural sciences subjects in total						
OECD average	27	26	26	25	24	24
Germany	38	34	33	33	29	29

Source: OECD (2011): *Bildung auf einen Blick* (Education at a Glance), Tab. F5-20web.

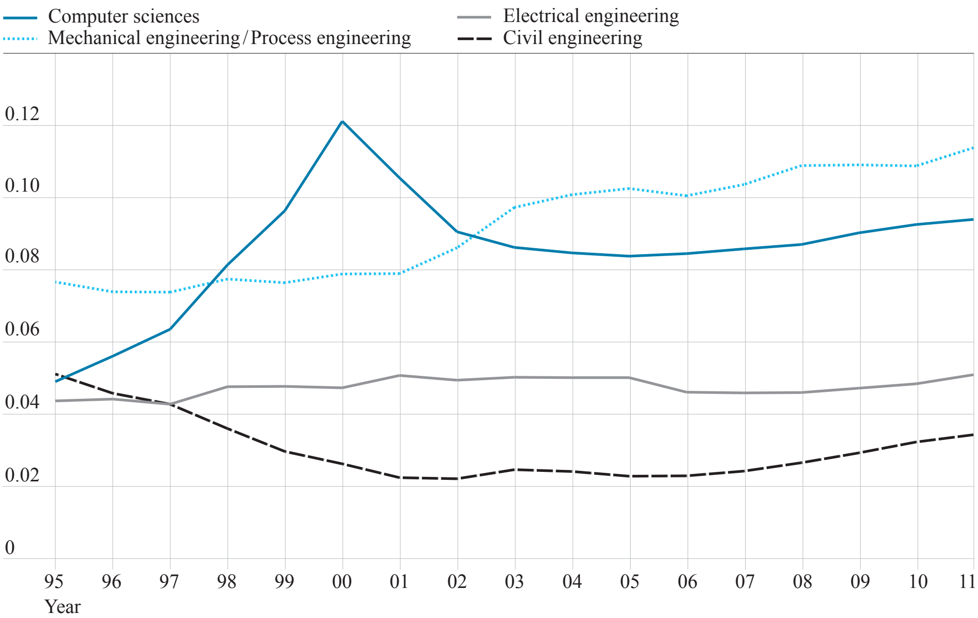
Figure 9 clearly demonstrates that, when measured against the overall number of new enrollments, the proportion of first-year students especially in electrical engineering and civil engineering has remained fairly stable over the last two decades, while the proportion of students in mechanical engineering has increased slightly. Striking evidence also exists for a rapid rise in the proportion of computer sciences students prior to the bursting of the dotcom bubble, and an almost equally rapid downturn following the bursting, which ultimately led to a stable medium position within the MINT subjects group.

Figure 10 further shows that the absolute number of students in electrical engineering and civil engineering at German higher education institutions has barely increased over the last two decades, while the total number of students has increased dramatically over the same period of time. This goes to show that engineering study programmes – with the exception of mechanical engineering – have only marginally benefitted from this significant growth in student numbers.

Yet, a high number of graduates from engineering sciences would be particularly relevant as a higher proportion of engineering graduates is generally accompanied by an increase in macroeconomic growth. This has been suggested by important studies on the correlation between the proportion of different academic subjects and a country's economic growth.[163] Hence, one of the main challenges in developing Germany's higher education system will be the implementation of education policies that succeed to attract sufficient numbers of students to those fields of study that are growth and innovation-oriented.

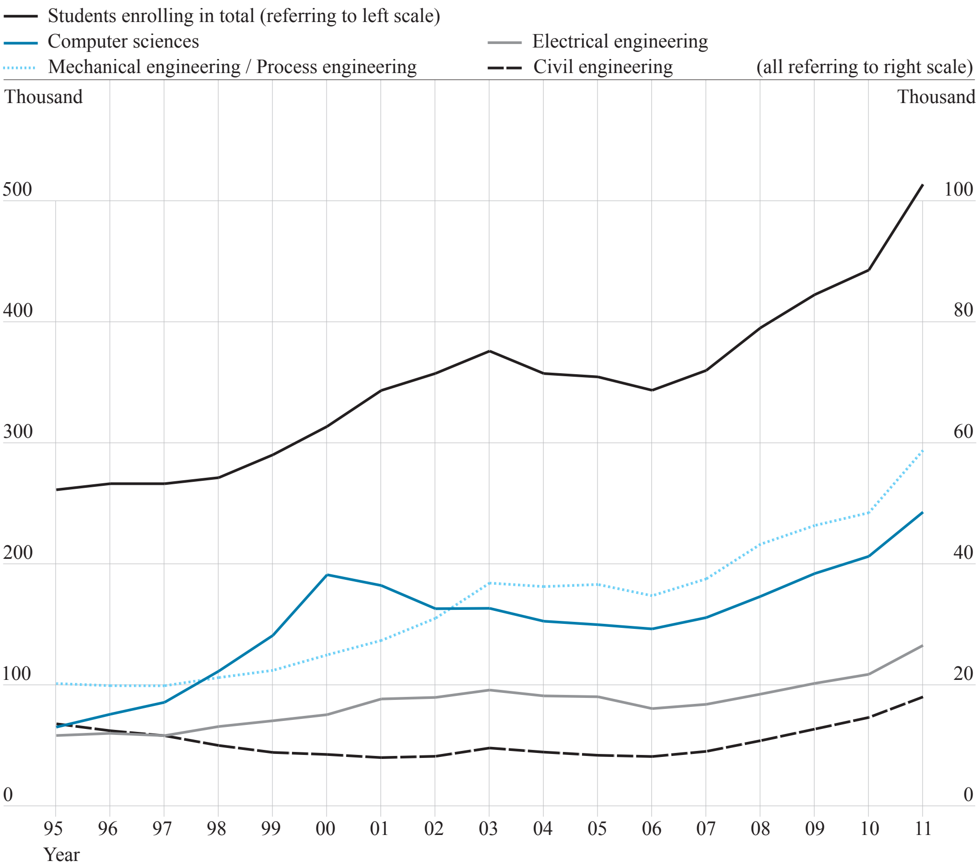
All the same, the structural transition caused by Germany's demographic change cannot be overcome by primarily focussing on those entering the labour market – regardless of whether they are graduates of the dual system or tertiary graduates. Instead, the existing labour force will have to be supplied with systematic training and qualifications. This means that the system for further training is becoming ever more important. Yet, at this stage, Germany is so far not well prepared to take on this challenge. To avoid excessive windfall profits, the primary goal of public support measures should be to increase the participation of underrepresented groups of society in further education measures. Others, e.g. the large majority of participants in further training are already reaping individual benefits from participating in continuous training. Given the increase in demand for highly skilled employees, it is in fact in the employees' own interest to enhance their efforts in vocational training.

Proportion of students enrolling in MINT subjects of all students enrolling (1995 – 2011) FIG 09



Source: Federal Statistical Office (*Statistisches Bundesamt* 2011): *Bildung und Kultur, Schnellmeldungsergebnisse der Hochschulstatistik zu Studierenden und Studienanfänger/-innen*, preliminary results for the winter semester of 2011/2012, Wiesbaden 2011, p. 13.

Absolute growth in the number of students enrolling FIG 10



Source: Federal Statistical Office (*Statistisches Bundesamt* 2011): *Bildung und Kultur, Schnellmeldungsergebnisse der Hochschulstatistik zu Studierenden und Studienanfänger/-innen*, preliminary results for the winter semester of 2011/2012, Wiesbaden 2011, p. 11 ff.

Those groups of employees that have been underrepresented – primarily low-skilled workers, immigrants and persons with disabilities – should receive more training, which will better prepare them for the ongoing structural change and the different qualification requirements that are associated with it. As a matter of fact, vocational training as it is today is not a means of compensating for a lack of training in the past; rather, it is sharpening existing differences within the workforce.[164] In order to activate disadvantaged groups of employees, the use of education vouchers is recommendable. Experimental studies have shown that education vouchers prove to be useful and efficient instruments, provided that certain criteria are met.[165] As regards the contents of further training, government intervention or support is required especially in those cases where training candidates are lacking essential basic skills that are a prerequisite for participating in further training. These skills include reading, writing and arithmetic, but also the use of information technologies and new media.

Businesses must also become more committed to providing continuous training and development options in the workplace; especially with regard to low-skilled workers.The willingness of low-skilled workers to get involved in training measures is likely to increase if training options are provided onsite.[166] One of the challenges will be to train low-skilled workers who are employed in small enterprises, since participation in further training proves to be particularly low in small enterprises. This is an issue that appears to be even more pressing as approximately 60 percent of employees in Germany work for small and medium-sized companies.[167] Thus the relatively low participation rate of small and medium-sized enterprises in further training is posing a major problem to the objective of lifelong learning.[168]

Not only the anticipated structural changes in the demand for goods and services, but also the economy's knowledge intensification is creating substantial changes in Germany's labour market. To address the issues emerging from this, occupational mobility will have to be increased both horizontally and vertically. In order to improve horizontal mobility, it is particularly important to grant acknowledgement for skills acquired in professional life, and also to provide qualification components which employees might have missed out on earlier. To improve vertical mobility and to keep the dual vocational training system attractive, the institutionalised further education system and the permeability of the higher education system have to be improved. In the course of this development, the higher education sector will be under increased pressure to provide attractive, academically sound options for further education qualifications. If not sooner, the pressure is expected to increase once the number of first-year students drops as a result of demographic change.

This development will further promote the process of differentiation and division of labour that is currently underway in Germany's higher education system. In the future, higher education institutions will have to sharpen their profiles and highlight more clearly their individual comparative advantages, while positioning themselves based on individually defined "roles and missions". None of the higher education institutions will be able to cater for the whole academic range, i.e. first-class basic research, application-oriented development, training of top researchers, training of first generation students, provision of full-time study programmes and part-time degrees for professionals. Therefore it is vital that higher education institutions develop a distinguishable profile. Depending on a university's focus, this differentiation process will also have to be designed according to different sources of financing (i.e. public sector, private sector, individuals). In the course of this process, new types of collaboration between universities and universities of applied sciences may also emerge. However, the comparative advantages of such collaborations should not blur the differences between these two types of education institution.

Improving conditions in the school system – promoting MINT subjects from an early age

The foundations for lifelong learning and occupational flexibility are laid in the school system. Because of this, it is important to also systematically improve and strengthen the German school system. Drop-outs are still too frequent a problem in Germany, and the public sector does not sufficiently cater for children from low socio-economic backgrounds. Thus, in the most recent PISA survey, the proportion of German children from low socio-economic backgrounds who made it to the upper third of (national or international) results was dramatically low in international comparison.[169] Test results of economically disadvantaged children were especially weak if the children did not speak the respective national language at home and if their school offered only a low number of mandatory classes in science subjects.[170] Therefore, education policy should ensure to promote the language skills of children from a migrant background. In addition to that, the choice of courses in science subjects should be expanded and adapted to the requirements of disadvantaged groups. Contrary to popular assumptions, barely any evidence exists to prove the hypothesis that a school's equipment has a positive impact on the success of children from low socio-economic backgrounds. Instead, a much more important factor seems to be the pupils' self-assessment and self-esteem, as well as the study time invested.[171]

The important role of science subjects in schools has also been emphasised in other research publications. When choosing their course of study, male first generation students, i.e. tertiary students whose parents do not have an academic education, most frequently choose mechanical engineering degrees (28 percent), followed by business studies (17 percent), mathematics/computer sciences (12 percent) and electrical engineering (9 percent). The selection of an engineering programme is particularly likely among individuals who had chosen MINT subjects as their advanced courses in upper secondary school. As regards female first generation students, the teaching professions have proven to be the most typical field of study.[172]

Extending the period of work – making better use of older employees' talents

As a supporting measure to master the challenges of demographic change, it is also important to ensure that older employees remain in the labour force for longer. New empirical studies demonstrate that there is no evidence for the naive assumption that elderly employees generally perform less efficiently than their younger counterparts. On the contrary, it has been shown that performance may vary throughout one's professional life, and that older employees, too, are characterised by a high ability to learn and a strong willingness to engage in further training.[173] To extend the duration of peoples' working lives, it is necessary to revise pension-related regulations and, even more importantly, to adjust companies' organisational structures.[174] The latter entails a greater use of teams of mixed ages, as well as workplaces that promote learning; both measures contribute to maintaining the mental fitness of older employees.[175] It is here also essential to find the ideal balance between age structure and operational organisation. Approaches for achieving such balance have been presented e.g. in the context of the recent "Demopass" project.[176] To complement these efforts, the idea of lifelong learning will also have to be advanced, and valuable human capital will have to be sustainably utilised via "second careers", i.e. employment in different fields of work, taken up at a later stage of an extended working life.[177] Second careers are especially suitable in cases where continued employment in traditional occupational fields is not an option due to age reasons.[178] Provided that such employment is more easily found e.g. in the services sector (as opposed to the industrial sector), an enhanced permeability between different types of qualifications could facilitate access to a second career. Again, lifelong learning and the systematic acknowledgement of skills acquired during one's professional career will play a key role in this process.

The implications and consequences of extending the working life of older employees still produce a range of unresolved issues from various disciplinary perspectives. To address these issues, the Federal Cabinet has launched its cross-departmental "Research Agenda of the Federal Government for Demographic Change", a research plan that focusses on older employees' later working life. Adopted in November 2011, the agenda can be regarded as a major contribution to developing solutions to this problem. In the light of the current demographic change, and the challenges to the social insurance systems that are resulting from this, there is no doubt about the necessity to extend the duration of working lives.

Utilising the labour market's "hidden labour market reserves"

Compared with other countries, Germany possesses extensive "hidden labour market reserves", i.e. a qualified female workforce that is not active in the labour market. Thus the participation of women in the labour market is rather weak when compared with other industrialised countries. Although participation of women in the labour market has increased, there are still six million women of working age who are economically inactive. Many of these have obtained mid-level and higher qualifications but do not contribute their skills to the labour market. What is more, only 55 percent of women who are economically active work on a full-time basis,[179] which puts Germany second from last in EU rankings. Moreover, when it comes to part-time employment, the average number of weekly hours worked by women is slightly below 18; this is a very low value that puts Germany last from among all of the EU-15 countries.[180]

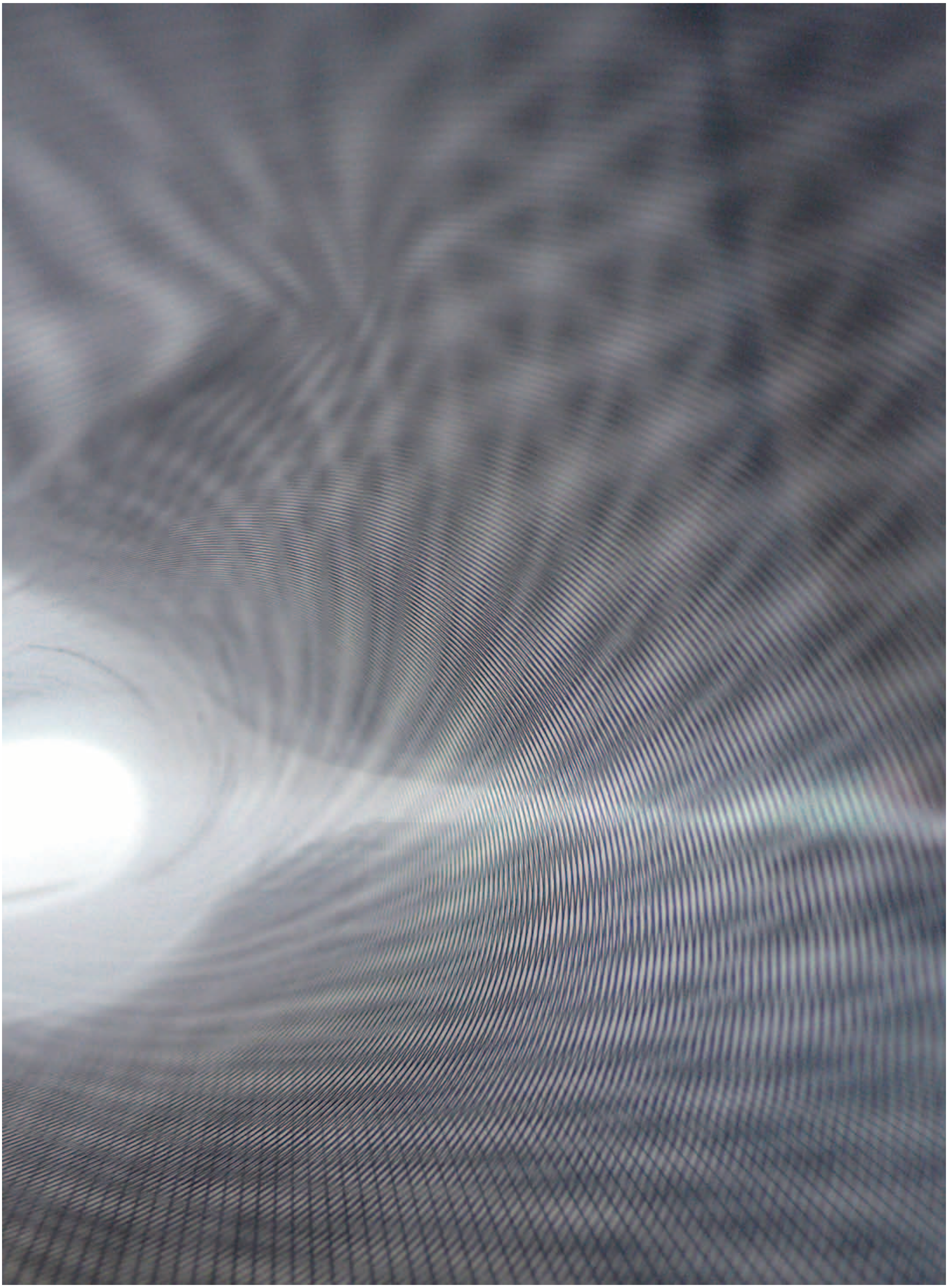
Here, efforts should be made to integrate women into the labour market during and after having a family. Again, further training – during and after parental leave – will play a major role. Another important objective is to reconcile work and family life in order to improve womens' willingness to return, and their opportunities for returning to the workforce. Successful examples in this regard include the "Women in technical professions" (FiT) programme[181] that was launched by Cologne-based Ford-Werke GmbH, as well as measures launched by Airbus S.A.S. in Hamburg, which aim at increasing the proportion of women on apprenticeship, skilled labour and management levels.[182]

Given the strategic importance of the female labour force potential, the issue of reconciling work and family life should no longer be regarded as a womens' issue, unless we are willing to accept the risk that the "hidden labour market reserves" be utilised at the expense of a further decrease in population due to a decrease in birth rates.[183] Women must be given a clearer message that they are needed and welcome in the workplace with or without children. It must be highlighted more clearly to men that they are needed and welcome in the domain of child-rearing and family labour. Unfortunately, tax regulations such as the *Ehegattensplitting* – that is, the taxation of the total income of a married couple on the basis of equal halves – has a negative effect on women mostly, since the spouse with the lower income will be disadvantaged in terms of tax deductions. This creates a disincentive primarily for women to engage in paid labour as women are often those with the lower wage. Similarly, social benefits such as the planned childcare supplement for parents who are not engaged in paid labour create further incentives for staying outside the labour market. In short, any provisions that create an incentive mostly for women to refrain from work, or to work only to a minor extent, have a detrimental effect on Germany as an innovation location. Such provisions should be abolished, or not be implemented at all.

Another important issue to be addressed is the rather one-sided choice of young women when deciding on their course of studies, as MINT subjects in particular are being largely disregarded. When compared on an international scale, it appears that the proportion of female graduates from science subjects had increased disproportionately from 32 percent in 2000 to 44 percent in 2009 (i.e. 12 percentage points). Yet, the proportion of female graduates from engineering programmes largely remained at its low starting level (cf. Table 5). It merely increased by 2 percentage points, from 20 percent to 22 percent. Thus, in 2009, the proportion of female engineering graduates in Germany was even further below the OECD average than it was in 2000.[184] Still, Germany managed to surpass OECD levels with a highly disproportionate increase in female scientists within the same period of time.[185] This suggests that women in Germany do not generally dislike study programmes from the MINT subjects group. More likely, it is engineering programmes that seem to have only little appeal to women. Stakeholders from politics, science and business should not take the current dislike as a given – instead, they should take suitable measures to catch up with countries such as Denmark, Estonia, Iceland, Poland, or Spain. All of these countries have managed to increase the proportion of female graduates in engineering degrees to approximately one third of the total of engineering graduates.

In Germany, the number of female graduates from tertiary institutions has increased significantly over the last years. Yet, this increase is almost exclusively on the account of arts and humanities, while engineering programmes remain to be unattractive to women (cf. Table 6).[186]

A more detailed breakdown of academic fields available in Germany, based on data from the Federal Statistical Office, further demonstrates that since 1995 the increase in female graduates has been particularly evident in veterinary medicine (a course of study that has almost turned into an all-female domain) and in the fields of human medicine / health



5/10 Moiré effect: line pattern
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6/10 Accelerated movement of elements with reflective surfaces
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Proportion of women among graduates from higher education institutions in engineering and natural sciences subjects (2000 and 2009) in international comparison (figures in percent)

TAB 05

	2000			2009		
	Total	Engineering*	Natural sciences	Total	Engineering	Natural sciences
Country						
Australia	57	22	41	56	25	37
Denmark	49	26	42	60	32	37
Germany	*45*	*20*	*32*	*55*	*22*	*44*
Finland	58	19	46	63	23	46
France	56	24	43	54	29	38
Great Britain	54	20	44	56	23	38
Iceland	67	25	49	66	35	40
Japan	36	9	25	41	12	25
Canada	58	23	45	60	24	49
Netherlands	55	13	28	57	19	21
New Zealand	61	33	45	61	30	44
Norway	62	27	28	61	25	37
Austria	46	18	33	54	26	33
Poland	64	24	65	65	34	44
Sweden	59	25	47	64	28	46
Switzerland	38	11	24	50	19	33
Spain	59	27	47	60	34	42
South Korea	45	23	47	46	23	39
Hungary	55	21	31	65	24	35
USA	57	21	44	58	21	44
OECD average	**54**	**23**	**40**	**58**	**26**	**41**

* Engineering, manufacturing and construction
Source: Figures according to Lesczensky et al. (2012).

sciences. These are followed, albeit at a considerable distance, by agricultural sciences/forestry/nutrition sciences, as well as law/business and social sciences (cf. Table 7).

Recent empirical studies on the career progress of pupils who had obtained their study entrance qualification in 2006 demonstrate that the more technical fields of study, electrical engineering and mechanical engineering, are increasingly turning into an all-male domain, while gender-specific differences in other fields of study have changed only little since 2002. The surveys were conducted on the basis of data from the Higher Education Information System (HIS).[187]

The Expert Commission speculates that the low proportion of women in engineering programmes cannot be overcome on the basis of education policy measures alone. The choice of a study field or occupational area seems to be closely linked with the graduates' anticipated employment opportunities and working conditions, as well as the perceived opportunities for reconciling work and family life in the respective occupational field. Women will become more interested in taking up engineering degrees if and only if companies can offer technical, engineering-related jobs that are attractive to women. Recent empirical studies have examined the underlying reasons for the significantly low proportion of women in German technical/engineering programmes. One of the findings was that a major reason for gender-specific differences in the choice of a study programme lies in differences in life and career planning patterns.[188] Another reason, which is even more important, is that women tend to perceive that they have no comparable advantages when it comes to technical skills.

TAB 06 **Proportion of women among graduates according to subjects in 2009 and 2000: Germany and the OECD in comparison** (figures in percent)

	All subjects groups	Education sciences	Human-ities and arts	Health and welfare	Social sciences, business and law	Services	Engineer-ing, manu-facturing and con-struction	Natural sciences	Agri-cultural sciences
2000									
OECD average	54	74	65	68	52	43	23	40	43
Difference to OECD	–9	–3	2	–12	–10	15	–2	–8	4
Germany	45	71	67	56	42	58	20	32	47
2009									
OECD average	58	77	66	75	58	54	26	41	52
Difference to OECD	–3	–4	7	–7	–6	2	–4	3	1
Germany	55	73	73	68	52	56	22	44	53

grey fields: proportion in Germany below OECD average; blue fields: proportion in Germany above OECD average.
Figures according to OECD (2011): *Bildung auf einen Blick* (Education at a Glance), p. 101.

TAB 07 **Proportion of female higher education graduates* among all graduates from first-degree studies for the years 1995, 2000, and 2005 to 2008 according to subjects groups** (figures in percent)

		Subjects groups**								
Year of final exams	**Graduates (male and female) from all subjects groups**	**Lin-guistics, cultural studies**	**Sports**	**Law, business and social sciences**	**Math-ematics, natural sciences**	**Human medicine/ health sciences**	**Veterinary medicine**	**Agricul-ture, forestry and nutrition sciences**	**Engineer-ing**	**Art and art-related subjects**
1995	41.2	72.2	51.9	45.3	37.5	44.6	63.8	47.0	14.0	63.1
2000	45.6	72.7	53.5	46.3	38.3	47.6	77.8	51.9	19.5	64.7
2005	50.8	76.8	49.9	52.2	39.6	57.3	85.2	56.8	22.4	65.3
2006	51.6	77.1	51.1	52.8	40.3	60.4	84.6	57.1	22.5	66.0
2007	51.8	77.2	50.7	53.0	40.1	62.1	85.6	57.9	22.7	66.0
2008	52.2	77.2	49.7	53.2	40.9	64.2	86.7	57.7	22.8	66.5

* including public administration universities of applied sciences
** Breakdown does not include the subjects group "other than fields of study classified"
Source: Statistical offices of the Federation and the *Länder*, higher education statistics.

Government programmes such as the "Go MINT!" initiative, which was launched as part of the National Pact for Women in MINT Careers, but also promotional programmes from research facilities and businesses such as FiT, FEMTEC and Girls' Campus[189] are certainly steps in the right direction. These initiatives reflect a growing social awareness for the necessity to attract more women to professions in the technical/sciences occupational fields.

Managing and shaping migration flows

Finally, it is up to national migration policy to meet the structural shortage of specialists that will remain in spite of the introduction of the above-mentioned measures. This has to be done swiftly, and with a sustainable outlook. Efforts to improve integration of foreign employees will have to be advanced on all qualification levels. The priority review has already been abolished in shortage occupations. This step is pointing in the right direction, and so is the planned reduction of income thresholds for foreign employees. The points system employed by the Canadian government as an instrument for managing migration can be regarded as an appropriate advancement in migration policy. At the same time, policy-makers have to ensure that an influx of qualified migration is not perceived as a threat but rather as an opportunity for Germany and its domestic employees.

BOX 09

The Canadian points system for managing migration

In the view of the Expert Commission, the Federal Government should develop a system to facilitate immigration of highly qualified workers. This could be implemented based on the model employed by countries such as Canada or Australia. The launch of an immigration system would contribute to strengthening economic growth in Germany. Immigration into Canada for instance is regulated based on the following criteria: completed education, language skills, work experience, age, presumed adaptability to the country, and availability of job positions. Canada, too, is currently undergoing a process of demographic change. Because of this, the Canadian approach is not oriented towards concrete employment but rather at attracting human capital as such. The Canadian approach thus aims to secure additional knowledge in an economy that is increasingly knowledge-based. The 2005 Canadian immigration law provides different regulations for the influx of highly qualified personnel such as scientists, teaching staff and senior managers: individuals who are able to demonstrate a high level of qualification can enter Canada more freely and take up employment more easily. However, the Canadian approach does not cater e.g. for specialist workers, who are actually sought after by the industrial sector. These are recruited via provincial complementary nomination procedures and temporary work programmes.[190]

A necessary prerequisite for introducing such a points system will be the recognition of foreign educational qualifications. With its "Recognition Act", to come into effect on 1 March 2012, the Federal Government has now created a modern basis for the recognition of foreign professional qualifications.[191] The new "Assessment and Recognition of Foreign Professional Qualifications Act" entitles citizens of EU member states and third-country nationals to apply for an individual equivalence review. In the past, the exercise of a profession and access to such recognition procedures, had been reserved for individuals with German citizenship or citizenship from other EU countries; a regulation that affected a wide range of occupational fields in Germany. The new legislation largely abolishes this linkage to a person's citizenship. Based on the new law, a Turkish medical doctor for instance can obtain a doctor's licence provided that he or she meets the professional requirements. Previously, this could not be done – even if the doctor had completed his or her studies in Germany.[192]

According to the new law, the decision regarding the equivalence or non-equivalence of a qualification is due within the course of three months. The Recognition Act aims to simplify and improve the inconsistent practice of assessment that had previously been in place. The implementation of the assessment procedures falls to the federal states, which are entitled to bundle responsibilities for recognition procedures according to regions of origin or occupational groups.

A more open migration policy will most likely not result in a massive influx of foreign workers, as has often been assumed. The following recent example

BOX 10

Germany's new immigration law: the legislative proposal for implementing the "Blue Card" Directive

The Federal Government has amended its legislation for the immigration of highly qualified workers from non-EU member states. With its new immigration act, Germany seeks to establish easier and more attractive entry conditions.[193]

Once the German Parliament *(Bundestag)* and the Federal Council *(Bundesrat)* have granted consent, the new legislation could come into force in the second half of 2012. The legislative proposal is based on an EU Directive on the admission of highly skilled immigrants. The Directive also provides for the introduction of the "EU Blue Card", which entitles potential immigrants to a work and residence permit of up to four years. To obtain the EU Blue Card, applicants have to demonstrate that they have completed tertiary education and that their annual income is at least EUR 44,000. For highly skilled personnel from occupations that are subject to shortage, an annual income of EUR 33,000 suffices. Shortage occupations include all fields of engineering, academic and comparable staff in information and communication technology, as well as medical doctors. Provided all of these conditions are met, a priority review in favour of domestic employees will be abandoned in the future. After two years of employment subject to mandatory social insurance contributions, the holder of an EU Blue Card can obtain a permanent residence permit. Family members of such highly qualified immigrants are entitled to immediately take up unrestricted employment.

As regards the permanent residence permit, the Federal Government's legislative proposal goes beyond the provisions of the Blue Card scheme. Currently, to obtain an immediate permanent residence permit or settlement permit without the waiting period entailed in the EU Directive, highly skilled workers have to have an annual income of at least EUR 66,000. According to the new legislative proposal, this income threshold has been lowered to EUR 48,000 per year. However, if a person receives unemployment or social benefits within three years of obtaining the settlement permit, he or she will lose their unlimited residence entitlement.

According to the new legislative proposal, foreign graduates of German higher education institutions shall have one-year unrestricted access to the labour market to find employment that corresponds to their academic qualifications. According to the legal provisions that are currently in place, foreign graduates are allowed to engage in paid labour for only 90 days within that year. In addition to that, the procedure for providing researchers with work entitlement shall also be facilitated. In the future, the hosting agreement between the researcher and the research organisation will not have to specify a concrete research venture. The current regulation has often been criticised by research organisations as they felt they would disclose confidential information by specifying the exact title of a research venture.

The Federal Government's legislative proposal partially corresponds with the recommendations made by the German non-partisan initiative *Hochrangige Konsensgruppe Fachkräftebedarf und Zuwanderung* ("High-level Consent Group Skill Needs and Migration"). Yet, in several major points it falls short of the recommendations made by this panel of experts. The current immigration law provides for a general ban on recruiting new foreign labour, albeit with permit reservations. In the view of the Consent Group, recruitment should be generally permitted, and a ban reservation should be allowed for only in specific cases. The objective of such reverse policy is to clearly signal to highly skilled international workers that they are welcome in Germany.

The Expert Commission welcomes the existence of a non-partisan proposal for reform in a subject domain that is politically challenging. The Expert Commission is particularly in favour of complementing the German immigration law by adding criteria-based immigration options, as suggested by the Consent Group.[194]

may illustrate this. Since 1 May 2011, workers from the Czech Republic, Estonia, Latvia, Lithuania, Hungary, Poland, Slovenia and Slovakia (known as the EU-8 countries) are entitled to immigrate to Germany without restrictions. All of these Central and Eastern European countries had become EU members in 2004. Contrary to concerns expressed before the enactment of these new regulations,[195] the number of immigrants from the EU-8 countries has increased only moderately. According to recent estimates from the Institute for Employment Research (IAB), net migration for 2011 amounted to 50,000 to 60,000 persons.

Compared with estimates for the period prior to the expiry of the interim provisions, these numbers are relatively low, which suggests that an increase in migration activity has not taken place. A much higher increase has been observed in the number of domestic employees whose country of origin is an EU-8 country. This suggests that persons who had been previously self-employed and persons who had been recorded by the labour market statistics as economically inactive have since taken up employment.[196]

To complement a migration policy that will attract qualified workers, it is also important to facilitate employment for foreign graduates who have successfully completed their studies in Germany and wish to remain. Migration policy and the legislation governing admission to higher education must be designed in a way that will attract the largest possible number of international top-class candidates, while at the same time providing simplified conditions (i.e. without elaborate tests) for those who wish to remain in Germany following their graduation. The abolition of the priority review for foreign graduates from German higher education institutions, and the provision of a one-year residence permit that enables graduates to seek suitable employment after the completion of tertiary education, are important moves in the right direction. At the same time, surveys among foreign university students show that the options available for remaining in Germany are often misperceived: thus, two thirds of the surveyed students stated that they could envisage staying in Germany following their graduation – only one third of surveyed students felt that they would be welcome on the German labour market and that it would be possible to remain in the country. This view was expressed by students from engineering and natural sciences[197] in particular; who indeed have the qualifications that will be increasingly needed in the future. This goes to show that, in addition to improving existing rules and regulations, it is also important to improve information policies and campaigning, with the aim of keeping the best foreign graduates in the country – a policy that is employed by traditional immigration countries such as Australia or Canada.

In view of the expected shortage of skilled workers, it is also worth considering attracting higher numbers of apprentices from abroad. This might in fact create a win-win situation with Southern EU member states or other countries that have a high youth unemployment rate. To integrate these young people into the workplace, priority should be attached to solving language issues from the start. Since a standard apprenticeship does not allow for time and financial resources that are required for learning an entirely new language, support from the public sector is particularly important here.

The measures outlined above should be complemented by systematic efforts to win back highly qualified German expatriates by offering them attractive working conditions. These efforts should be applied not only to experts from the science sector but also to engineers, managers and skilled workers.[198]

Maintaining and enhancing flexibility and mobility of the German education system

Given the demographic change anticipated, it is generally agreed that a future skills shortage is a very likely scenario. Yet, when it comes to identifying the very occupational fields that will be affected by this, no clear-cut answers have been provided yet. Projections that have been made so far either differ considerably or have not been very convincing in the first place.[199] Some of the surveys suggest that there will be a substantial shortage in higher education graduates as such; yet the subject-specific needs have not been outlined in detail. Other surveys, mostly those based on estimates from industries, increasingly indicate that there will also be a shortage in traditional German skilled workers in certain industries and certain regions. The Expert Commission believes that also in the future no clear-cut answers are to be expected, especially since the industrial and technical development of knowledge-based economies is generally difficult to predict.

It is for precisely this reason that it is necessary to make the German education system more flexible. There are two main approaches for achieving this. First, training programmes will have to be designed in a way that provides graduates with more flexible employment options. This means that Bachelor's degrees will have to supply students with a solid basic knowledge that can be applied broadly and diversely. Only in a second step would students then obtain specialist knowledge through a Master's programme, or obtain a concrete occupational specialisation via vocational training programmes.[200] Second, Germany's education system will have to be further developed so as to ensure the highest possible degree of vertical and horizontal permeability.[201] This would also imply that education policy cannot solely focus on guaranteeing the largest possible number of tertiary graduates. Instead, education policy-makers should aim to provide high-quality education on all levels and to create maximum permeability between vocational and academic training programmes.[202] An emphasis on increased permeability would also pay justice to the fact that the emerging need of skilled personnel cannot be fully covered by persons who have newly entered the job market. Instead, it takes into consideration those persons who are already part of the workforce and embark on further education.

In this regard it is also worth keeping in mind that the combination of dual vocational training and academic tertiary training constitute the main pillar of the German innovation system. Thus other education systems that have a stronger focus on the higher education sector cannot provide a useful reference point for the further development of the German education system. These systems keep increasing their numbers of university graduates to solve the problem of the qualification shortage in the workforce. Due to Germany's functioning dual vocational training system, this issue does not exist to such a great extent.

Recommendations: increasing permeability of the education system – making better use of labour force potentials

German education policy will have to focus on increasing vertical and horizontal permeability of the entire education system. A sustainable education policy for Germany cannot solely focus on ensuring a sufficient number of tertiary graduates; it must also provide the highest possible quality of education on all levels, particularly apprenticeship graduates, while at the same time allowing for maximum permeability between vocational and academic training programmes. Both the dual vocational training system and the higher education system will have to be strengthened.

In the face of decreasing pupil numbers, the attractiveness of the vocational training system will have to be highlighted more clearly. The aim is to attract sufficient numbers of qualified secondary drop-outs to take up dual vocational training.

To increase vertical mobility and maintain the attractiveness of dual training places, formal continuous training measures and the permeability of the higher education system will have to be further developed. This however requires that higher education institutions sharpen their profiles to a much greater degree; a task which some of the universities will then treat as one of their priority issue.

In the future, higher education institutions should focus much more on their comparative advantages and strive to position themselves on the market, based on their defined "role and mission". While in recent years the emphasis had been on vertical differentiation, e.g. within the framework of the Excellence Initiative, increasing attention should now also be paid to horizontal differentiation between educational facilities. The spectrum of profile-building options is broad and has to be adjusted to the different financing options available. These may range from public sector funding to foundation-based funding and corporate funding, or tuition fees within the framework of "executive education" models.[203] In terms of contents, the scope of options comprises basic research, application-oriented development, as well as initial training, further training, full-time study programmes and part-time courses for working professionals. When developing one's profile, thought

Drop-out rates* for German students in first-degree studies in 2006 according to subjects groups, types of diploma and selected fields of study (figures in percent)

TAB 08

Student drop-out rate in percent	Total	Male	Female
Total	21	26	15
Universities	20	25	16
Universities of Applied Sciences	22	26	14
According to type of diploma			
Diplom / Magister	26	–	–
Staatsexamen	7	–	–
Bachelor's	30	–	–
Bachelor's Universities	25	34	19
Bachelor's Universities of Applied Sciences	39	42	35
Universities (field of study, subjects group)			
Linguistics, cultural studies, sports	27	35	24
Linguistics, cultural studies	32	–	–
Education sciences, sports	20	–	–
Law, business, social sciences	19	24	14
Social sciences	10	–	–
Law	9	–	–
Business	27	–	–
Mathematics, natural sciences	28	31	24
Mathematics	31	–	–
Computer sciences	32	–	–
Physics, geology	36	–	–
Chemistry	31	–	–
Pharmacy	6	–	–
Biology	15	–	–
Geography	15	–	–
Medicine	5	3	6
Human medicine	5	–	–
Dentistry, veterinary medicine	3	–	–
Agriculture, forestry, nutrition sciences	7	14	2
Engineering	25	28	16
Mechanical engineering	34	–	–
Electrical engineering	33	–	–
Construction	16	–	–
Art	12	17	10
Teacher training	8	8	8
Universities of Applied Sciences (field of study, subjects group)			
Business, welfare	19	28	13
Welfare	13	–	–
Business	24	–	–
Mathematics, natural sciences	26	25	32
Computer sciences	25	–	–
Agriculture, forestry, nutrition sciences	12	16	9
Engineering	26	28	19
Mechanical engineering	32	–	–
Electrical engineering	36	–	–
Construction	14	–	–

* Calculation method according to the Higher Education Information System (HIS), excluding foreign students and excluding second-degree students. The student drop-out rate is calculated as the quotient of final year graduates and university entrants of the respective years of enrollment (cf. www.his.de/pdf/pub_kia/kia200501.pdf for more detailed information on this procedure.)

should also be given to developing a system that offers a wide choice of Bachelor's study programmes, combined with more specialised Master's and further training programmes. Moreover, new forms of collaboration should also be considered, e.g. between universities and universities of applied sciences, between the higher education sector and the private sector, and between higher education institutions and non-university research institutions. Education policy-makers should support the development and implementation of new, ambitious profiles by providing suitable financing incentives and experimental clauses.

To complement this process, higher education institutions will have to ensure study conditions that make innovation-oriented and growth-oriented study programmes, and engineering programmes in particular, more attractive as an option. The same has to be achieved on the part of the private sector: again, businesses have to make an effort and design work places in a way that will make these occupational fields more attractive to the public. Here, the important target group of women should be taken into consideration as much as possible.

Since the foundations for choosing a study programmes in natural sciences/technical fields are laid in primary and secondary school, the range of hard sciences subjects should be broadened and adapted to the needs of social groups that have been disadvantaged in the past. Furthermore, schools have to even more vigorously promote language skills of children from migrant backgrounds, since language skills are one of the major prerequisites for successfully participating in any type of further education.

The continuing training system has to be further developed in a way that promotes the participation of employees who have been underrepresented in the past. Disadvantages or shortcomings in initial education have to be levelled out through further education. The support of the public sector is particularly important in those cases where potential training participants are lacking basic skills that are a prerequisite for taking part in continuing training measures. If a person lacks reading, writing, or arithmetic skills, or lacks basic knowledge in new information technologies, he or she will not be able to successfully participate in most of the training measures available. Employees and apprentices from migrant backgrounds who have insufficient German language skills are particularly affected by this predicament.

In addition to this, efforts to integrate foreign employees into the German labour market have to be increased on all qualification levels. The Expert Commission welcomes measures such as improved immigration regulations for tertiary graduates, well-qualified foreigners and foreigners participating in an apprenticeship, as well as an improved information policy regarding residence options available. These recruiting activities should be flanked by measures aimed at fostering public awareness for the need for immigration and at promoting societal support for the integration of foreigners.

Concerted efforts in several policy areas must be taken to motivate those women who are currently part of the "hidden labour market reserve" to use their talents and skills on the labour market. In the future, women must be given a much clearer message that they are needed and welcome in the workplace, with or without children. Men must be given a much clearer message that they have to take on more responsibility in raising children and doing domestic work. Tax regulations such as the previously mentioned *Ehegattensplitting* and social benefits such as the planned childcare supplement create an incentive primarily for women to stay away from the job market. Considering Germany's demographic development, this is something that cannot be justified from a macroeconomic perspective.

B 3 CONDITIONS FOR GROWTH AND CONSTRAINTS ON GROWTH FOR START-UP BUSINESSES

Business start-ups significantly contribute to increasing a country's productivity and economic growth. New enterprises often develop and implement innovative products, processes and business models, and this is particularly the case with newly established enterprises in the field of high technology and knowledge-intensive services.[204] Thus business start-ups secure the creation of jobs in Germany through value added that is locally bound. In addition, they also significantly contribute to the process of structural change.[205] Existing companies are forced to increase their productivity and to further develop their products in order to be able to assert themselves against up-and-coming competitors.[206] Against this background, it should be a priority goal for policy-makers to create framework conditions that are business-friendly. In the following, the current situation of entrepreneurs and young businesses shall be presented, while existing difficulties will be highlighted and recommendations for action will be derived from these.

B 3–1 BUSINESS START-UPS – MOTIVES AND PROSPECTS FOR SUCCESS

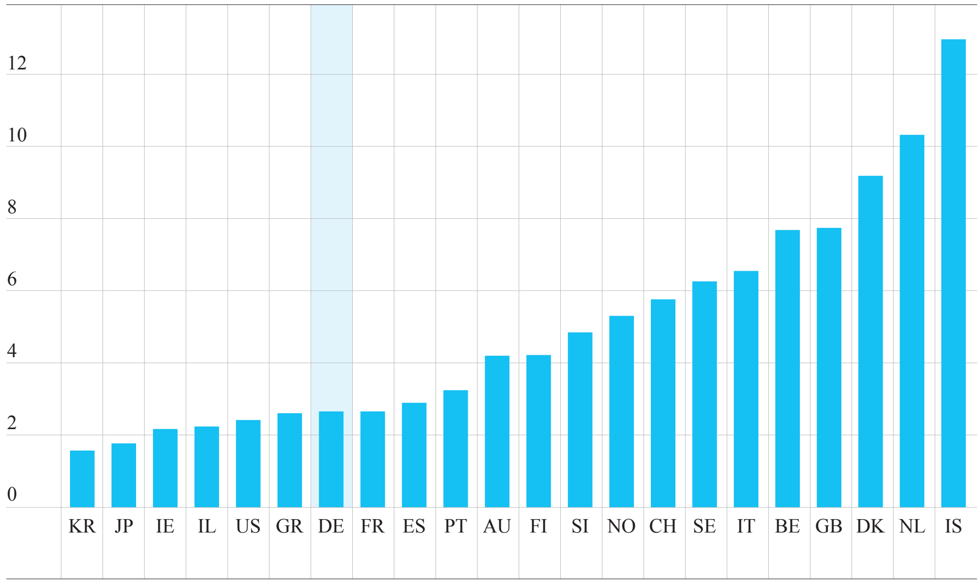
Motives for starting up a business; scarcity of entrepreneurs in the knowledge economy

There are several different motives for starting up a new enterprise. One of the typical motives is the prospect of exploiting a market opportunity. But also the lack of alternative employment options can be the decisive factor for venturing into self-employment. Compared with other countries, Germany displays a relatively low number of business start-ups that are directed at exploiting a market opportunity. Thus, for each new enterprise that has been established for a lack of alternative employment options there are only 2.6 new enterprises that aim to exploit a market opportunity (cf. Figure 11). Measured on an international scale, this is a relatively low value. This is a cause for concern because Germany's overall start-up rate (in proportion to the number of companies) is 4.2[207] and thus very low in international comparison.[208] Great Britain does not only have a higher start-up rate (6.5 percent)[209]; for each new enterprise that has been established for a lack of alternative income sources, Great Britain records 7.8 new enterprises that seek to exploit a market opportunity. Denmark records 9.2 new enterprises that seek to exploit a market opportunity, the Netherlands 10.3, and Iceland 13.0. Some of the countries that have a lower start-up rate than Germany still display a much more balanced proportion of start-ups that seek to exploit a market opportunity and start-ups that are pursued due to a lack of alternative income sources (e.g. Italy, Belgium, and Denmark).

What is more, only a small proportion of business start-ups in Germany are to be found in the field of the knowledge economy.[210] Out of seven new enterprises established in 2010 only one was established in a knowledge-driven business sector.[211] More than half of new enterprises are established in consumer-oriented services and in the trade sector; a further third is to be found in other business-oriented services, as well as construction, transport, postal services, mining, other manufacturing industries, and the energy sector.[212] The number of new enterprises within Germany's knowledge economy decreased significantly in the course of the first half of the last decade (cf. Figure 12). In 2000, a total of 38,300 new enterprises were recorded, while the lowest value was reached in 2007, with 23,500 new enterprises. Since 2008, the number of business start-ups in the knowledge economy has increased, reaching 28,800 start-ups in 2010 – a value that is still far behind that of the figures recorded in 2000.

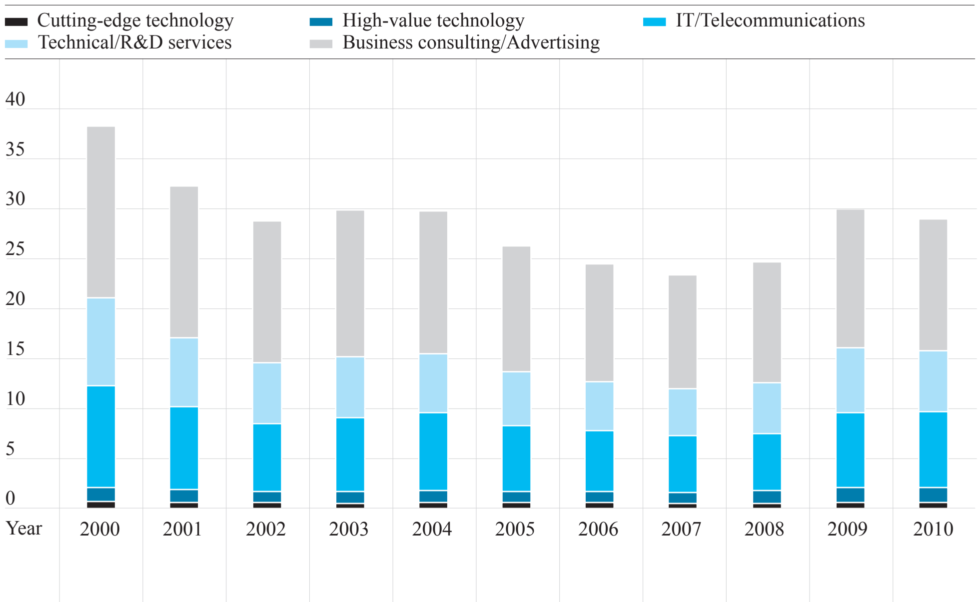
Compared with selected European countries, Germany's start-up rate in the knowledge economy (in proportion to the number of companies) occupies only an average position. Compared with leading economies, Germany is in fact lagging behind considerably. With a mere 5 percent in the field of high technology, Germany's start-up rate in high technology amounts to barely half the value of that of the Netherlands (10.2 percent). Also in the area of knowledge-intensive services, Germany would have to almost double its start-up rate of 9.7 percent if it were to reach the value recorded in the Netherlands (17.9 percent) (cf. Figure 13).

FIG 11 **Number of start-ups established to exploit a market opportunity per start-ups established for lack of alternative employment options**



Source: Global Entrepreneurship Monitor, Brixy et al. 2011.

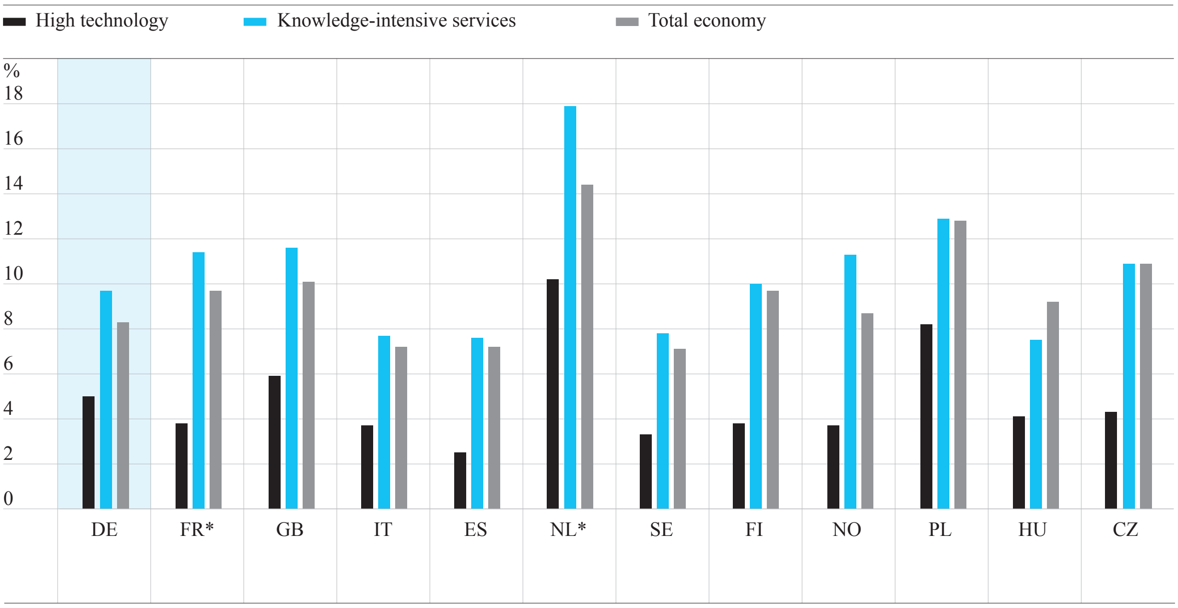
FIG 12 **Development in the number of business start-ups in the knowledge economy in Germany** (number of business start-ups in 1,000)



Source: Müller et al. 2012.

FIG 13

Start-up rates in 2009 in selected countries
(figures in percent)



Source: *Unternehmensdemographiestatistik,* Müller et al. 2012.
Number of business start-ups in percentage of total number of businesses, *2008.

Public funding of business start-ups

The Federal Government offers three funding programmes for technology-oriented business start-ups: the *ERP-Startfonds*, EXIST, and the *High-Tech Gründerfonds* (cf. Box 11). These funding programmes are designed to close the funding gap that often occurs in the starting phase of new enterprises, which is a major issue for technology-oriented start-ups in particular. In addition to this, there are numerous funding programmes to be found in the individual federal states.

Start-ups that have been launched from a position of unemployment are supported via the *Gründungszuschuss*, a start-up grant that is financed by the Federal Employment Agency. The *Gründungszuschuss* was launched on 1 August 2006 as a replacement for the earlier funding instruments of *Überbrückungsgeld* and *Ich-AG*. Several surveys conducted on the *Gründungszuschuss* have reached a positive conclusion regarding the design and the impact of this start-up grant. The fact of legal entitlement, and the self-employment retention rates of 75 to 84 percent have been assessed positively. Moreover, it appears that abuse and undesirable windfall gains only play a marginal role in the *Gründungszuschuss* programme.[213]

On 23 September 2011, the German *Bundestag* adopted its legislative proposal on improving integration opportunities within the labour market.[214] On 24 November 2011, the Federal Council *(Bundesrat)* gave their consent.[215] The new law also affects the design of the *Gründungszuschuss*, which shall be transformed from a mandatory allowance into a discretionary allowance. This planned amendment is met with skepticism among many labour market economists. It is feared that in the future it will not be factual considerations but rather budgetary considerations that will decide on the granting of allowances. Furthermore, it is feared that the time required for the assessment of an application is going to increase significantly, and that the transformation of the *Gründungszuschuss* into a discretionary allowance could result in increased windfall gains. This would be the case if funding were allocated to start-ups that are destined for success and would have been launched with or without public funding.[216]

The Expert Commission shares the above concerns and would like to stress that the revision of the law would have a negative impact on Germany's start-up culture and that it might decrease the motivation of unemployed persons to show entrepreneurial initiative. If it becomes more difficult to obtain support for a start-up venture, fewer start-ups will

BOX 11

Federal funding programmes for technology-oriented start-ups

ERP-Startfonds[217]
The *ERP-Startfonds* is designed for companies in the field of research and innovation that are no older than ten years at the time the application is submitted. Within the framework of the ERP funding programme, the KfW banking group takes a share in small innovative technology start-ups from the business sector. This is done under the condition that a lead investor co-finances the company with at least an equal amount. A financial holding company, a natural or a legal person may serve as the lead investor. The investment ceiling is EUR 5 million per company, with a maximum amount of EUR 2.5 million per twelve-month period. The programme allows for several funding rounds.

EXIST
The EXIST programme is part of the Federal Government's "High-Tech Strategy for Germany" and is co-financed by the European Social Fund (ESF). EXIST aims to improve the entrepreneurial environment at universities and non-university research institutions and to increase the number of technology-oriented and knowledge-based business start-ups. To achieve this, EXIST supports higher education institutions in developing and implementing strategies for the promotion of an entrepreneurial culture and entrepreneurial thinking. In addition to this, the EXIST start-up grants support innovative technology-oriented and knowledge-based start-up projects. EXIST also promotes development activities that are necessary for proving the technical feasibility of research-based start-up ideas.

High-Tech Gründerfonds
The *High-Tech Gründerfonds* (HTGF) provides technology-oriented business start-ups with grants of up to EUR 500,000 in the first funding round. The grant takes the form of a subordinated shareholder loan, and the HTGF may also participate in additional funding rounds. The HTGF further offers coaching and support with regard to raising venture capital for follow-up financing. The first of the funds, HTGF I, had a fund volume of EUR 272 million. Investors are the Federal Ministry of Economics and Technology (BMWi), the KfW banking group, as well as six industrial groups (BASF GmbH, Deutsche Telekom AG, Siemens AG, Robert Bosch GmbH, Daimler AG, and Carl Zeiss AG). Since 2005, about 250 businesses from the high technology sector have been supported by the programme. In October 2011, HTGF II was launched with a fund volume of EUR 288.5 million. In addition to BMWi and KfW, twelve industrial groups are participating in this fund (Altana AG, B. Braun Melsungen AG, BASF SE, Cewe Color AG & Co OHG, Daimler AG, Deutsche Post AG, Deutsche Telekom AG, Qiagen GmbH, Robert Bosch GmbH, Tengelmann Ventures GmbH, Vorwerk & Co. KG, and Carl Zeiss AG).[218]

be realised, which, in turn, will lead to a decrease in the number of role models to inspire potential entrepreneurs.

Determinants of entrepreneurial success

The affinity and probability of launching a business is influenced not only by existing institutional framework conditions, but also by the potential entrepreneur's characteristics. In the view of start-up experts from business, science and politics, Germany as a location can offer a whole range of advantages. These include e.g. the country's geographical infrastructure, effective public-sector funding programmes, as well as highly developed organisations for the protection of intellectual property. The availability of advisory services and suppliers is another factor that makes Germany an attractive location for entrepreneurs. What is more, German businesses and German consumers are generally open to innovative new products and services.[219]

In the view of start-up experts, one of the disadvantages for entrepreneurs is the lack of entrepreneurial education in secondary schools and in extracurricular activities of school-going children, and the fact that Germany's entrepreneurial culture is somewhat underdeveloped. One potential means of addressing these weaknesses could be to systematically promote entrepreneurship education in schools. This would improve entrepreneurial skills in the long run and would be likely to sustainably foster an entrepreneurial spirit among the larger public. Another

BOX 12

European limited liability company

More than 99 percent of businesses in the European Union are small and medium-sized enterprises (SMEs). From these, only 8 percent engage in cross-border trade, and only 5 percent have subsidiaries or joint ventures in other countries. Many SMEs would have the potential to expand their business activities on the European market; yet the translation of this potential into actual business is hindered by legal and administrative obstacles. Generally speaking, these obstacles also exist for larger companies, and yet to SMEs they are more of a threat due to their relatively low level of human and financial resources. These obstacles primarily consist in additional efforts and expenses associated with the launch of a business in those countries that a company wants to commence business in. Expenses are incurred e.g. due to a mandatory minimum capital requirement, charges for registries and notaries, charges for legal advice and compliance with the rules and regulations for operating a business.[220]

Against this background, the EU Commission presented an initiative for introducing a European limited liability company, i.e. a European private company, in 2008. This new European legal form is thought to increase the competiveness of SMEs by making it easier to establish new branches and new business operations within the internal European market. The Commission's proposal would allow companies to operate in all EU member states according to the same rules and regulations for launching and operating a business venture. This would result in a considerable decrease in efforts and expenses incurred in international business and trade.[221]

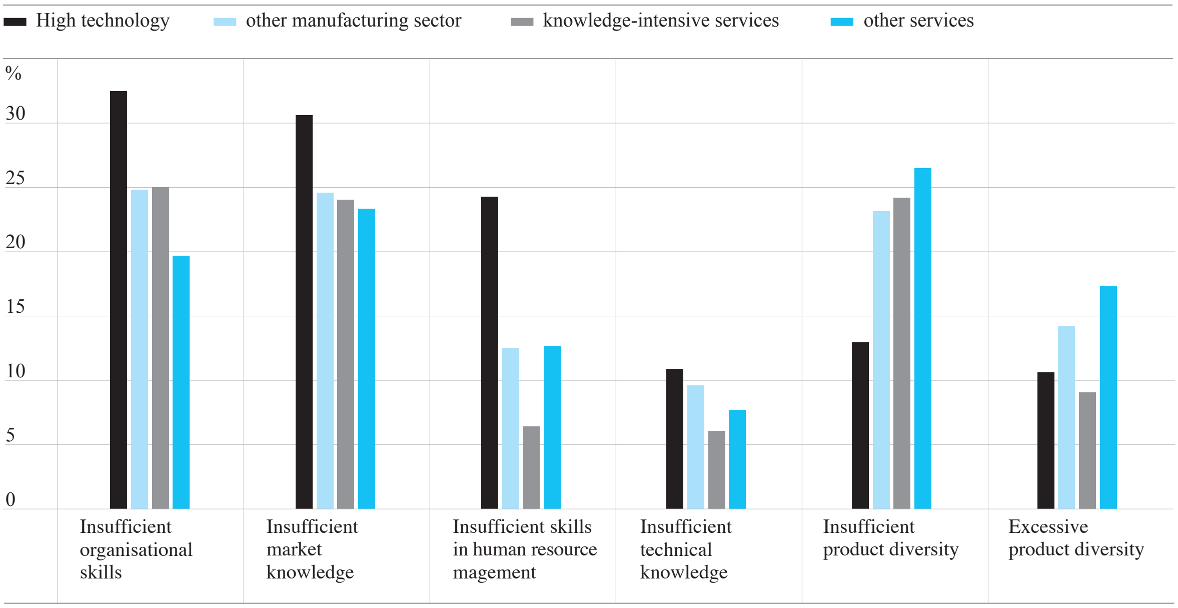
In June 2008, the EU Commission presented a proposal for the layout of the European limited liability company, which was approved by the European Parliament in March 2009. Yet, the introduction of the new legal form failed in December 2009 in front of the European Council, where Germany in particular expressed reservations concerning the transfer of a registered office, the minimum amount of capital, modes of share transfer, and employee participation. In the spring of 2011, negotiations were taken up again, but at the meeting of the Competitive Council that was held in May 2011, no agreement could be reached on the conditions for introducing a European limited liability company.[222]

point that has been criticised by start-up experts is that, compared with established companies, new enterprises benefit to a lesser extent from knowledge transfer from universities and non-university research institutions. Other factors that have been criticised include market entry barriers, considerable bureaucratic obstacles, and insufficient transparency of the German tax system.[223] [224]

German companies that seek to establish a subsidiary in another European country are faced with another substantial barrier: the lack of a common legal form for small enterprises that is valid throughout Europe. While the European company (SE) has already been introduced, no agreement could be reached over the launch of a European private limited liability company. This means that a company seeking to expand its business throughout Europe will have to establish an individual company in each individual country; an activity that incurs considerable organisational and financial efforts (cf. Box 12). The Expert Commission therefore stresses the importance of swiftly reaching an agreement in the negotiations regarding the launch of a European private limited liability company.

Personal characteristics of a potential entrepreneur play an important role for the success of a business start-up. Generally speaking, the probability of starting up a new enterprise increases with the potential entrepreneur's level of net household income. The influence of the entrepreneur's age follows a reverse U-shaped curve. This means that the probability of starting up a new business increases up to a certain age – in Germany, typically up to the age of 35 to 45 – and then decreases again.[225] Individuals with a migration background venture into self-employment more often than individuals who do not have a migration background.[226] Examples from other countries demonstrate indeed the major role that immigrants can play in starting up new businesses. In the Silicon Valley for instance, half of all new enterprises are founded or co-founded by (mostly highly-qualified) immigrants.[227]

FIG 14 **Management problems as causes for business closures: frequency according to industry** (figures in percent)



Source: *ZEW-Marktaustrittsbefragung 2009,* Egeln et al. 2012.

The human capital of (potential) entrepreneurs plays a major role not only for the probability of launching a business, but also in terms of the growth and survival of the new enterprise. The higher the level of the entrepreneur's education, the more likely it is that the business will be successful. Moreover, qualifications from the field of hard sciences have a positive impact both on the probability of starting up a new enterprise and on the business' prospects for success. Since academic qualifications particularly in the field of hard sciences are relatively scarce, and are expected to remain scarce, there will be increasing competition for qualified individuals in this field.[228]

Another important success factor for the growth and survival of young businesses is industry experience and management experience on the part of the entrepreneur. These are skills that cannot be taught through academic and vocational training; they have to be obtained through respective activities in the course of a person's career.[229] Because of this, it seems particularly important to provide young entrepreneurs with support and advice from more experienced partners.

CLOSURE OF YOUNG BUSINESSES B 3–2

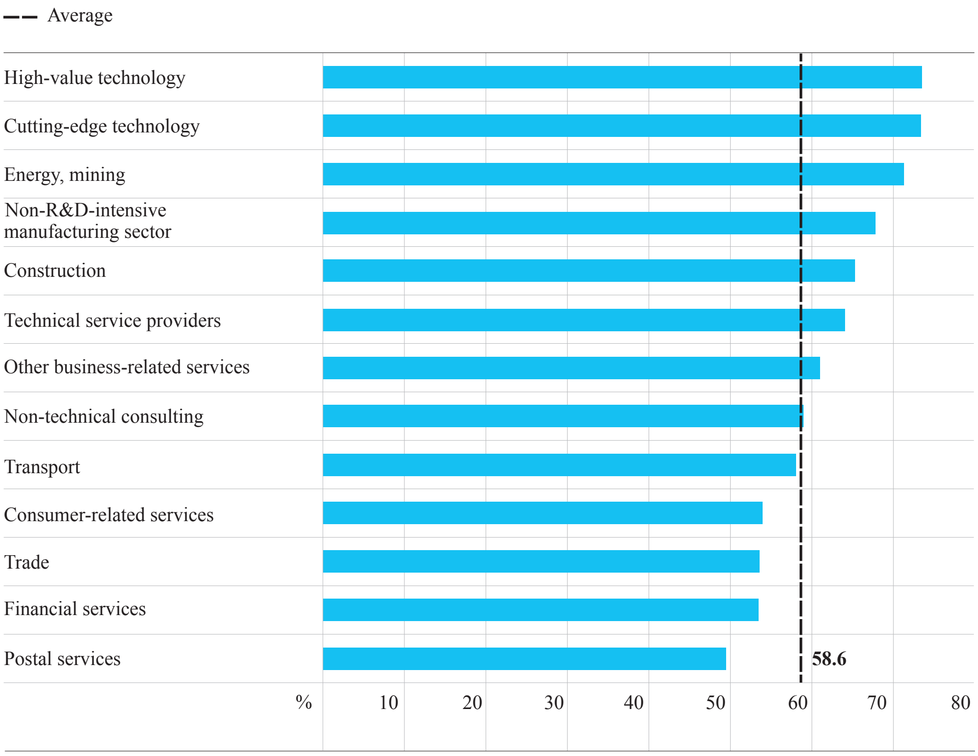
Not every newly established business turns out to be successful. The question of how well a company can deal with difficulties that may occur depends on internal factors such as the entrepreneur's personality and his or her strategic management of the company. Yet, the company environment can also be a decisive factor; especially conditions in the sales and factor markets are relevant here[230]

Internal factors

Strategic, target-oriented decision-making can be regarded as a key success factor for the survival of any business venture. Administrators in insolvency and business consultants experienced in liquidation issues often point to the poor quality of business planning and controlling among entrepreneurs. Moreover, they find fault in terms of suitable risk management, especially when it comes to securing liquidity.[231] In companies from the industrial sector's high technology branches, and in companies from knowledge-intensive services, the entrepreneur's lack in organisational skills is significantly more often

Survival rates of young businesses according to industry
(percentage of business start-ups that are still active in the market after five years)

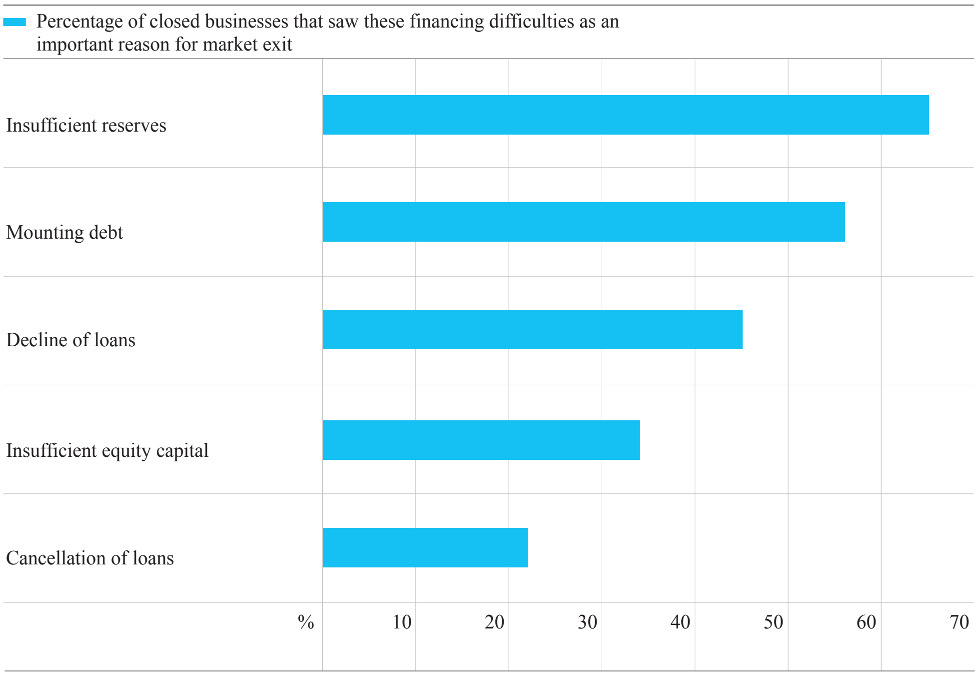
FIG 15



Source: *ZEW Mannheimer Unternehmenspanel* (businesses from start-up cohorts 2004 and 2005 only); Egeln et al. 2012.

Relevance of financial difficulties as a reason for market exit
(in the view of businesses affected)

FIG 16



Source: *ZEW-Marktaustrittsbefragung 2009,* Egeln et al. 2010.

among the main reasons for closing a business than is the case in other sectors (cf. Figure 14).

Another important factor for the success or failure of a new enterprise is the entrepreneur's industry experience. The more experienced the entrepreneur, the less likely he or she is to exit the market, and the longer the company's survival period.[232]

Contrary to common expectations, businesses from the high technology sector and the manufacturing sector survive longer than businesses from other sectors (cf. Figure 15). Selection effects are a possible reason for this: in these economic sectors, market entry barriers are high due to the sector's high capital requirements. Thus it can be argued that only the best business models can convince capital providers and be implemented eventually. These findings also correspond with evidence from other European countries, which confirm that closure rates for businesses from high technology and knowledge-intensive services are relatively lower than those of the total economy.[233]

Company environment and factor markets

Entrepreneurs frequently mention financing problems as a cause for closing down their businesses. Financial issues are not necessarily caused by internal difficulties; they can also result from external difficulties. These include e.g. default on receivables from clients, a lack in self-financing capacity, cost increases resulting from price increases on the procurement markets, or the necessity to buy out one of the partners. These external factors can lead to an insufficient accumulation of reserves, the refusal of subsequent borrowing, payment difficulties, and even insolvency. Figure 16 shows the proportion of businesses that mentioned diverse financial problems as the main reason for their market exit. Thus in 65 percent of business closures, insufficient reserves significantly contributed to the company's market exit.[234]

Excessive debt or the lack of reserves as a closure reason are less frequently mentioned by high technology companies in the industrial sector (cutting-edge and high-value technology) and knowledge-intensive services when compared with companies from other sectors. Still, in 20 to 50 percent of cases, financial difficulties were one of the main reasons for market exit.[235]

More than 80 percent of companies that filed for insolvency had previously been able to generate profits; 73 percent of companies that closed for personal reasons had reached the profit zone; and 61 percent of companies that closed due to economic or financial reasons without filing for insolvency had surpassed the break-even point in the course of the company's lifespan. These observations suggest that many companies that filed for insolvency, or retired from the market without filing for insolvency, at least temporarily operated on the market successfully but encountered payment difficulties due to sudden incidents of liquidity shortages.[236]

As a matter of fact, between 33 and 45 percent of companies that had retired from the market stated that the loss of receivables had been a major reason for closure. When analysing the relevance of financial problems according to sector in more detail, it appears that high technology companies from the industrial sector and knowledge-intensive services are less affected by financial difficulties caused by external factors as is the case with companies from other sectors. Default on receivables can turn into a threat especially for young businesses with a non-diversified client base. Thus unfavourable market conditions in combination with frequently found thin capitalisation can have a serious effect on new enterprises. Thin capitalisation from the start will make it difficult to compensate for financial setbacks, which can result in failure for otherwise promising business ventures.[237]

To sum up, these empirical findings lead to the conclusion that many business start-ups in Germany either enter the market with too little initial capital, or fail to create sufficient reserves in the course of their business operations to be able to cope with financial setbacks such as the loss of receivables.

Insolvency procedures in need of reform

Between 2000 and 2008, an annual average of approximately 30,000 young businesses (i.e. companies no older than 5 years) exited the German market.[238] From these, about one quarter retired from the market by means of insolvency procedures. Within the same period of time, about 45,000 jobs were lost in the course of insolvency procedures. Company closures without insolvency procedures, which typically affect smaller businesses, resulted in the loss of approximately 55,000 jobs per year between 2000 and 2008.

Starting up a business is an inherently risky activity; hence it is inevitable that a certain proportion of start-ups fail because the initial business idea does not prove to be sustainable. From a macroeconomic perspective, company closures are a cause for concern if they happen due to temporary liquidity shortages, and not due to a business model that is non-viable in the long term.

In the event of an actual insolvency, insolvency procedures should focus on financially restructuring the business and strive to avoid closures that are inefficient from a macroeconomic viewpoint. Germany's insolvency act from 1999 states that insolvency proceedings "shall serve the purpose of collective satisfaction of a debtor's creditors by liquidation of the debtor's assets and by distribution of the proceeds, or by reaching an arrangement in an insolvency plan, particularly in order to maintain the enterprise."[239] Yet, the insolvency plan stipulated in the insolvency act failed to live up to its standards. As a rule, insolvency leads to closure, and this is particularly true for young businesses.

This is problematic, especially since it has been demonstrated, as described above, that companies often suffered closure although they could have been successful players on the market but did not manage to cope with a temporary crisis. It is these very companies however that should be provided with the opportunity to restructure financially.[240]

Current German legislation throws numerous obstacles in the way of financially reorganising companies that are threatened by insolvency. Insolvency procedures are characterised by a high degree of uncertainty for both the debtor and his or her creditors: stakeholders have hardly any influence on the selection of the insolvency administrator. Furthermore, the duration of the procedures is barely predictable, since individual creditors can delay the process via legal means. What is more, German courts only reluctantly employ the right to self-administration, which allows the debtor to maintain his or her power of administration and disposal after the onset of the procedures. Due to this, a timely insolvency filing that strives to financially restructure a company still remains a major exception to the rule. Against this background, the Federal Government's recent legislative proposal on further facilitating the financial reorganisation of companies[241] aims to increase opportunities for restructuring businesses. This entails the integration of debtors and creditors into the selection of key stakeholders, and the improvement of planning security during the course of insolvency procedures.[242]

The Expert Commission welcomes these endeavours. In order to facilitate the restructuring of small enterprises in particular, several organisational and thematic issues will have to be addressed when revising the current insolvency law. Interviews with insolvency administrators suggest that it would be desirable to increase the relevant economic expertise of judges and judicial officers who are involved in insolvency procedures. This could be achieved by creating specialised courts or special chambers that deal with insolvency issues. In addition to this, remuneration law for insolvency administrators should be revised in a way that it would set monetary incentives for maintaining young businesses. Another promising measure would be to provide companies with consultants who possess advanced economic expertise and who would advise them during insolvency procedures. Another desirable reform approach would be to provide for out-of-court restructuring procedures.[243] Germany's insolvency law and insolvency practice should focus much more on restructuring and maintaining businesses. In the view of the Expert Commission, this would have a positive impact especially on Germany's technological performance.

FINANCING AS A MAIN OBSTACLE FOR THE ESTABLISHMENT AND GROWTH OF ENTERPRISES

B 3–3

Financing represents a key challenge for enterprises; not only in the start-up phase, but also in the growth phase. For young innovative enterprises, it is particularly difficult to secure sufficient funding. In many cases, internal funding is rarely an option as most companies generate little or no revenue in the beginning and are thus unable to use their revenue to make investments and to cover current expenditure. Thus in the planning and start-up phase, young businesses often make use of their own private resources or receive support from friends and family. However, highly innovative companies often require funds amounting to several million euro, which is beyond the scope of what can be accumulated from these sources.

That is why external financing is often indispensable during the start-up phase of a young business. One way of external funding is the borrowing of capital in the form of bank loans. Yet, this also may cause major problems for young enterprises as it is difficult for banks to assess a company's prospects for success, especially when it comes to innovative business start-ups. In addition to this, major information asymmetries regarding the entrepreneur's skills and risk preferences can also be observed. These are issues that could generally be reduced by providing collaterals. Since young companies are often unable to present collaterals at an early stage, banks are often very reluctant to grant loans to young entrepreneurs.

Another means of external funding is equity capital. Equity investors provide entrepreneurs and young businesses with equity, thereby obtaining a share in the capital growth and the profits of a company in the event that the business succeeds. Equity capital is especially suitable for innovative business start-ups that have a venturous business idea that promises large profits in the event of success. In the earlier stages of a start-up, business angels are often a suitable source of financing; these are often experienced entrepreneurs themselves. In terms of its organisational make-up, this type of financing can be located somewhere between informal funding options (i.e. friends and family) and formal funding options such as equity funds. Yet, during the start-up phase this type of financing is only available to a limited extent, which typically results in a financing gap. One option for filling this gap is funding via state contributions.

In the growth phase of a young business, it is often venture capital providers who provide funding. Venture capital is formal equity capital raised via funds and managed by fund managers.[244]

Not all companies are equally successful when it comes to acquiring equity capital. A recent study has shown that the probability of obtaining equity capital increases if a company has been established by a team, or if the entrepreneurs have a graduate or postgraduate degree in a natural sciences subject.[245] According to the study, approximately 2 percent of German businesses make use of equity capital.[246]

Whether or not equity investors will invest in a business largely depends on the entrepreneur's human capital. Here, informal human capital is much more crucial than formal human capital: the decisive factors that were most frequently mentioned by surveyed capital providers are industry expertise, a convincing entrepreneurial personality, and the combination of commercial and technical management skills. Another vital factor is a young company's innovation-related activities and its competitive environment. It is also considered positive if the product or service is a novelty at least on the German market, or if the number of competitors is very limited. Furthermore, equity investors are inclined to provide funding for enterprises that have their own R&D, as well as enterprises that possess a patent or an alternative protection right. The equity investors' estimations confirm what has been said earlier regarding the positive effects of human capital on the success of a business. Investment requests will primarily be rejected if a competitive advantage cannot be detected or appears to be unsustainable, if financial planning appears to be unrealistic, or if the business idea does not match the portfolio of the fund.[247]

In the following, different types of financing that become relevant in different phases of business development shall be analysed with a view to potential issues that may arise.

Early-stage investment by the public sector

The *High-Tech Gründerfonds* (HTGF) was established in 2005 in order to support financing of business start-ups in the high technology sector (cf. Box 11). To date, approximately 250 businesses have received funding from the HTGF. In addition to financial assistance, the HTGF also offers coaching, as well as support in acquiring additional venture capital for follow-up financing. In October 2011, HTGF II was launched with a fund volume of EUR 288.5 million. The Federal Ministry of Economics and Technology

(BMWi), the KfW banking group, as well as twelve industrial groups are involved in this fund.[248]

The HTGF I funding programme was assessed positively overall. Over the last decade, German private venture capital providers have been focussing on the less risky growth phase, while relatively risky early-stage financing has been stagnating[249]; a trend that could also be observed in other European countries. HTGF I could partially fill the financing gap resulting from this, thereby contributing to the (re)vitalisation of the German market for early-stage investments. Today, HTGF is in fact Germany's major investor in early-stage financing. The evaluation of the programme did not provide any indications suggesting that the HTGF has caused a crowding out of private venture capital investments. Rather, private venture capital investors perceive the HTGF as an instrument that will open doors to promising investment opportunities in later financing phases.[250]

Several studies on public-sector venture capital funds indicate that these funds achieve particularly successful results if entrepreneurs are supplied with specialist advice by experienced stakeholders, if public funds concentrate on the seed and start-up phase, and if the funded business is co-financed by private funds.[251] In view of these findings, it is therefore pleasing that public-sector venture capital in Germany largely meets these criteria. As discussed earlier, public funding plays a vital role in Germany's market for early-stage financing, and links between private and public funds are also strong. Thus, between 2007 and 2009, more than one third of private venture capital providers made use of a public funding programme in the context of their investment activities.[252]

Business angels

Business angels have become an important source of equity in the early-stage financing period. Especially in recent years, the relevance of business angels has increased as venture capital companies have increasingly retired from the risk-intensive field of early-stage financing and have started focussing on investment in later phases of growth. In Europe, investments by business angels have increased from approximately USD 150 million in 2006 to more than USD 250 million in 2009. At the same time it can be observed that the sector is becoming more and more formalised and organised through the establishment of business angels associations and networks. In 2006, a little more than 800 networks for business angels existed in Europe. In 2009, this number had already gone up to more than 1,400.[253] Investments by business angels usually have a strong regional focus, which means that the number, development degree and dynamics of business angels' activities may vary considerably between regions. Due to this, support measures for business angels' networks in the United States and Canada are often implemented regionally and not nationally.[254]

Considering the gap in supply of equity capital in the early phase caused by many venture capital providers' shifting towards the less risky growth phase, and given the positive external effects of start-ups on the overall economy, it seems generally desirable to promote the market for business angels. However, there are no reliable data yet for assessing the market for business angels and political measures relating to business angels, since business angels do not usually publish their investments. Besides, we are still lacking a uniform definition of the term "business angel", which would be needed for the sake of statistical documentation. Thus it is sometimes the case that informal venture capital (e.g. money from friends or family) is subsumed under business angel investments. Therefore efforts should be made to seek a common definition on a European level. Based on this, activities of business angels should be documented more clearly, which would allow for an improved evaluation of funding measures and facilitate the identification of effective funding measures.[255]

Tax incentives are one way of promoting activities of business angels. These have been identified as the main criterion considered by business angels when deciding on potential investments.[256] With its law on the modernisation of framework conditions for capital investment companies, the Federal Government has taken a step in the right direction (cf. Annual Report 2009). While this legislative proposal failed in the European Commission's verification procedure, the Commission did not raise any objections against the introduction of tax credits for business angels.[257]

In the view of the Expert Commission, it would make sense to introduce a promotional system similar to the Enterprise Investment Scheme (EIS, cf. Box 13), a tax relief scheme that was launched in Great Britain in 1994. This would serve as an efficient instrument for implementing support for business angels in Germany. One of the main advantages of the EIS is the fact that its compatibility with the EU provisions on state aids has already been assessed by the European Commission. The Expert Commission therefore strongly recommends that the Federal Government introduce a promotional measure that is equivalent to the EIS.

Co-investment funds are another means of supporting the activities of business angels. The idea is to combine private investments of business angels with corresponding investments from public funds, with the aim of supporting the development and professionalisation of the business angels market via well-designed innovation processes. Co-financing of business angel activities already takes place within the framework of the *ERP-Startfonds*[258], where investments by the fund are made under the same conditions and to the same amount as those of the private investor.[259] Yet, co-investment of this type can only be successful provided that business angels' networks are pre-existent.

Business angels' networks are public or private associations of business angels that systematically organise the selection and promotion of young businesses that are seeking growth capital. In 2009, the number of business angels' networks amounted to 38; the average number of members was 51, and, on average, each network received around 290 applications for funding.[260] On average, five participations per year were secured via business angels' networks, albeit the procurement rate varies significantly between the individual networks. The existence of professional structures (such as a fund vehicle within the business angels' network) and the network's profit orientation are statistically relevant determinants for the number of participations secured. A regional focus of a business angels' network however has a negative impact on the number of participations secured.

BOX 13

Great Britain's Enterprise Investment Scheme (EIS)[261]

The EIS was introduced as early as 1994 and has been adapted several times since then. By providing tax incentives, the scheme encourages private investors to obtain shares in small enterprises. Among other things, the provisions of the EIS allow for an income tax reduction of up to 30 percent (until September 2011: 20 percent) of the amount invested (with a ceiling of GBP 500,000), a deferral on taxation on investment income, and an exemption from capital gains tax on gains on disposal. Tax benefits are only granted for investments in enterprises that have less than 50 employees and gross assets of less than GBP 7 million.

The enterprises in which shares are acquired may not be quoted on the stock market or be controlled by other companies. Shares are centrally recorded at the Small Company Enterprise Centre. Certain companies are excluded from the scheme, among them businesses that are primarily active in financial services, property trading, shipbuilding, as well as legal and tax advisory services. The investors, too, have to meet certain conditions. Thus the scheme does not provide for shares in affiliated companies, and the investor may not be employed by the enterprise. Moreover, a minimum holding period of three years applies.

In 2010/2011, the EIS programme incurred costs amounting to GBP 170 million. In the previous year, approximately 1,900 enterprises had received equity capital in the region of approximately GBP 610 million. Since the EIS was established as early as 1994, numerous evaluations have been conducted to date, and most of these surveys present a very positive picture.

Venture capital

Germany's venture capital market is substantially smaller than that of other countries. In 2010, venture capital investments in Germany amounted to EUR 708 million; within the same period, venture capital providers in the United States invested a total of USD 13.3 billion.[262] But also in European comparison, Germany is situated merely in the middle range: with a proportion of venture capital investments of 0.028 percent of GDP, Germany is positioned only slightly above the European average of 0.027 percent (cf. Figure 17). In the leading group that comprises Sweden, Norway and Finland, this ratio is between 0.055 and 0.068 percent. If Germany wants to catch up with these countries, it would have to at least double its venture capital investments.

One of the main reasons for the comparatively weak development of Germany's venture capital market is the small size of funds. Institutional investors have an interest in investing a certain minimum volume per fund. When investing in small funds, investors will raise a large proportion of the entire capital of the fund, which results in a low degree of diversification and a higher risk for the investor. Because of this, institutional investors are reluctant to invest in German venture capital funds. The critical fund size that would attract institutional investors would be EUR 100 million. Yet, only rarely is this fund size achieved by German venture capital funds.[263]

Moreover, Germany is lacking one particular type of institutional investor that is very relevant in other European countries: pension funds. In countries with funded pension provisions, pension funds often function as anchor investors, which gives a strong signal to international investors. Since Germany has a pay-as-you-go pension system, it is lacking these anchor investors. Therefore it is even more important that other institutional investors from the public sector are active in this field. In light of this, it is particularly alarming that KfW, the Federal development bank, recently retired from investments in new German venture capital funds.

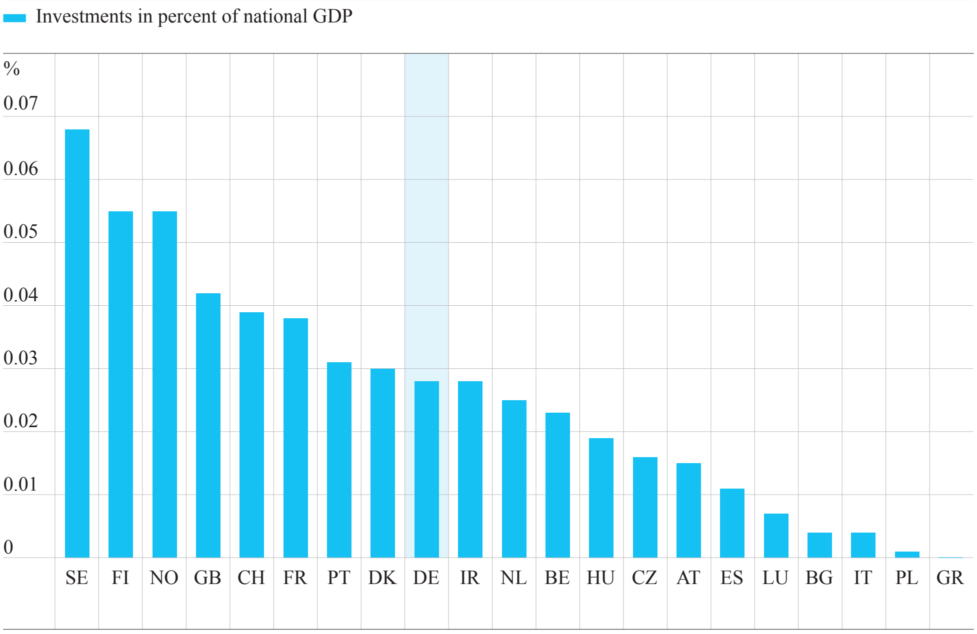
The venture capital market is subject to pronounced cycles[264] reminiscent of classical pork cycles. By the late 1990s, the German venture capital market had undergone a very positive development, with large amounts of funding going into Internet enterprises. With the bursting of the dot-com bubble, this process came to an abrupt end. Now only few options remained for investing the capital that had already been raised. The subsequent poor performance of this capital prompted investors to retire from the venture capital market. This was followed by an economic upturn during which attractive investment opportunities emerged, but capital was now scarce. The relatively small amount of venture capital that was available during this period performed well, which resulted in more capital flowing to the venture capital market. With the onset of the financial crisis in 2008, the venture capital market suffered another major setback. The development of the venture capital market's business climate is recorded by the "German Private Equity Barometer". Figure 18 shows that Germany's venture capital market – similar to other countries' venture capital markets – is highly volatile and strongly influenced by cyclical fluctuations.[265]

This pork cycle is largely caused by the fact that venture capital funds are set to run and be closed within a period of 8 to 10 years. In order to break these cycles, it would require liquid secondary markets, which means there would have to be a market for investors to trade their shares in venture capital funds. The existence of flexible exit options would increase incentives for investors to invest in venture capital funds. This is even more so because it has been shown that exit conditions are regarded as one of the major factors for assessing the commercial situation in early stage financing.[266]

A further difficulty lies in the fact that potential investors investing in a German venture capital fund have to take into account that the fund might be classified as a trade conducting activity. Although in practice the Federal Ministry of Finance (BMF) has ordered to treat venture capital funds as asset management companies,[267] this has not been anchored in law, which creates a source of legal uncertainty for potential investors (cf. Annual Report 2008).[268] Thus a pension fund that is based in the United States would lose its tax advantages in the event that the German fund it invests in is classified as conducting trade. Paradoxically, this has led to the fact that German capital investors go abroad to set up funds – which results in tax revenue losses for Germany's fiscal authorities.

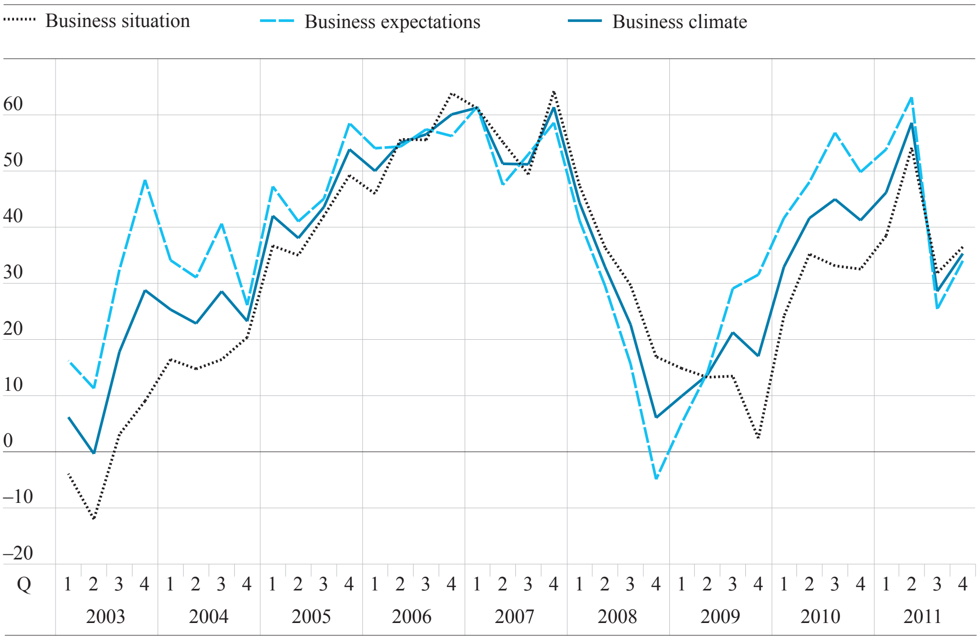
In short, the main reasons for the weak development of the German venture capital market are not a lack of investment options. Instead it can be stated that funds encounter difficulties in raising capital, which ultimately limits their scope of investment activities.

FIG 17 **Proportion of venture capital investments of national GDP based on the portfolio company's registered office** (data in percent)



Source: BVK 2011.

FIG 18 **German Private Equity Barometer**



Source: KfW/BVK survey.

EU initiative for facilitating access to finance for small and medium-sized enterprises

Small and medium-sized enterprises (SMEs) play a key role in economic growth and employment within the EU. Since financial difficulties are the major barrier to growth for small or medium-sized enterprises, the EU's Europe 2020 strategy has established as one of its main objectives easier access to financial capital for SMEs. To complement these efforts, a recently published action plan of the European Commission[269] provides for additional regulatory measures, and funds from the EU budget shall also be made available. Furthermore, the European Commission is planning to take on a co-ordinating role, with the aim of exploiting the synergy potential of EU member states' measures and EU measures (cf. Box 14).

The Expert Commission welcomes these initiatives, especially those that are directed at supplying information and facilitating access to loans and venture capital. In this context, attention should be attached to ensuring that the implementation of measures does not create additional obstacles for SMEs; the development of costly parallel structures should be avoided by all means.[270]

BOX 14

Measures proposed by the European Commission within the framework of the action plan for facilitating access to finance for small and medium-sized enterprises

The new framework conditions shall enable venture capital funds to conduct their activities on the European single market. This shall be achieved by removing regulatory and tax-related obstacles for cross-border activities. The European Commission has already amended its state aids provisions by increasing the threshold for public equity investments in the start-up phase from EUR 1.5 million to EUR 2.5 million. To improve access to finance for SMEs, the European Commission suggests integrating a section relating to "SME growth markets" into the EU's capital market legislation. The European Commission further suggests improving EU-wide availability of mandatory information on listed SMEs. This would lower the access threshold for investors and commercial providers of information on SMEs. Moreover, the rules for rendering and auditing of accounts should be simplified for SMEs.

The European Commission is further planning to investigate the impact that the capital requirements framework for banks and investment firms – CRD III, and the proposed CRD IV and CRR[271] – has on small and medium-sized companies. Depending on the outcome, the European Commission might suggest reducing the risk weight for SMEs. The European Commission also draws attention to the issue of delayed payment of invoices, which is a problem for SMEs in particular, and calls EU member states to introduce the Late Payments Directive[272] even before the expiry of the implementation time-limit in March 2013. The implementation of this Directive could result in a substantial decrease in demand for external financing. In the course of allocating funds from the EU budget, the European Commission has suggested the launch of an enhanced, extended EU debt investment instrument to facilitate the lending of credit to SMEs. The proposal further provides for implementing a sub-programme within the EU Programme for Social Change and Innovation, which aims at supporting microfinancing for microenterprises. As regards venture capital, the European Commission argues for an extended equity financing instrument for supplying SMEs with easier access to venture capital. Finally, the European Commission also suggests establishing an umbrella fund, which would allocate capital to venture capital funds that invest in several EU member states.

In the context of the planned co-ordinative measures for improving framework conditions for SMEs, the European Commission is also going to expand financial resources for advisory services of the Enterprise Europe Network.[273] In addition, information on different EU financing programmes for SMEs shall be made available on an online portal. Furthermore, the European Commission calls on the banking sector and the SME associations to advance the introduction of qualitative ratings that will complement the standard quantitative assessment of creditworthiness. Alongside these efforts, the European Commission encourages member states and interest groups to establish national "SME financial fora", a measure that has already been introduced in several member states.[274]

Facilitating private follow-up financing

The commitment of public funds has managed to at least partially fill the financing gap in early-stage financing. The focus now has to be on follow-up financing from the private sector. In this area, the supply is clearly too scarce in Germany.[275] What is more, a clear legal framework for private equity funds is not in place. The shortage of venture capital in Germany cannot be compensated by investments of foreign enterprises alone. For assessing the potential success of a business idea or an innovation, a solid knowledge of the target market is required. Foreign investors are often lacking this knowledge, which is the reason why domestic investors are needed to fully exploit Germany's innovation and entrepreneurial potential. Furthermore, foreign venture capital providers sometimes demand that the portfolio business moves to their country of origin. This however results in the loss of value added in Germany, and a technology drain from Germany. Due to this, it is vital that international venture capital is raised by German funds with the aim of investing in Germany. If this is to succeed, Germany must be transformed into an attractive location for venture capital providers.

In a European comparison of regulatory and fiscal framework conditions for venture capital, France was deemed as the country with the most favourable conditions in Europe.[276] This positive conclusion was based on the structures for venture capital funds, which offer tax transparency for national and international funds. Another factor that was assessed positively was the granting of tax incentives for venture capital: individuals who invest in venture capital funds in France can save up to EUR 50,000 in taxes per year.

Due to various institutional framework conditions, Germany is perceived as largely unattractive as a location for venture capital providers when compared with other countries.

One of the reasons for this is the current uncertainty regarding the treatment of venture capital companies' activities as either being asset management or trade conducting activities. If they are treated as asset management companies, this means that taxation applies only to investors in holding companies, but not to the holding company itself. It is therefore high time that the German legislator finally establishes a binding legal framework for the venture capital market and private equity investments.

Another feature that Germany is lacking when compared with France is tax incentives to promote private investment in venture capital funds.[277] Such promotional measures will have to be given thought.

In addition to this, Germany's restrictive treatment of carried-over losses has a negative impact on the venture capital providers' willingness to invest in German technology-based start-up businesses. Accumulated loss carryforwards will be partially or fully lost if shares in a company are transferred (§ 8c of the Law on Corporation Tax, KStG). As opposed to that, France and Great Britain treat carried-over losses less restrictively, which creates a location disadvantage for Germany.[278] Innovative start-ups in particular have high R&D expenditures in the early years and, on top of that, it takes several years before they reach the breakeven point. If costs for R&D work done are not taken into account after the business has been taken over, the business will be less attractive for potential buyers. Thus poor resale options will also make initial investment less attractive (cf. Annual Report 2008).

When compared on an international scale, another disadvantage for German equity funds is the VAT that applies to management fees. It is common practice that managing partners of equity capital companies receive an annual compensation of 2 percent of the funds volume to cover the costs of their investment and consulting services. In Germany, these management fees are subjected to VAT, which is not the case in other countries. Since deduction of input tax does not apply, this results in a definitive tax burden on the fund level.[279]

Utilising new opportunities for a venture capital act

European efforts to facilitate equity financing for SMEs and business start-ups are in progress, thereby unleashing new opportunities for the Federal Government to establish a sound, globally competitive legal framework for venture capital. After many years of misguided policies in this area, this is an excellent opportunity for Germany to achieve progress in this policy field.

The Directive 2011/61/EU on Alternative Investment Fund Managers[280], also known as the AIFM Directive, has to be incorporated into national legislation before 22 July 2013. In its Annual Report 2011, the Expert Commission commented in depth on the impact of the AIFM Directive while also providing recommendations for action. Like other observers, the Expert Commission also pointed out that, with regard to venture capital funds, a strict application of the measures stipulated in the Directive would not be advisable. The proposed legal framework as laid out by the AIFM Directive primarily aimed at regulating hedge funds and private investment companies; the provisions were not quite suitable for managers of typical venture capital funds.

In the meantime, improved framework conditions have been developed to specifically meet the requirements of this type of investor. Thus, in December 2011, the European Commission presented its proposal for a regulation[281], which provides for uniform European provisions for managing venture capital funds. Funds that subject themselves to this optional set of rules shall be enabled to operate under the title of European Venture Capital Fund (EVCF). According to the proposal, EVCF do not have to meet the often complex requirements of the individual member states but are now operating under a harmonised European regulation. This shall make it easier for young businesses to raise capital internationally. Box 15 explains the requirements that the funds, organisations and investors have to meet.

BOX 15

Requirements for European venture capital funds according to the European Commission's proposed Directive 2011/0417

A European Venture Capital Fund (EVCF) dedicates at least 70 percent of the capital paid in by shareholders to investments in SMEs. The EVCF shall provide equity or quasi-equity[282] for these SMEs. The EVCF refrains from any financial leverage (e.g. by means of borrowing), which means that the amount invested by the fund may not exceed the amount paid in by the shareholders.[283] The assets managed by an EVCF manager may not exceed the threshold of EUR 500 million.

Funds that use the title of EVCF have to comply with the uniform requirements and quality standards stipulated in the regulation. These include provisions on the disclosure of investment strategies, investment objects, costs and fees, risk and return profiles, as well as the calculation of the remuneration of the venture capital fund's manager, and, finally, operational requirements for shareholders. Managers of EVCF shall be provided with the option of using a European venture capital passport that will guarantee uniform framework conditions for their activities within the EU. In the AIFM Directive, such a passport was stipulated only for fund managers with a managed fund capital of more than EUR 500 million.

The regulation also specifies the organisational structure of a European Venture Capital Fund, and shareholders, too, are subjected to uniform requirements. Thus professional shareholders are only eligible if they meet the requirements of the MiFID Directive (Markets in Financial Instruments Directive). Furthermore, the regulation shall also allow for investment opportunities for business angels.[284]

The Expert Commission welcomes the European Commission's initiative to further improve SMEs' access to capital and facilitate the launch of new businesses. Especially the introduction of a European venture capital passport passport for managers and venture capital funds could prove to be a useful measure. Furthermore, when implementing the proposed framework conditions in Germany, the Federal Government could attach tax regulations to the status of EVCF to keep Germany's fiscal costs low.[285] Yet, the regulation will have to be more specific in certain respects. Thus it is still unclear how e.g. the requirement of "sufficient own funds" or "adequate human and technical resources" shall be fulfilled in practice.

General appeals addressed to different Federal Governments over the years to introduce a reliable, internationally competitive framework for venture capital investments have not led to any results yet. In the view of the Expert Commission, the Modernisation of the Provisions for Capital Holdings Act (MoRaKG, cf. Annual Report 2008), which was introduced in 2008, did not lead to the desired results either. Furthermore, it has proven to be incompatible with the European Commission's aid frameworks.

With its current framework conditions for venture capital, Germany is thus situated only in the (lower) middle range when compared with other European countries. This deficit remains to be an obstacle for innovative progress in Germany. Should the political stakeholders keep up their reluctance, recent positive trends in the area of start-ups – which could be observed in several German regions (and most notably in Berlin) – could suffer in the long term. After more than ten years of hesitation and failures in this policy area, it is now the time for consistent action.

B 4 ECONOMIC ASSESSMENT OF PUBLIC R&D FUNDING

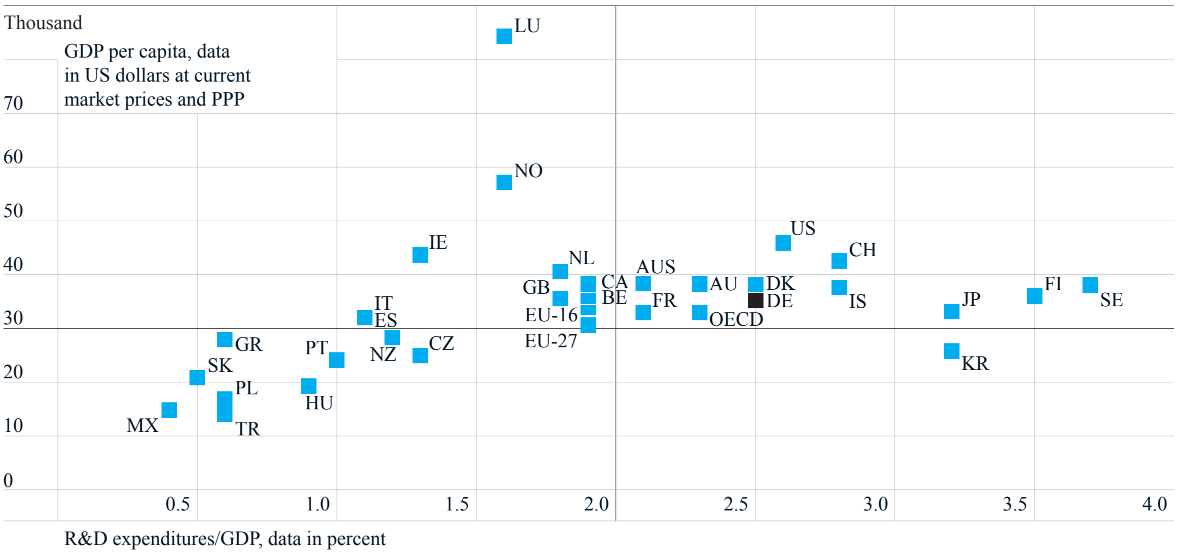
Research and development (R&D) are essential driving forces for an economy's international competitiveness and long-term growth.[286] The R&D process leads to the creation of new knowledge and contributes to the development of innovations. Hence, investment in R&D can be regarded as an instrument for increasing prosperity of knowledge-based industrialised countries. Figure 19 illustrates the link between national R&D expenditures and the gross domestic product (GDP) per capita. Typically, countries with a high GDP per capita display an R&D intensity of 2.0 to 3.6 percent; these are located at the upper right area of the chart. Countries with a low GDP per capita usually invest a smaller proportion of GDP in research and development (0.5 to 1.5 percent according to the diagram at the lower left area of Figure 19). As a general rule, long-term growth and a sustainable increase in productivity can only be achieved via a high level of R&D investment.[287]

On average, 64 percent of R&D funding in the OECD countries is attributable to the private sector, and 28 percent to the public sector.[288] The individual OECD countries pursue different strategies of mixed financing: in some of the economies the proportion of public funding of R&D activities is relatively high; these countries include France (39 percent), Great Britain (31 percent), and Canada (34 percent). In Germany, the proportion of R&D funded by the public sector amounts to 28 percent, thus corresponding to the OECD average. The difference is even more remarkable when one compares the allocation of public R&D expenditures. In the course of the last decade, many countries supported the particularly dynamic expansion of R&D in the private sector with targeted funding measures, while Germany remained largely reluctant in this regard. The major part of Germany's public R&D expenditures is still channeled into public R&D activities – the proportion of financing allocated to private R&D activities is relatively low in Germany.[289]

In light on these figures, the key questions to be asked include the following: why should governments conduct R&D activities, or support R&D activities? How can limited public resources be distributed to different funding measures and priority areas? How can the effectiveness of public measures be systematically monitored?[290]

GDP per capita and proportion of national R&D expenditures of GDP

FIG 19



Annual average values, 2006 – 2008 period.
Source: own chart and calculations based on OECD figures.
For country abbreviations, please refer to the list of abbreviations in the appendix of the report.

Rationale for public R&D funding

From an economic perspective, the implementation of public R&D activities and the funding of private R&D activities by the public sector are fully justifiable.[291] It is often the case that businesses that conduct research are not capable of appropriating the entire returns derived from their R&D activities. Other stakeholders, such as competitors, suppliers and clients, may gratuitously take advantage of the knowledge created in the R&D process and use it for newly developing or advancing their own products and processes (cf. Box 16). When deciding on the level of expenditure for R&D, businesses that strive for profit maximisation take into account only the private returns from their R&D activities. This leads to underinvestment in R&D, since the impact on the knowledge created by R&D on other economic stakeholders is not sufficiently taken into account. Measures on the part of the public sector can at least partially contribute to balancing out this market failure.

When supporting R&D activities, governments may prioritise the expansion of public research, or, alternatively, focus on promoting the implementation of R&D in the private sector. In Germany, the proportion of public R&D expenditures amounts to approximately one third of the total economy's R&D expenditures; the remaining two thirds are attributable to private expenditure. The largest part of public R&D expenditure is allocated to higher education institutions (39 percent) and non-university research institutions (48 percent); 13 percent of public spending go to the promotion of R&D activities in the private sector.

There are two types of public research financing: institutional funding and project funding. Institutional funding comprises basic funding of higher education institutions and non-university research institutions, which also includes federal department research institutions. The Federal Government here largely focusses on the financing of basic research. Due to particularly strong external effects, as described in Box 16, the private sector is engaged in this area only to a limited extent. Because of this, public funding in basic research is particularly important. While basic research in Germany is also supported by means of project funding (e.g. from the German Research Foundation), the largest proportion of resources for project funding is allocated to application-oriented research.

When supporting R&D in the private sector, the focus is primarily on pre-competitive and application-oriented research. Here, several instruments are available to the government. In most cases, project support is granted within the framework of specialised programmes that aim to promote certain technologies. For example, the BMWi's specialised programme ATEM supports research and development on propulsion systems for electrical and hybrid vehicles. As regards funding programmes that are not linked to a particular technological field, the government does not exert an influence on the type or contents of technologies funded. An example for this type of funding would be the Federal Government's "Central Innovation Programme for SMEs" (ZIM), which provides grants and low-interest loans for financing research and innovation projects of small and medium-sized enterprises.

An indirect type of funding is the granting of tax credits for R&D. In economic terms, tax credits reduce the marginal costs of implementing R&D activities. This is an instrument that is available in the majority of OECD and EU member states. To

BOX 16

Non-rivalry and non-exclusivity of knowledge

From an economic point of view, knowledge is characterised by two important features. First, it is characterised by non-rivalry in consumption: if one stakeholder uses knowledge, this does not decrease the utilisation possibilities of another stakeholder. Second, other stakeholders cannot, or only to a limited degree, be excluded from the utilisation of knowledge (non-exclusivity). If the knowledge created by an innovation-generating company comprises these two features, competing stakeholders can make use of the knowledge gratuitously. In economic reality, this situation is most frequently found in the area of basic research. In applied research and development however, businesses can try to keep the knowledge created by R&D confidential, or limit the use of this knowledge by third parties via intellectual property rights such as patents. Yet, in most cases both of these measures can only partially compensate for the existing market failure.

date, Germany has not made any use of this type of funding.

Positive effects of basic research

Despite the fact that the government allocates extensive funding in basic research, it is very challenging indeed to quantify the returns generated from this. One of the reasons for this is that the knowledge generated by basic research is only rarely available in codified form; more often than not, it takes the form of implicit knowledge. Hence, when transferring this type of knowledge, problem solution processes and learning processes based on experience play a major role,[292] which are generally difficult to measure statistically.

Despite these constraints, numerous studies have been conducted over the last few years that set out to document the impact of publicly-funded basic research on private businesses.[293] Interviews with companies, as well as economic surveys, suggest that collaboration with publicly funded research facilities has a positive impact not only on the development of new products, but also on the companies' revenue. Beyond this, surveys have also shown that stakeholders attach great importance to informal exchange between private businesses and publicly funded research organisations.[294]

Moreover, basic research conducted at higher education institutions and non-university research institutions considerably contributes to the training of highly skilled employees. Following the completion of their training or scientific work, these individuals usually find employment at public research institutes or in the industrial sector. For private companies with complex work processes, the analytical problem-solving skills of these employees are often indispensable. Thus is seems obvious that the personnel transfer of scientists from publicly funded research leads to positive effects; yet it remains difficult to quantify these effects more precisely.[295]

Public R&D funding creates incentives for additional R&D activities in the private sector

Over the last few years, there have been numerous studies analysing the impact of public R&D funding on the R&D expenditure of private enterprises. These studies confirm that public R&D investments result in an increase in R&D expenditure in the private sector.[296] It has been feared that funded businesses would substitute private R&D expenditure by public funding resources. Yet, these concerns can be invalidated as it has been shown that such knock-on effects usually occur to a relatively small extent.[297] To date, scientific research has not yet been able to draw a consistent picture of the exact level of funding effects. It can be observed that privately financed R&D expenditures of publicly funded companies are 15 to 40 percent higher than those of businesses that do not receive public funds.[298]

Macroeconomic effects of public R&D funding

As a rule, not only the research entity itself benefits from knowledge generated through R&D activities; other companies also obtain indirect revenues generated by means of knowledge spillover. Empirical surveys confirm the existence of such indirect revenue and demonstrate that this can reach a similar level as the direct revenue achieved by businesses that have invested in their own R&D.[299]

Yet, these surveys also indicate that the degree of knowledge spillover depends on the extent of the research activities by a business benefitting from external factors. Thus not all companies equally benefit from external knowledge. The important factor here is whether a company possesses sufficient competence to utilise the knowledge that exists in other companies.[300] This competence is usually strengthened by a company's own R&D activities.

Any public funding that aims to create domestic welfare gains also needs to consider the relationship between national knowledge spillover and international flows of knowledge. In some of the cases, research results can be transformed much more swiftly into added value by going abroad. This is an issue that has been explicitly addressed by more recent research on international knowledge spillover. Small, open economies such as Canada or Sweden are particularly affected by these effects.[301] Yet, the following findings also apply to Germany: funding impact cannot be strong if research is not met with a sufficiently strong industrial environment, or if the absorptive capacity of domestic companies is insufficiently developed for innovation. In such cases research might be extensively promoted in Germany, but the industrial implementation of the innovation is largely conducted abroad.

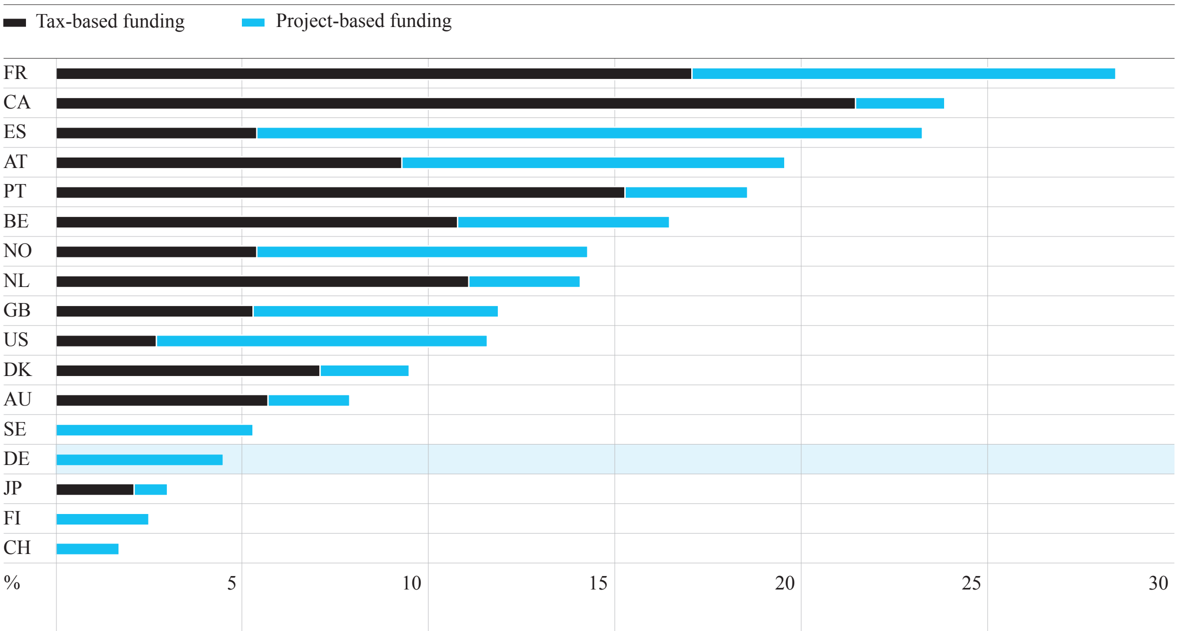
Because of this, the main focus of public research funding should be on areas that already have a highly developed national innovation system, or those areas where chances that such a system can be built up successfully are sufficiently high. This is also known as the ecology of innovation.[302] In addition to highly developed scientific research, ecology of innovation also includes effective collaboration between higher education institutions and industry, the existence of companies with onsite R&D facilities, the availability of venture capital, a highly developed patent system, as well as state regulations that support the innovation process in the respective field. All of these elements create reinforcement mechanisms and contribute to a strong domestic impact of publicly funded research.

R&D tax credits generate additional R&D expenditure in the private sector

Today, 26 of the 34 OECD countries and 15 of the 27 EU member states offer tax credits for R&D. In several OECD countries, the proportion of tax-based R&D funding already exceeds the proportion of direct public funding (cf. Figure 20).

Yet, the structuring of R&D support differs considerably across countries.[303] Regardless of these differences, several evaluation studies have confirmed[304] that tax-based R&D funding leads to an increase in private R&D expenditures.[305] The Industrial Research and Innovation Council (IRIC), a Canadian expert committee, recently presented a comprehensive assessment of tax-based R&D funding.[306] The report stresses the key importance of R&D tax credits as a measure that benefits SMEs in particular.[307] Moreover, many countries successfully use R&D tax credits as an instrument for attracting foreign investment.[308] Thus tax-related R&D funding has long become an instrument for competing business locations.[309] If Germany refrains from introducing tax credits for R&D, it will run the risk of fading into the background in the global competition for locations for multinationals and research-intensive industries.[310]

FIG 20 **Proportion of R&D expenditures in the economic sector that are directly or indirectly funded by the government, 2008** (figures in percent)



Source: OECD Main Science and Technology Indicators 2011-1 and OECD STI Scoreboard 2011. Calculations by ZEW.

BOX 17

Tax-based R&D funding

A recent study[311] analyses the organisational options and the anticipated effects of introducing fiscal R&D support measures in Germany. The authors of the study point out that the current German tax law contains a number of innovation-hampering provisions. These include the discrimination of self-financing as opposed to external financing, limited options for offsetting losses, as well as the treatment of intangible assets in terms of trade tax and cross-border function relocation.

The authors of the study further state that the aim of fiscal R&D support is to directly strengthen economic growth. To implement the measure planned in the Federal Government's coalition agreement, the study recommends volume-based funding that grants a tax credit that is proportional to the level of a company's R&D expenditure. A funding rate of 10 percent (for all companies)[312] would result in initial tax losses of approximately EUR 4.75 billion. A funding rate of 5 percent would result in tax losses of approximately EUR 2.38 billion. A particularly interesting approach according to the authors is the granting of tax credits for R&D personnel expenses, which could then be set against the wage tax that is payable on a monthly basis. This would result in immediate liquidity effects for the respective companies.

In addition to assessing the fiscal costs of tax-based R&D funding in Germany, the study also assesses the macroeconomic impact of R&D funding. When transferring relatively reliable results from international surveys to the German context, it can be assumed that for each euro of tax income that is lost to the public sector, EUR 1.25 of additional R&D expenditure is being generated. Based on fairly conservative parameter assumptions[313], the survey identifies the economic net benefits of this measure as approximately EUR 750 million.[314] This corresponds to approximately 15 percent of the financial volume invested. R&D funding of 10 percent would correspond to an increase in growth of 0.1 percentage points of GDP. Alongside its economic effectiveness, a major advantage of this measure is that businesses can decide if, when and how to invest in R&D – irrespective of government decisions and application procedures.

Already in its earlier reports, the Expert Commission indicated that the instrument of fiscal R&D support can be flexibly adapted. Should the government wish to use the instrument for limiting tax losses, tax credits could be capped, or, alternatively, large companies could be subjected to lower funding rates. This would concentrate the effect of funding on small and medium-sized enterprises, which is justifiable seeing that restrictions on financing have a stronger impact on SMEs than they have on large-scale enterprises. Yet, such an adaptation of the measure would contribute to securing the location only to a lesser extent, since it is primarily large-scale enterprises that relocate their R&D facilities. Thus it has been the case that major German car manufacturers have relocated large parts of their R&D activities to Austria to benefit from R&D tax credits there.

Improving impact analysis

Improved efficiency of fiscal R&D support can also be expected from strengthening and qualitatively advancing impact analysis. The last few years have seen the development of scientifically founded procedures for improving the evaluation of R&D funding measures. Yet, innovation research is far from systematically using impact analysis as a method of evaluation. In contrast to this, labour market research has made substantial progress in analysing the impact of public support ever since the 1990s. The integration of systematic evaluation standards has established a robust basis for analysing measures conclusively. In this regard, the specification of control groups has been particularly important.[315] Surveys in innovation research that integrated control groups into their analysis have also achieved significant initial results. This has been the case e.g. in the context of evaluating the *High-Tech Gründerfonds*[316] programme, and also in the context of evaluating the promotion of technology and innovation among medium-sized companies.[317]

Developing a suitable data infrastructure

Even at this stage, the Federal Government collects data that are essential for an impact analysis in their R&D funding databases. Yet, there is no provision for allowing unlimited use of data for the purpose of academic research. The Expert Commission therefore asks the Federal Government to provide scholars with unbureaucratic access to the data available in its R&D funding databases.[318]

In addition to merely making existing data available, it is also vital to develop a reliable, coherent data infrastructure. Other countries have already made initial achievements in this field. Belgium and Brazil, and most notably the United States, can be regarded as pioneers in the development of databases that consolidate information on public research funding, while also documenting scientific results and the effects of funding measures (cf. Box 18). Since the establishment of such databases has proved positive in several other countries, the Expert Commission recommends introducing comparable projects in Germany.

BOX 18

The STAR METRICS programme

STAR METRICS (Science and Technology for America's Reinvestment: Measuring the Effects of Research on Innovation, Competitiveness and Science) is a collaboration between the White House Office of Science and Technology Policy (OSTP), the National Science Foundation (NSF) and the National Institutes of Health. The programme aims to develop a single data infrastructure that will provide a basis for a standardised evaluation of research projects in the United States. By bundling administrative tasks in reporting, the programme will soon allow for a comprehensive cost-benefit analysis of research projects. STAR METRICS was launched in 2009 with a total of seven research institutes involved. In 2010, as many as 60 research institutes were participating in the programme, while another 50 institutes have expressed an interest in future collaboration.

The development of the STAR METRICS programme can be divided into two phases. The first phase aims to record the direct impact that public-sector investment in research has on the employment situation in the science sector. Since the required data are collected in the participating research facilities themselves, this first phase primarily allows for a systematic impact analysis of existing data. In the second phase, it is attempted to broadly document the scientific, social and economic effect of investment in research. Prior to the start of the survey, representatives from the government and the research institutes are integrated in order to decide on the reporting form and establish uniform evaluation indicators and methods. To date, numerous pilot projects have been initiated within the framework of STAR METRICS. With this programme, innovation research is following successful examples that have been set in education, labour and health research.[319]

B 5 THE CHALLENGE OF CHINA

China as a growth engine for the world economy

The rise of China to being one of the world's leading economic powers, as well as China's enhanced efforts in science, research and high technology make it necessary to examine the Chinese innovation system in depth. Germany's competitive position is strongly influenced by China. For the past three decades, China has displayed impressive economic growth, and the country also takes a leading role in driving and consolidating global economic development. To date, annual average growth rates have amounted to approximately 10 percent. Even the global economic and financial crisis in 2008 and 2009 did not curb China's extraordinary economic development. Thus, even in the course of 2009, China's GDP increased by 9.2 percent – compared with –0.7 percent worldwide, and –5.1 percent in Germany.[320] In 2010, China's GDP increased by 10.3 percent, and again in 2011 an increase of 9.2 percent was achieved.[321] After China had assumed Germany's position in 2007 as the third-largest economy worldwide,[322] it then went on to surpass Japan in 2010, which up until then had been the world's second-largest economy. Presuming that China's economic dynamics will largely remain the same, it is expected that soon China will surpass the United States, thereby becoming the world's leading economy.[323]

At the core of China's growth over the last decades are comprehensive, continuous reforms of the entire economic system. Introduced by Deng Xiaoping in 1978, reforms were initially limited to attempts to deregulate the agricultural sector. Encouraged by the success of these measures, further deregulation processes were initiated, first in the industrial sector, and then also in the services sector, albeit to a limited extent.[324] Despite the introduction of these economic reforms, the one-party system under the Chinese Communist Party (CCP) remained largely untouched.

China's transition into a market economy system has been accompanied by measures to attract settlement of foreign companies in China. The government in Beijing opened up selected parts of its markets, while at the same time demanding that foreign investors transfer technologies and know-how to China. By enforcing joint ventures with Chinese state enterprises and by regulating the development of production and R&D in China, the country aimed to overcome its technological backwardness. Although Chinese companies managed to continuously improve their productivity and their capacity to innovative, Chinese industrial and technological policies still failed to produce the desired results for quite a long time. Chinese high technology products still depend to a large extent on know-how and primary products from abroad. Moreover, the quality of research and development has not yet reached the level of the Triad countries (US, Japan, EU).[325] In 2006, China's State Council therefore presented a long-term plan for science and technology, with the objective of boosting the performance of the Chinese innovation system, while primarily strengthening domestic skills.[326]

Special economic zones played an important role in the reform of China's economic system. These areas served the purpose of testing economic developments before they were applied on a national level. The launch of the first special economic zone in 1979, Shenzhen, marked the beginning of China's "open door policy", which has remained the official title since 1983. Step by step, the Chinese market was opened to foreign goods, technologies and investments. Soon foreign enterprises also began settling in China's special economic zones, which were characterised by a strong export orientation from the start and that often had a focus on particular industries. Yet, the relevance of these special economic zones has decreased since 2000, as the Chinese innovation strategy was readjusted and the entire system was opened up further. When China acceded to the World Trade Association (WTO) in 2001, the process of integration into the world economy was further enhanced. In the course of this, the role of the special economic zones was curtailed in favour of other structural changes.

Economic growth accompanied by increasing inequalities

China's dynamic growth is accompanied by severe disparities and structural imbalances. Geographical, social and political disparities bear extensive potential for conflict, and tremendous efforts are made to bring them under control repeatedly. While the newly created growth centres significantly contribute to China's economic boom, they also exacerbate economic and social inequalities between the progressive coastal regions and the economically underdeveloped regions, particularly in the country's west.[327] The process of economic and social segregation is not just limited to the relationship between the provinces; it is also reflected in a substantial urban-rural gap and the rural exodus that accompanies it.[328]

Strong growth is accompanied by an increasing imbalance in the distribution of income and wealth. Today, China is characterised by severe social disparities and conflicts resulting from these disparities. Already in 2003, the wealthiest 10 percent of the population were allotted around 30 percent of total income, while the poorest 10 percent were allotted only 1.8 percent.[329] No less concerning is the fact that inequality within China's population is steadily growing. This increase in social disparities is illustrated by a rise in the Gini index[330] from 0.29 to 0.42 percent between 1990 and 2007.[331] On a positive note, the proportion of people living in poverty in China has decreased significantly. Measured against the World Bank's Headcount Index, which is commonly used for measuring poverty, China has made significant improvements since the 1980s.[332] At the same time, China ascended the United Nations' Human Development Index which measures the overall prosperity of countries.[333]

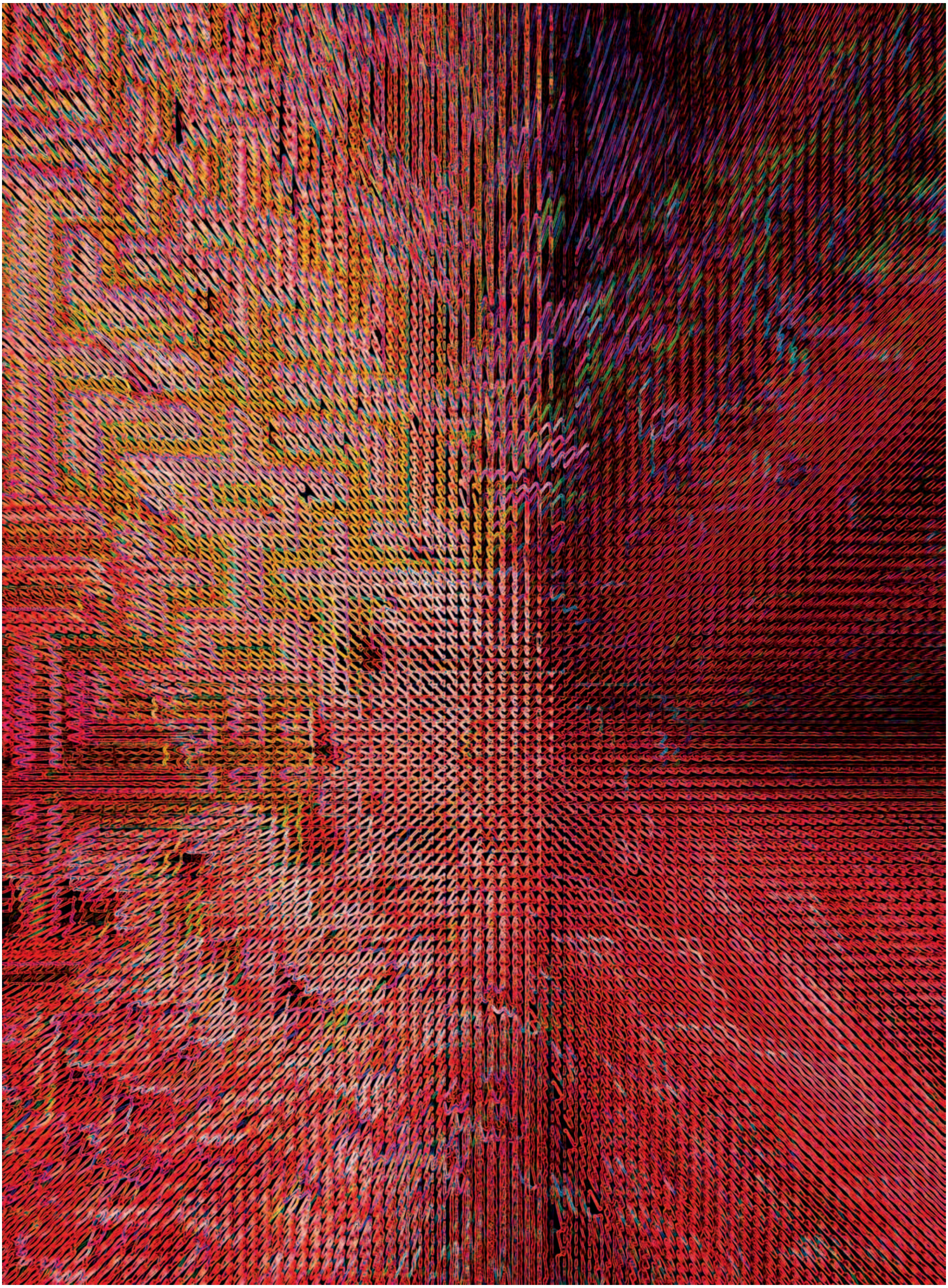
Redesign of central policies

Regardless of the comprehensive market economy reforms, the Chinese leadership continues to employ its Five-Year Plans as a major policy instrument. Although this is still the case, notions regarding the plans' function have changed over the years. Since the adoption of the 11th Five-Year Plan, these plans do not serve as "instructions" anymore but rather take on the role of "macro-steering" instruments.[334] While many of the planned targets have been achieved, and China's annual economic growth rate amounts to 10 percent – thus clearly exceeding the envisaged benchmark of 7.5 percent – China has only been partially successful in redesigning its growth model by giving it a stronger grounding in the domestic market. Not only the increase of innovative performance, but also the decrease in social inequalities and the development of domestic demand failed to live up to China's self-defined expectations. In fact, Prime Minister Wen Jiabao openly criticised China's economic development as being "imbalanced, uncoordinated and unsustainable."[335] China's transformation towards more social, technological and ecological sustainability shall now be enforced in the course of the 12th Five-Year Plan. Accordingly, the government's key objective of "growth" has now been replaced by that of "development". In this context, President Hu Jintao also stressed his notion of "inclusive growth", i.e. growth that is beneficial to all citizens.[336] Recent Chinese economic policy has been focussing on developing the domestic market and reducing China's dependency on export markets. To achieve this, China's leadership is willing to accept a decline in economic growth of approximately 7 percent per year.

Strong focus on research and innovation

China has adopted an offensive innovation strategy that specifically focusses on developing science and research. Between 1995 and 2009, national R&D expenditures increased from USD 11 billion to USD 154 billion.[337] This corresponds to an average annual growth rate of 21 percent. In the same period, the OECD's average R&D expenditures increased by 6 percent per year, and Germany's R&D expenditures by 5 percent per year. China's steady increase in R&D intensity illustrates the country's strong focus on research and development. In 1992, the proportion of R&D expenditures of GDP was a mere 0.6 percent. This ratio was increased to 1.7 percent up until 2009. Today, China's research intensity is similar to that of Great Britain or the Netherlands. While the self-defined target of 2.0 percent of GDP for 2010 was not achieved, it is very likely that this target was met in 2011. The relative importance of R&D shall be further enhanced via additional public R&D efforts as well as promotional measures in the private sector. For 2015, the Chinese government aims at increasing R&D intensity to 2.2 percent of GDP, and for 2020 a benchmark of 2.5 percent is envisaged.[338]

Owing to an ambitious development of the national R&D system since 2000, China has managed to gradually advance its R&D capacities, at least quantitatively, to the level of several leading industrialised



7/10 Chinese symbols on dried fibre felt
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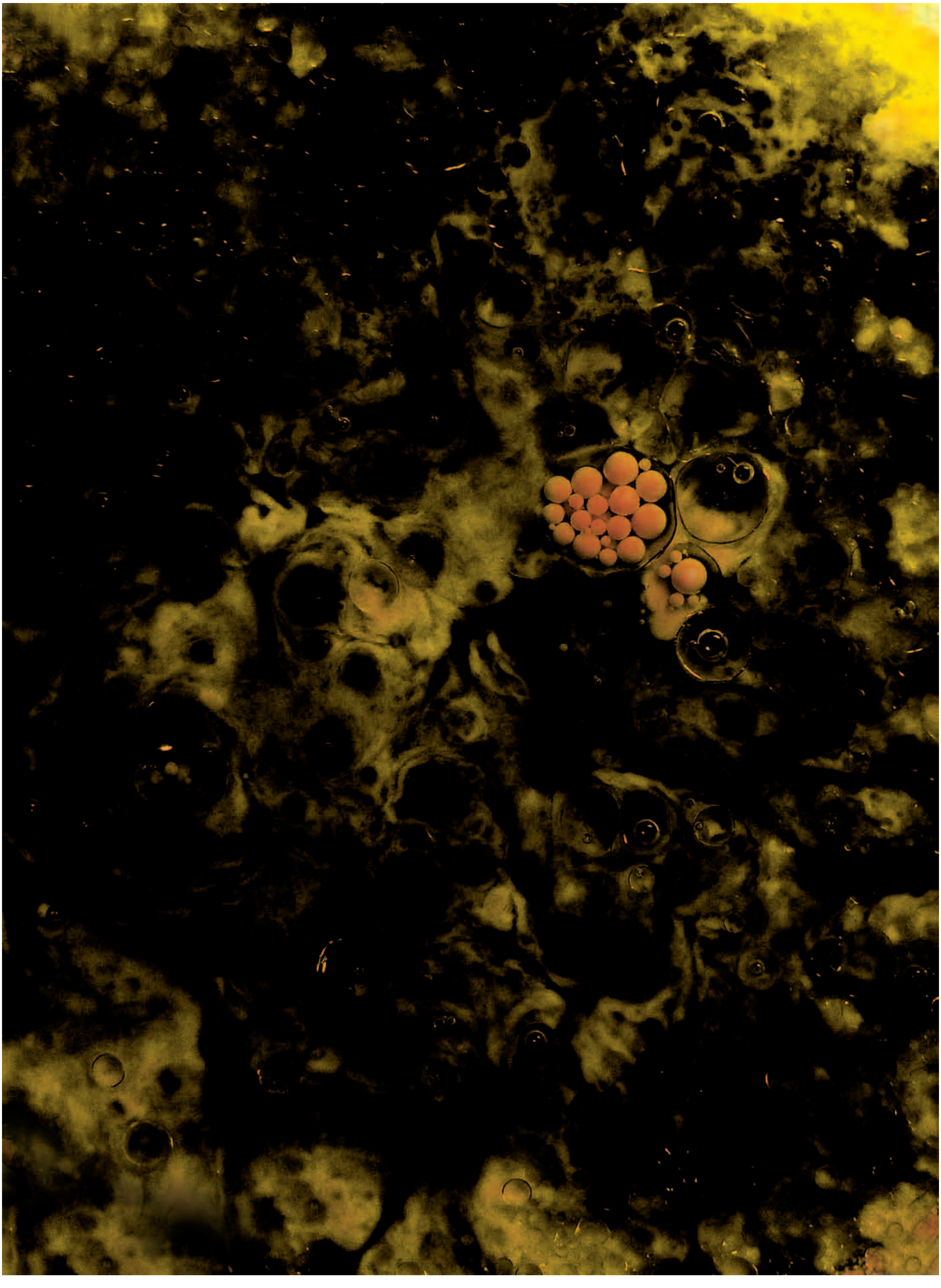

8/10 Oil mixture with encapsulated liquid
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countries. At the start of the last decade, China thus surpassed Great Britain and France, and since 2006 China has spent, in absolute terms, more on R&D than Germany has. With R&D expenditures of USD 154 billion, China also replaced Japan in 2009 as the world's second most research-intensive economy, and Asia's most research-intensive economy.[339] The development of China's national R&D system is primarily owing to a strong increase in private R&D. Both Chinese companies and foreign corporations in China have been consistently increasing their R&D efforts. While R&D expenditures of the private sector amounted to only 0.25 percent of GDP in 1995, this value had been increased to 1.25 percent in 2009, with R&D expenditures of USD 113 billion. Also in this regard China exceeded Japan and is now ranked second place in the world, with approximately twice the amount of private R&D expenditure than Germany. With 26 percent, the annual growth rate of China's private R&D expenditure is substantially higher than that of Germany (5.4 percent), the United States (6.4 percent) and the group of OECD countries (6.5 percent). Yet, when comparing China's R&D performance on a global scale, it should be noted that vast differences exist between China's and the OECD countries' approach to data collection in the field of R&D.[340]

China's industrial policy

China has completed its transformation process towards a modern industrialised economy in the country's highly developed regions. In the course of this process, China consistently focussed on the most recent technology and foreign know-how. In the first phase of liberalisation between 1978 and 1995, the emphasis was placed on developing the manufacturing industry with an initial focus on wage-intensive and export-oriented industries. At the same time, China's development strategy also tackled the following four types of economic entities: (1) large, state-owned enterprises (SOE) that take on a key role in strategically important economic sectors such as power generation and telecommunications; (2) joint ventures between foreign enterprises and state-owned enterprises, e.g. in the automotive sector and the chemical industry; (3) newly emerging Chinese medium-sized enterprises with high growth potential; (4) subsidiaries of foreign companies with their own manufacturing plants and their own R&D.

Already in the mid-1990s, a strong focus was placed on high technology and knowledge-intensive industries and services sectors. Domestic R&D, the development of high technology sectors and the promotion of "national champions" were gaining ever more relevance. Alongside these efforts, the computer, electronics and telecommunications sector was further developed. In collaboration with companies from Asia and the United States, China set up offshore centres in China for use by foreign companies to produce for export markets. China thereby managed to expand value added and exports in the information and telecommunications industries. During the 10th and 11th Five-Year Plan, further key industries were integrated, with the aim of expanding production and development capacities in the respective sectors. Especially with regard to the development of the automotive and component supplier industry, the chemical industry as well as machinery and plant engineering, German enterprises played an important role both as ground-breakers and investors.

The measures described above have turned China into the "workshop of the world". In 1990, China still held the 7th position in the world's leading production locations for manufacturing industries. Back then, China's share in global value added in the respective sector amounted to no more than 3 percent. By 2007, China had managed to surpass leading competitors such as Japan and Germany and is now, with a share of 14 percent in global production volume, in second place after the United States. China is also becoming more and more important as a production location for cutting-edge technology goods.[341] With a proportion of 14 percent of gross value added in the field of cutting-edge technology, China came in second after the United States in 2007. This is also reflected in the country's export shares illustrated in Figure 22. China steadily increased its global export shares between 1995 and 2010 in the area of R&D-intensive goods.[342] In the same period, world market shares of both the United States and Japan decreased considerably. China's photovoltaics industry may serve as an example for the strategic development of the high technology industries (see Box 19).

BOX 19

China's photovoltaics industry

Between 2000 and 2010, the global market for solar cell modules grew on average by more than 40 percent per year. In 2010 the total market volume reached a value of EUR 35 billion. The driving force for this rapid market growth was several countries' efforts to transform their energy supply systems into more sustainable models. In Germany, the implementation of this policy was largely based on the Renewable Energy Sources Act, in which feed-in tariffs are specified. These feed-in tariffs had a dimension that allowed for considerable profits not only for the producing solar energy sector, but also for investors in solar energy. Due to this, the sector saw a dynamic development in demand.

The Chinese government and Chinese companies were quick in detecting the growth potential of the solar market; from 2000 onwards, they started investing heavily in the development of photovoltaics production capacities. The Chinese government supported this process by making available extensive amounts of cheap capital.[343] In parallel with this, German and Japanese companies in particular swiftly expanded their production capacities, a process that led to a considerable overcapacity in the production of photovoltaic modules. Towards the end of 2011, a demand of approximately 20 GWp[344] was met by a module production capacity of at least 40 GWp. More than half of this production capacity is located in China.

Technological and market developments have led to a pronounced asymmetry: due to market launch programmes, the market for photovoltaic modules has been growing sharply and steadily, especially in Germany and several other European countries. Yet, a large proportion of products are sourced from China.[345] It should therefore be asked what impact this development is going to have on Germany.

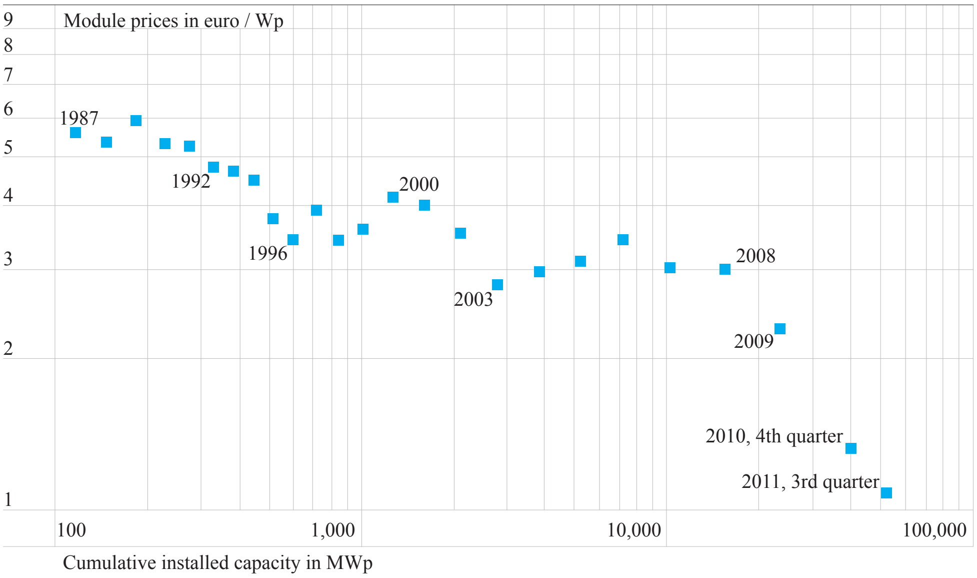
Technological progress, mass production, overcapacities in production, and the current economic climate have lead to a sharp price decline for photovoltaic modules (cf. Figure 21). This erosion of prices has not only considerably reduced the costs of solar energy; it has also led to dwindling profits for companies and investors worldwide. The price reduction in the field of photovoltaic modules is supporting Germany in developing a cost-efficient energy generation system that is environmentally acceptable[346] In late 2011, the proportion of solar energy contributions to the German energy supply was 3.2 percent; this rate is due to increase further due to continuing price reductions.

In the area of development and supply of production plants, Germany has benefitted from the worldwide growth of the photovoltaics industry. A large proportion of major, technologically relevant components from China's current production lines were supplied by German mechanical engineering companies.[347] At the same time, the export of turnkey production facilities and plant building served as the prime source of gain in know-how for Chinese companies in the photovoltaics industry. There is little doubt that several German companies are encountering economic difficulties caused by competition from China. Yet, it should also be noted that this is also true for large Chinese companies that will not be able to compete with cheap competition in their local market.[348]

In the area of photovoltaics, Germany provides an excellent industrial basis and arguably the world's best scientific infrastructure. Germany thus has the chance of serving the market segment for high-value, technologically advanced photovoltaics products. This is particularly the case as labour costs in photovoltaics – a semiconductor technology – are well below ten percent. Based on continuous innovation, a high-wage country such as Germany can thus continue to position itself clearly on the world market, both in application and production.

Price trend for photovoltaic modules

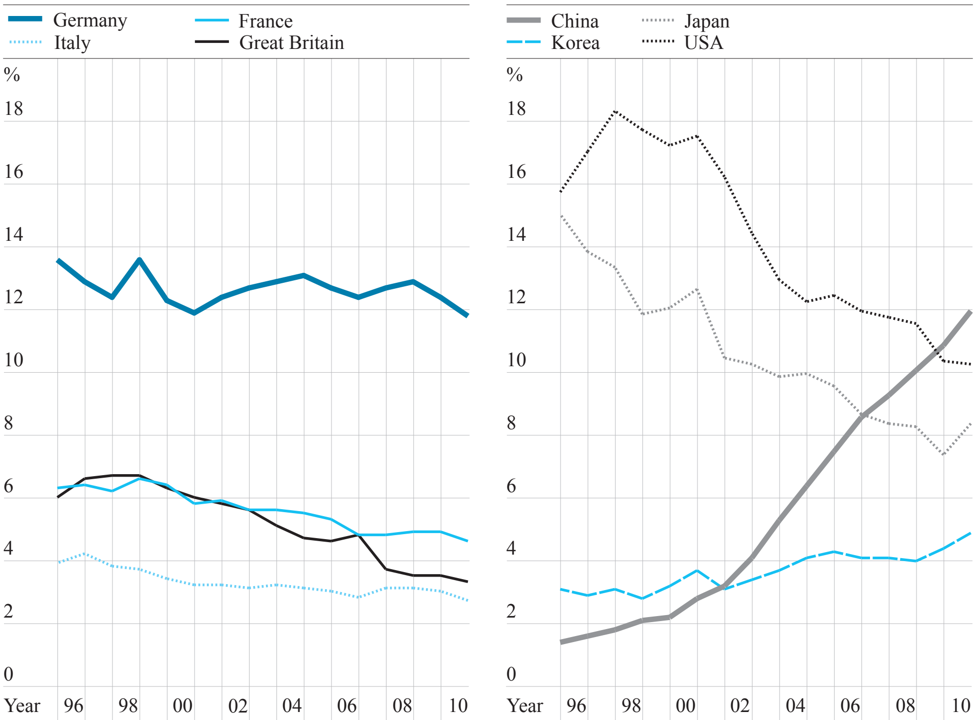
FIG 21



Source: Fraunhofer ISE and PSE Ag, annual periods 1987 – 2009; Solar Energy Research Institute of Singapore, Barclays Capital and Deutsche Bank, quarterly figures 2010 and 2011.
Price-experience curve for photovoltaic modules.[349] Both axes use a logarithmic scale.

Structural change and development of export shares in the field of R&D-intensive goods[350]
(shares in percent)

FIG 22



World trade share: share of a country's exports in world exports in percent. World exports for 2010 are based on estimates.
Source: Gehrke and Krawcyk (2012: 23).

R&D investments by foreign enterprises

In terms of China's technological development and modernisation, foreign enterprises have been paving the way and continue to do so. Foreign enterprises receive massive support from the Chinese central government and provinces, especially when they are willing to transfer R&D and advanced technology to China. Foreign companies, in turn, perceive China as an attractive and rapidly growing market that requires both long-term investment strategies and the necessity to comply with strict obligations. For many investors, business with China is both difficult and tempting. To enter the Chinese market, products and services have to be adjusted to customer needs and local standards. At the same time, companies that are active in China obtain important stimulus for innovation and new business models in Asia. China's transformation provides foreign companies with an important "real world experiment" with distinct learning effects: there is hardly any other country in which it is possible to study the world's most serious problems – such as climate change, urbanisation and the emergence of mega cities, as well as modern transportation systems – while actively participating in solving these problems. Onsite R&D facilitates the development of promising new solutions that will open up growth opportunities not only for other Asian markets, but also on a global scale.[351] China is shaping the important markets of the future, particularly those of emerging countries.

Foreign enterprises have thus attached high priority to entering the Chinese market and are, increasingly, building R&D facilities onsite. Today, these account for a substantial part of the Chinese economy's R&D expenditure. In particular, foreign enterprises account for leading high-tech developments and a high proportion of patent applications in China. In 2009, the Chinese economy's R&D expenditure amounted to USD 113 billion. Of this amount, approximately USD 19 billion was generated by foreign multinationals. This is complemented by investments from Taiwan and Hong Kong, amounting to USD 10 billion.[352] Between 2000 and 2009, the share of foreign companies in the total R&D expenditures of China's economy rose from 12 percent to 17 percent.[353]

The relevance of foreign R&D units is expected to increase further in the future. Since 2005, surveys among managers of multinational corporations show that China as a business location ranks at the top of their priority lists when it comes to developing R&D facilities.[354] This trend is further enhanced by the fact that the Chinese government expressly demands foreign companies to establish R&D centres in China once they have completed the development of domestic production plants. A large number of incentives and support measures at national level and in the provinces further add to this trend; especially since these are often coupled with the demand to generate and file patents nationally (see also the following sections on patent strategies).

R&D activities of multinational corporations are primarily focussed on sectors for which the Chinese market is particularly attractive. Moreover, in some technical areas, China can offer large numbers of well-trained R&D personnel, and some of the leading international research centres offer their services as partners.[355] In addition to this, the strong financial position of state-owned enterprises in particular provides further incentives for cross-border co-operation and the establishment of R&D in China.[356] The vast majority of R&D subsidiaries of foreign companies is to be found in the computer and information technology industry, software and IT services, telecommunications, semiconductor and consumer electronics, as well as the chemical and pharmaceutical industries.[357] With a large number of R&D facilities in China, US companies are the most active stakeholders in these sectors.

US investors are immediately followed by investors from Japan and Western Europe. German companies are playing an increasingly important role and have their own R&D facilities in China primarily in the electrical, chemical and pharmaceutical industries as well as in the automotive industry.[358] With its internationally-oriented centres of growth, China has turned into a major R&D location.[359] To date, the majority of foreign companies have been limiting their activities to adapting developments to Chinese customers' needs and local standards. Given the high mobility of Chinese personnel and the continuing gap in the protection of intellectual property, strategically important technologies and core competencies will continue to be concentrated in the foreign companies' home country or, respectively, developed at locations that are able to safeguard the company's internal protection of know-how.

BOX 20

Electromobility in China

In dealing with its immense challenges in the area of transport, China has put a strategic focus on electromobility. Growing traffic-related environmental issues caused by fossil-fueled cars are posing major environmental problems for China's mega cities. Electromobility does not generate any local pollutants[360] and is a low-noise mode of transportation. This makes electromobility a sustainable means of transport that is particularly suitable for use in mega cities.

China has the potential to become a lead market[361] in electromobility. This is primarily owing to the following points: (1) traffic problems in China's mega cities cannot be overcome on the basis of conventional drive concepts that are based on fossil fuels; (2) automobilisation in China's cities is largely oriented towards small cars, which makes the launch of or transition to electric vehicles easier than it is in Europe; (3) China has a considerable market for vehicles that are used solely in urban transport; (4) electric vehicles help China to reduce its dependency on fossil fuels.

China is already highly successful in employing electro scooters in large cities like Shanghai and Beijing: today, in their inner cities, fossil-powered scooters or motorcycles are only rarely used, and the benefits of emission-free transport are clearly demonstrated to the public. It should be kept in mind however that the technology used for electro scooters is very different from the technology used for electric cars. Yet, for essential components such as wheel hub motors it should be possible to benefit from the knowledge gained in the fast-growing market for electro scooters and apply it to the development of electric cars.

China has set itself ambitious goals in the area of electromobility: by 2015, one million electric vehicles are supposed to be in use, and ten million by 2020. The market launch of electric vehicles will be accelerated primarily via government subsidies for manufacturers and buyers.[362] Furthermore, electric vehicles are guaranteed permission for road travel, which is a prerequisite for operating a vehicle in China.

The German automotive industry is very active in China in the area of electric vehicles. In partnership with Chinese automotive companies, German manufacturers develop electric vehicles for the Chinese market. Thus Daimler is collaborating with BYD, Volkswagen with FAW, and BMW with Brilliance.[363] This type of partnership is a mandatory requirement by the Chinese government: other than partnerships, foreign companies have no other option to be active in the field of electromobility in China. In addition to these enforced co-operations, China is also strategically developing purely national industries in the area of electric vehicles and key components such as batteries.[364] The Chinese government supports these efforts to a considerable extent.

German universities and non-university research institutes are either very active in China, or progressing considerably in developing activities in China. Examples include: (1), the Fraunhofer-Gesellschaft's Center for Advanced Electromobility in Shanghai, which will be operated in close co-operation with Tongji University; (2) a BMBF-funded co-operation between nine German technical universities (TU9)[365] and five Chinese universities for the development of a German-Chinese research network; (3) the co-operation between the BMU (via its Development Co-operation Agency, GIZ) and the China Automotive Technology and Research Center CATARC in the area of electric vehicles.[366] In the view of the Expert Commission, these activities are not sufficiently co-ordinated, and the assumed benefit for Germany of these various R&D activities in China is not communicated adequately.

In the opinion of the Expert Commission, China, and not Germany, is building up a lead market in the field of electromobility. Germany still has the chance to establish itself as a supplier of vehicle components, information and communication technology, and high-value electric vehicles. To achieve this, it is crucial to develop a co-ordinated strategy between German industry, government bodies and research facilities.

It should be noted however that foreign enterprises, including German enterprises, keep expanding their R&D units in China and perform technologically advanced work in various fields that cannot be implemented elsewhere. This applies especially to fields that are characterised by a concentration of talent and promising markets in China. Examples include mobile communications, medical technology, new transportation systems, as well as Internet and e-commerce. Especially in the field of electromobility, China has initiated promising developments that attract the attention of foreign companies and research institutes (see Box 20). It is these fields that can accelerate leading developments in China and Germany. Hence, scientific collaboration between the two countries should be concentrated on these areas.

Priorities of the 12th Five-Year Plan

China's innovation policy and China's medium-term and long-term planning are largely determined by the State Council's "Steering Committee of Science, Technology and Education (SCSTE)". This steering committee consists of members of the major ministries and academies. SCSTE has prepared the National Medium- and Long-Term Plan for the Development of Science and Technology (2006–2020). The 12th Five-Year Plan serves to specify the scientific and technological priorities and identify the key areas of innovation policy for the period 2011 to 2015. The following innovation policy objectives outline the strategic focus of the 12th Five-Year Plan.

1. Promoting scientific and technological progress.
2. Accelerating the development of the economy's innovation system.
3. Expanding the scientific and technical infrastructure.
4. Policies and frameworks for the promotion of research and technological innovation.

China's industrial policy is largely determined by its priority on "New Emerging Strategic Industries" which has been specified by a high-level inter-ministerial working group led by the National Development and Reform Commission (NDRC). In the period 2011 – 2015, the following industries are in the focus of development planning: (1) the energy and environmental sector; (2) information technology; (3) biotechnology; (4) the capital goods industry (especially aircraft construction and mechanical engineering); (5) new energy systems; (6) new materials; and (7) automotive industry, electric vehicles in particular.

These seven industries and their respective sectoral and technological priorities are further specified in Box 21. Noteworthy in particular is the tenacity with which the objectives of growth and sustainability are pursued to an equal degree. Another striking feature is the scope and intensity with which China is tapping into these growth markets. The priority fields are largely the same as those that are on the development agenda of many of the highly industrialised countries such as the United States, Japan and Germany. In international comparison, the high degree of duplication becomes apparent. The Expert Commission therefore sees the necessity to carefully monitor the similarities between China's innovation policies and the Federal Government's High-Tech Strategy.

According to the 12th Five-Year Plan, China's innovation competence shall be substantially enhanced, with the aim of transforming the country from a technology follower to a technology leader. It is China's declared intention to build up their own highly developed research system and to cover and dominate the entire value chain in key areas of high technology. Furthermore, major emphasis shall be placed on domestic innovation, i.e. R&D that is decidedly Chinese in character and conducted in China, as well as intellectual property that is generated within the country. With its objective of "Indigenous Innovation" ("zizhu chuangxin") – more aptly translated as "self-owned innovation" – the Chinese government aims to strengthen innovation in national property that is controlled or dominated by Chinese right holders. The aim is to reduce the dependency on technology imports; an aim that had already been declared in the outline for the medium- and long term planning. Here, the catchphrase "Voluntary is the new mandatory" serves to describe the strong state influence on local and foreign innovators to subject any economic activities to the political mandate of national policies and to actively support the goals of the Chinese government.

In addition to this, high priority is also being attached to promoting the expansion and consolidation of large companies in key industries. The Chinese

BOX 21

Innovation and development of new strategic industries

1. **Energy conservation and environmental protection industries**
   Implement major exemplary projects in energy conservation and environmental protection, and promote the industrialisation of efficient energy conservation, advanced environmental protection and resource recycling.

2. **New-generation IT industry**
   Construct new-generation mobile communication networks, the new-generation Internet, and digital broadcast and television networks. Implement exemplary application projects of the Internet of things and special industrialisation projects of network products. Construction industrial bases of IC, panel display, software and information services.

3. **Biological industry/Biotechnology**
   Build databases of gene resources for pharmaceuticals, important plants and animals, and industrial microbial bacteria. Construct R&D and industrialisation bases for biopharmaceuticals and biomedical engineering products, biological breeding, testing, detection and fine breeding bases, and exemplary bio-manufacturing application platforms.

4. **High-end equipment manufacturing industry**
   Construct industrialisation platforms for home-made trunk and feeder airplanes, general-purpose airplanes and helicopters, and a spatial infrastructure framework composed of navigation, remote sensing and communication satellites, and develop intelligent control systems, high-class numerically controlled machines, high-speed trains and urban rail traffic equipment, etc.

5. **New energy industry**
   Construct industrial bases for new-generation nuclear power equipment, large wind power generating sets and parts, new assemblies of efficient solar power generation and heat utilisation, biomass energy conversion and utilisation technologies, and intelligent power grid equipment, and implement exemplary large-scale application projects of marine wind power, solar power and biomass energy.

6. **New material industry**
   Promote the R&D and industrialisation of carbon fibers, semiconductor materials, high temperature alloy materials, superconductive materials, high-performance rare earth materials and nanometer materials for aviation and spaceflight, energy and resources, traffic and transport, and major equipment.

7. **New-energy automobile industry**
   Conduct R&D and large-scale commercialisation demonstration projects for plug-in hybrid electric vehicles and pure electric vehicles, and promote industrialised application.

government aims to systematically promote its "national champions", that is, strong global leaders with brand names of international reputation. In key industries, core elements of the value chain shall be provided by strong national companies. The stated goal is to "field" two competing Chinese world leaders in all of the major growth segments. Examples include Huawei and ZTE (telecommunications) and Lenovo (personal computers), all of which have gained an international standing, as well as other companies that are listed in Table 9.

China's public research system

The Chinese leadership has embarked on an ambitious innovation strategy, with the stated goal of turning the country into one of the world's leading centres of innovation before 2020. Existing deficiencies in certain areas are planned to be overcome by applying "leapfrogging strategies" in key fields of science and technology.[367] To systematically expand China's national innovation system, ten different types of measures shall be employed.[368] The government is taking steps to ensure that the defined target for 2015 is achieved, i.e. national R&D expenditure of

TAB 09 **Examples of Chinese world market leaders in growth areas**

Growth area	Company	revenue in billion euro	R&D expenditures in billion euro	Employees
Mobile communication (manufacturers)	Huawei	23.2	2.07	110,000
	ZTE	8.8	0.89	85,232
Mobile communication (operating companies)	China Mobile	60.7	6.07	164,336
	China Unicom	21.4	n.p.	215,820
Consumer electronics	TCL	6.5	0.23	50,000
	Haier	4.5	0.01	18,200
Photovoltaics	Suntech	2.4	0.03	20,200
	Trina	1.5	0.02	13,000
Internet	Baidu	1.0	0.09	11,000
	Alibaba	0.7	0.07	13,674
Computers/ PC	Lenovo	13.8	0.18	22,205
	Founder TG	0.8	n.p.	4,500
Electromobility (battery technology)	BYD	2.1	0.07	55,000

Source: Internet research based on annual reports for 2010. All figures refer to 2010.
(BYD: figures refer to 2007).

2.2 percent of GDP. This includes measures to stimulate R&D in the private sector, as well as active strategies for further expanding the public research system. The central government's declared goal is to significantly increase the research and technology budget's proportion of public expenditure. The provincial governments are also obliged to considerably increase their investments in R&D.[369]

In recent years, China's public R&D expenditures have been increased significantly, even though they could not keep pace with the dynamic expansion of R&D in the private sector. Between 1995 and 2009, overall R&D expenditures in the public research system increased by 15 percent each year (compared with this, R&D in the private sector increased by 26 percent per annum).[370] About 70 percent of publicly performed research is attributable to public research institutions and 30 percent to university-based research facilities. Compared with other OECD countries, China is characterised by a greater institutional separation between dedicated research institutions and higher education institutions. In China, high-level research with comparatively ample funding primarilytakes place at the institutes of the Academy of Sciences (CAS) and a few selected elite universities.[371] Several other universities that are part of Project 211 conduct research in a small number of selected fields.[372] Other than that, a very large number of China's universities are confined to their academic training role.

Due to the aforementioned increase in research spending within the public science system, China's research performance (as measured by publications) has also seen a rapid growth. This was further enhanced by efforts to realign and systematically evaluate research conducted. The number of publications in international journals has increased significantly. In 2010, Chinese scholars ranked second worldwide; in 2000 they had merely occupied the eight position. Yet, it should be noted that the quality and relevance of Chinese publications are still below global standards.

Between 2000 and 2008, the citation rate of Chinese publications rose from 1.3 to 3.1. However, the worldwide average is 3.7, and leading science nations achieve values above 5.0 (cf. Table 10 for an analysis of the structural changes in publications and citations).

In spite of these remarkable developments in terms of resources used (research input) and research results (such as publications), critical voices in China keep expressing concern over existing deficits. Above all, the following issues have been subject to criticism: the underfunding of the public research system, the brain drain of talented young professionals to the private sector and abroad, the overall insufficient quality of research, and the continuous problem of attracting and retaining top talents.[374] In China, basic research accounts for a comparatively small

TAB 10 **Shares of leading countries in publications from the Science Citation Index (SCI) and the Social Science Citation Index (SSCI)[373] as well as citation rates** (shares in percent)

	2000	2008	2010
Share in publications			
USA	32.1	28.7	28.0
China	3.5	9.2	11.0
Great Britain	9.3	7.9	7.8
Germany	8.1	7.2	7.3
Japan	8.7	6.6	6.0
France	5.9	5.3	5.2
Canada	4.2	4.5	4.5
Italy	3.9	4.3	4.3
India	2.0	3.3	3.4
Korea	1.6	2.9	3.3
Citation rate			
Worldwide citation rate	2.9	3.7	
USA	4.6	5.6	
China	1.3	3.1	
Great Britain	3.8	5.4	
Germany	3.5	5.1	
Japan	2.7	3.6	

Source: Analyses from Web of Science, publications and citations in the SCI and the SSCI, based on Schmoch et al. (2012).

proportion of research. Staffing budgets and remuneration structures in the public research system are extremely unfavourable and unable to compete with those of the private sector.[375]

Strategies for patent protection and law enforcement

At a very early stage, China recognised the strategic value of patents for the process of national development. Based on this insight, the Chinese patent law was reformed in several steps. Yet, the adoption of Western legal structures and legal systems will have to be reconciled with Chinese cultural paradigms and legal interpretations that still persist. Thus, in Chinese culture, imitation has been considered desirable for centuries. There is ample evidence for patent violations and product and brand piracy.[376] Thus it is for a good reason that political stakeholders from Western countries are attaching great attention to the subject of intellectual property in China.[377]

Also from within the Chinese system, a number of measures and policies have been implemented to promote patents and intellectual property and reconcile them with the national innovation strategy.[378] These measures, and the systematic expansion of R&D activities, have led to a sharp rise in the number of Chinese patent applications in recent years. Between 2002 and 2009, the Chinese Patent Office recorded an increase in patent applications from Chinese residents from 40,000 to 230,000 (representing an annual growth rate of 28 percent). The number of patents filed by Chinese researchers at the European Patent Office and the US Patent Office has also risen sharply. Individual Chinese companies such as Huawei and ZTE now occupy leading positions in rankings of international patent applicants.

The rapid growth in the number of patent applications should not blind us to the deficits that still exist. With a growth rate that is significantly higher than that of foreign companies, patent applications from Chinese applicants at the Chinese Patent Office have been increasing since 2004. Yet, the patent grant rate, i.e. the proportion of applications that result in an actual patent, is still very low in China (cf. Table 11).[379] In terms of patents granted, foreign applicants had been dominating up until 2007. Since 2008, Chinese researchers have been able to draw level with foreign companies in terms of patents granted. Yet, the time and expenses invested in the application are much higher, and a large number of patent applications still accounts for low-quality developments. The influence of multinational corporations on China's technological development remains to be high.

Another factor that complicates collaboration between Chinese and foreign corporations is the fact that technology developed in China-based subsidiaries are subject to priority registration with the Chinese Patent Office (SIPO). In the event that a foreign company is unwilling to follow this requirement, the company has to obtain prior permission from the Chinese government for conducting a priority application abroad. Multinational corporations have internal guidelines for international patent application, and these are often conflicting with the requirement of priority patent application in China. What is more, the initial assessment and granting of a patent application in China is often accompanied by language-related issues, and may also result in

TAB 11 **Development in patent applications and granting of patents by the Chinese Patent Office**

	2002	2004	2006	2008	2010
Chinese applicants					
Patent applications	39,806	65,786	122,318	194,579	293,086
Patents granted	5,868	18,241	25,077	46,590	79,767
Grant rate (%)	14.7	27.7	20.5	23.9	27.2
Foreign applicants					
Patent applications	40,426	64,347	88,172	95,259	95,259
Patents granted	15,605	31,119	32,709	47,116	47,116
Grant rate (%)	38.6	48.4	37.1	49.5	49.5

Source: SIPO Annual Report 2010.

considerable loopholes in global patent protection. Beyond patent application, additional restrictions on the export of products and technologies have been put in place for developments that China-based subsidiaries participated in. For a number of companies in the United States and Western Europe, this has led to major disruptions in transnational development ventures. Currently it is expected that foreign companies will be calling into question further R&D collaborations with China, or limiting their efforts altogether.

Due to the weakness of the Chinese patent jurisdiction, Western companies are unable to defend themselves effectively. The topic of "patent protection and intellectual property management in China" remains to be a central issue that affects collaboration with foreign partners. In the period of the 12th Five-Year Plan, and also in the long term, the expansion of China's innovation system should be accompanied by a further development of the patent system and patent jurisdiction. Any further advancement in this field should consider the interest of both Chinese innovators and partners from abroad.

This entails in particular the provision of active support for contract and licencing agreements in research and development. Foreign innovators in China should be equipped with sufficient rights to protect themselves against state interference with the foreign innovator's freedom of contract. In addition, threats via mechanisms such as compulsory licences and rights for the use of foreign technology should be avoided as much as possible.

Standard-setting strategies in China

Today, one of the most important levers in the international innovation competition is an early influence on standards that are not only valid for local markets and certain groups of countries, but that also determine product configuration, entry conditions and the game rules employed in global markets. Influence on and control of standards is critical to a country's ability to develop its own innovative

BOX 22

Patenting strategies in China

Chinese companies apply for large numbers of patents that are only copies or mildly modified versions of foreign technology. It is a common strategy of many companies to sift through foreign patent databases and specifically occupy any identifiable gaps in application. The corresponding areas of know-how that are otherwise unprotected are then registered in China and presented as original achievements.

Another common strategy is to register utility models that are attributable to existing patents, thereby obtaining protection for supposedly original inventions. This may even go as far as attempts to "overturn" the original patent applicant on the Chinese market. Because of this accumulation of patent and utility model applications attributable to an invention, – also known as "patent thickets" and "patent tsunamis" – foreign companies can be forced to enter into negotiations and cross-licencing agreements.

strength and avoid dependencies on foreign suppliers. With its initial focus on importing Western technologies, China was running the risk of becoming too dependent on standards that are controlled by leading foreign countries and organisations.

Based on its experience in the adaptation of technologies and advanced systems in the field of telecommunications, transportation technology and energy technology, China came to realise the threats of increasing dependency on imports and licence fees. To avoid further dependency, China decided to establish standards for the domestic market, which would have to be adopted by foreign companies. This was temporarily attempted in mobile phone standards and Internet standards, albeit with the result of sub-optimal solutions and dependencies on local suppliers. Furthermore, all-Chinese standards have the disadvantage of largely undermining subsequent export strategies for Chinese companies.

For a country like China, a workable alternative is the "standard leapfrogging strategy", whereby supplier groups on the world market are being observed with regard to their standards offered. The supposedly best standard is then selected, developed and tested. As a next step, a Chinese standard is developed, which is applicable to the large domestic market. Chinese companies, research organisations and national standard setting bodies are involved in the development and implementation of this standard. Yet, to ensure optimal solutions, leading foreign companies are also integrated into this process.

In strategically important market segments, it can be observed that this "standard leapfrogging strategy" is systematically applied. Foreign companies actively participate in the first phase. In parallel, Chinese suppliers are qualified as the central stakeholders. Standards and technical standards are then developed. Finally, the Chinese companies involved conquer the national market to the largest possible extent. At a later stage, Chinese suppliers also set out to enter international markets. Striking examples for this strategy can be found in the fields of telecommunications, rapid transit systems and wind energy. The "standard leapfrogging strategy" is made possible by a national standard setting policy that divides participants into two types of standard-setting consortia: full members and associate members; while the latter may even be classified as observers. Only Chinese companies and Chinese research organisations are entitled to obtain full membership. Full members are equipped with full voting rights and can actively participate in important steering committees, which largely determine the development of standards. Opposed to this, associate members have no voting rights, and they also pay a higher membership fee than full members. To date, foreign companies have only been allowed to participate in China's standard-setting consortia as associate partners.

Such discrimination against foreign companies with R&D and production facilities in China is extremely problematic and heavily burdens collaboration in important areas of innovation. Especially when it comes to future co-operation between Germany and China, the practices described above will have to be overcome. This applies e.g. to the fields of electromobility, environmental technology and renewable energy. In its 2011 position paper, the European Chamber of Commerce has presented recommendations for improving co-operation between Chinese and foreign companies through standard-setting agreements.[380]

Conclusion and recommendations

As one of the leading science nations worldwide, China is currently making a considerable effort to improve its position in several key strategic areas through its 12th Five-Year Plan. For Germany, these efforts entail opportunities, but also threats. Thus new perspectives for enhanced collaboration are opening up in areas that are beneficial for both countries. Yet, Germany also has to accept the increased risks and challenges that accompany it. In addressing these risks and challenges, German companies and research organisations can build on stable, long-standing relationships with their co-operation partners.

International division of labour in progress: recognising the challenges

China's position in global competition is becoming stronger and stronger. Especially through state influence on economic sectors and research areas, China is conquering more and more areas of expertise that have traditionally been occupied by Germany. In light of this, the further development of China's innovation system should be monitored with great attention and continuously analysed for opportunities and threats.

"China innovation" must be given high priority by Germany's policy makers; it should not be left to experts in companies, ministries and research organisations alone. In order to respond adequately to the challenge of China, the Federal Chancellery, the heads of the respective ministries, as well as academic bodies and the Federal Government's advisory committees should, on a regular basis, announce coordinated strategies for dealing with this issue. At intervals of about two years (i.e. twice per legislative term) the Federal Chancellery should specifically promote dialogue on "China innovation" and integrate key players into this process. A possible platform for this dialogue could be the Federal Government's Innovation Dialogue, which could address Germany's national China strategy as a special topic in due course. In addition to this, the "Research Union Economy – Science" *(Forschungsunion Wirtschaft und Wissenschaft)* and the scientific academies should also dedicate themselves to a greater extent to the subject of "China innovation".

Strengthening co-operation with China on all levels

On a federal level, several departments are involved in co-operations with China. The BMBF has initiated major projects in the field of scientific and educational co-operation. The BMWi is the lead agency in Chinese-German projects in the field of foreign trade policy, energy policy and standardisation work. Several other federal ministries (e.g. Ministry of Foreign Affairs, Ministry of Transport, and the Ministry of Environment) regularly deal with aspects of China-related collaboration. All these initiatives should be consolidated to a greater degree. Thus the Expert Commission recommends improving co-ordination between the participating federal ministries, but also between the *Länder* governments involved. This could be achieved e.g. by setting up an interministerial working group (consisting of BMBF, BMWi, BMU, BMA, etc.), which would offer guidance to strategic projects and also review the progress of collaboration between the two countries.

The Federal Government has initiated a process of enhanced collaboration as part of the 2011 German-Chinese intergovernmental consultations. Between the BMBF and the Chinese Ministry of Science and Technology (MOST), several co-operation agreements in the areas of research, innovation and education, as well as promising platform projects, have been launched. In parallel, several other federal ministries have launched important initiatives which are to be implemented via regular consultations at ministerial, secretary of state and head of department levels. The Expert Commission welcomes these initiatives and projects. To ensure the success of these newly established platforms and collaborative projects, and to draw a maximum benefit for both sides, it will be necessary to continuously monitor and evaluate the progress of projects, and to document both successful and unsuccessful examples of German-Chinese collaboration.

As regards the BMBF, the German-Chinese platform for innovation, research and innovation policy can be regarded as one of the major collaboration projects. In September 2011, leading experts from both countries laid the foundations for this project at a conference in Beijing. The launch of the platform will result in a subsequent conference to be held in Germany in 2012, and shall then be hosted on an annual basis. Important issues for the future dialogue between the two countries are: 1) innovation and standard setting in both countries; 2) patents and intellectual property, including IP management and licencing; 3) development of specific German-Chinese projects in the areas of electromobility, solar energy and hydrotechnology; 4) opportunities for bi-national R&D support programmes; 5) exchange of highly skilled personnel between both countries; and 6) establishment of a joint graduate programme with a focus on innovation research and innovation policy.

Creating reliable framework conditions for intellectual property and standards

The development of China's innovation system and the quality of China's co-operation with foreign partners heavily depends on the development of the patent system and a functioning system of intellectual property protection. The Federal Government should continuously monitor progress in intellectual property protection in China and regularly report on their findings. Collaboration between the EU delegation and the Chinese government in the field of patent protection and intellectual property should be continued and the previously developed recommendations should be systematically implemented.

The Expert Commission considers the development of norms and standards as an important starting point for promoting innovation projects in both countries and on equal terms. International, uniform norms and standards are preferable to unilateral national standardisation regulations. Chinese government agencies, companies and researchers should be confident and empowered to play an active role in key international standard setting organisations. But also the Chinese domestic market should place its focus on norms and standards that are fully compatible with international standards. In the event that national standards or modifications of international standards are continuously enforced in China, foreign companies should be enabled to participate as equal partners in Chinese standard-setting bodies and consortia.

The Expert Commission recommends strengthening co-ordination of German foreign science policy in China. Several major scientific organisations have each developed their own China strategy and established subsidiaries and research institutes in China. The large number of initiatives suggests that maybe too much of a good thing has been done. In the future, these diverse activities of foreign scientific organisations (DFG, FhG, HGF, MPG and others) should be consolidated even further, with the aim of strengthening the larger German scientific community in China.[381] Moreover, attention should be attached to avoiding too generous a transfer of academic results, especially in application-oriented areas. The exchange of scientific results and research groups should be balanced and mutually beneficial.

Strengthening expert knowledge on China in Germany

Enhanced collaboration between China and Germany will require a large number of professionals who are familiar with both cultures and both economic systems. Other countries have introduced training courses and development programmes for managers, which combine technical-scientific training with language training and intercultural competence on China. Germany is still lagging behind in this regard. Especially when training future management personnel in the field of engineering, natural sciences, law and economics, more attention should be paid to building up expert knowledge on Asia – and China in particular – at an early stage. To achieve this, new training programmes and further education courses at universities, as well as collaborations between German and Chinese higher education institutions, should be systematically promoted.

Maintaining technological advantages in photovoltaics and electromobility

Particularly in the field of photovoltaics, the development of a powerful Chinese industry has been fostered by providing virtually unlimited capital at extremely low interest rates. This has led to a substantial distortion of global competition in this field of technology. German companies have suffered greatly from this. The Federal Government should strive to swiftly eliminate this market distortion through agreements with the Chinese government.

In the view of the Expert Commission, China, and not Germany, is currently building up a lead market in the field of electromobility. Germany still has the chance to establish itself as a supplier of high-value electric vehicles, components, and information and communication technologies. To achieve this, it will be necessary to develop a co-ordinated strategy between German industry, government bodies and research organisations. The Expert Commission suggests that the National Platform for Electromobility (*Nationale Plattform Elektromobilität,* NPE) develop a suitable strategy for dealing with China.[382]

STRUCTURE AND TRENDS

C

C STRUCTURE AND TRENDS

C 1 EDUCATION AND QUALIFICATIONS

Between 1992 and 2010, Germany saw a 57 percent increase in the number of school-leavers qualified to enter higher education institutions. Within this period, numbers went up from 290,600 to 456,600 (cf. C 1 – 1). According to estimates, these numbers should further increase substantially and reach a level of approximately 520,000 by 2013. This increase is due to a double intake in school-leavers. After 2014, the number of potential third-level students is due to decrease again. Yet, based on current projections, it can be assumed that up until 2025, the number of potential third-level students will still be well above 400,000 – which would largely correspond to 2006 levels.

252,000 foreign students were enrolled at German higher education institutions in the academic year of 2010; in 1997, there had been only 150,000 foreign students (C 1 – 3) in Germany. This increase is largely attributable to *Bildungsausländer*, i.e. students who have a foreign citizenship and obtained their higher education entrance qualification abroad. Their proportion of all students was 8.3 percent in 2011. In contrast, non-mobile students *Bildungsinländer*, i.e. students who have a foreign passport but acquired their higher education entrance qualification in Germany, make up only 3 percent of all students.

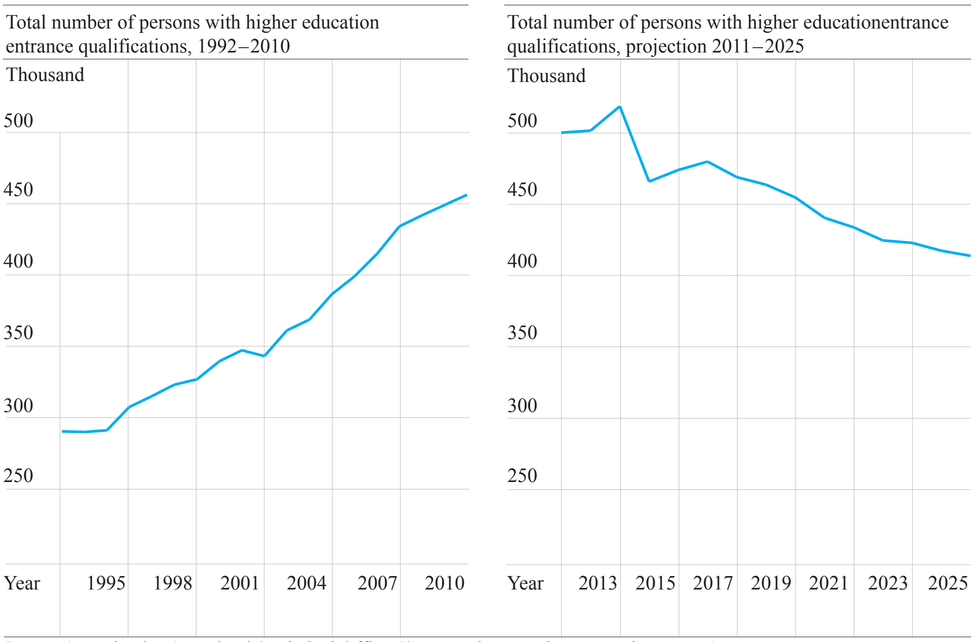
Yet, for a country's research and innovation system it is not solely the number of graduates that is relevant: it is particularly important to also train professionals for academic careers in the MINT subject groups. In this regard, the central subject groups of mathematics / natural sciences and engineering did not develop homogeneously (C 1 – 4). While the proportion of graduates from mathematics / natural sciences subjects has risen slightly from 14.1 to 16.5 percent since 1993, the proportion of engineering graduates has dropped significantly from 25.7 to 16.9 percent.

An international comparison of education levels is always difficult; this is due to differences in educational systems and differences in the weighing of degrees (C 1 – 6). Hence, the ISCED classification, which divides educational attainment into six stages, can serve as a rough frame of reference only. National characteristics and particularities will have to be taken into account in each case. Thus, in Germany for instance, many vocational qualifications are obtained through dual training, while in other countries the same vocational qualification would be acquired via academic degree courses. As a result, the proportion of graduates (ISCED 5A and 6) in the German workforce is 17.6 percent, which is significantly lower than the rate displayed by relevant European comparable countries such as Great Britain (27.2 percent) or the Netherlands (30.4 percent). In return, the (non-academic) further training qualifications of *Meister* (master tradesman) and *Techniker* (technician) play a comparatively important role in Germany. Individuals who have obtained such a further training qualification are regarded as highly qualified – like academics – and account for 10 percent of the total workforce. Finally, 60 percent of economically active people in Germany have an intermediate level of education (ISCED 3 and 4). In other European countries, the proportion of the workforce with intermediate qualifications tends to be substantially lower.

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 science.



Source (actual values): Federal Statistical Office (*Statistisches Bundesamt*, various years).
Source (projected values): statistical publications of the Conference of Ministers of Education and Cultural Affairs *(Kultusministerkonferenz)*, in: Leszczensky et al. (2012).

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

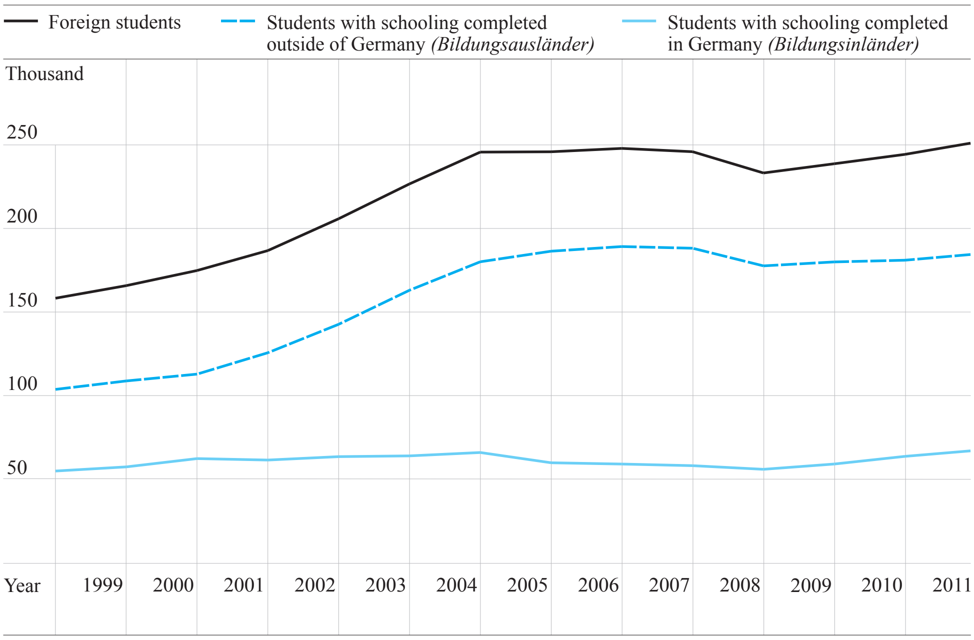
C 1–2

Entrance rate: proportion of newly enrolled students 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**	**2001**	**2003**	**2004**	**2005**	**2007**	**2008**	**2009**
Australia	–	59	65	68	70	82	86	87	94
Canada	–	–	–	–	–	–	–	–	–
Finland	39	71	72	73	73	73	71	70	69
France	–	37	37	39	–	–	–	–	–
Germany	*26*	*30*	*32*	*36*	*37*	*36*	*34*	*36*	*40*
Italy	–	39	44	54	55	56	53	51	50
Korea	41	45	49	47	49	54	61	71	–
Japan	31	35	37	40	40	41	46	48	49
Netherlands	44	53	54	52	56	59	60	62	63
Switzerland		29	33	38	38	37	39	38	–
Spain	–	47	47	46	44	43	41	41	46
Sweden	57	67	69	80	79	76	73	65	68
Great Britain	–	47	46	48	52	51	55	57	61
USA	–	43	42	63	63	64	65	64	70
OECD average	37	47	48	53	53	54	56	56	59

Sources: OECD: Bildung auf einen Blick (Education at a Glance) – OECD Indicators (various years), in: Leszczensky et al. (2012).

C 1–3 Foreign students at German higher education institutions



Source: Federal Statistical Office *(Statistisches Bundesamt)*; research in HIS-ICE, in: Leszczensky et al. (2012).

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 subjects studied

	1993	1995	2000	2005	2007	2009	2010
Total number of graduates	**173,756**	**197,015**	**176,654**	**207,936**	**239,877**	**287,997**	**294,330**
Percentage of women	39.8	41.2	45.6	50.8	51.8	51.7	52.1
Percentage who studied at a university		63.6	64.3	60.8	62.4	62.0	–
Linguistics, cultural studies			**29,911**	**35,732**	**43,827**	**53,003**	**54,808**
Percentage for that subject group			16.9	17.2	18.3	18.4	18.6
Law, business and social sciences	**53,170**	**66,538**	**62,732**	**76,566**	**85,838**	**101,391**	**102,315**
Percentage for that subject group			35.5	36.8	35.8	35.2	34.9
Medicine/health sciences			**10,620**	**11,817**	**13,358**	**15,142**	**15,222**
Percentage for that subject group			6.0	5.7	5.6	5.3	5.2
Agriculture, forestry, nutrition sciences	**5,477**	**5,527**	**4,761**	**5,312**	**5,661**	**6,363**	**6,215**
Percentage for that subject group			2.7	2.6	2.4	2.4	2.1
Art and art-related subjects			**7,630**	**9,678**	**10,399**	**11,541**	**11,820**
Percentage for that subject group			4.3	4.7	4.3	4.0	4.0
Mathematics, natural sciences			**21,844**	**30,737**	**38,417**	**47,782**	**48,561**
Percentage for that subject group	14.1	14.1	12.4	14.8	16.0	16.6	16.5
Engineering sciences	**44,629**	**47,295**	**35,725**	**34,339**	**38,065**	**47,004**	**49,860**
Percentage for that subject groups	25.7	24.0	20.2	16.5	15.9	16.3	16.9

Source: Federal Statistical Office *(Statistisches Bundesamt, Fachserie 11, Reihe 4.2)*, as well as research in HIS/ICE. Figures from Leszczensky et al. (2012).

Subject structure rate and graduation rate: the subject structure indicates the proportion of first-degree graduates who have completed their studies in a particular subject or group of subjects. The graduation rate indicates the proportion of persons of the population in the relevant age group who have newly graduated from a higher education institution.

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

C 1–5

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

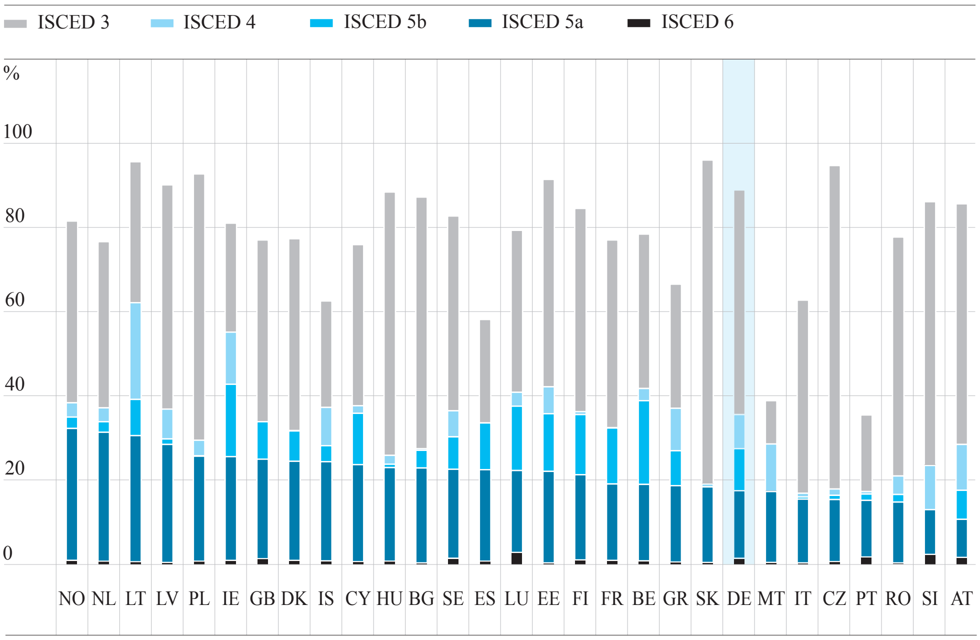
	1996	1997–1999	2000–2002	2003–2005	2006	2007	2008	2009	2010
Gainfully employed persons	**4.1**	**3.8**	**3.4**	**5.2**	**5.3**	**5.5**	**5.6**	**5.1**	**5.0**
low (ISCED 0–2)	1.1	1.0	0.9	1.3	1.3	1.1	1.3	1.0	1.1
medium (ISCED 3–4)	3.8	3.4	3.1	3.8	3.9	4.0	4.1	3.7	3.4
high (ISCED 5–6)	6.7	6.2	5.4	10.0	10.6	10.8	10.8	9.4	9.7
Unemployed persons	**5.5**	**4.5**	**4.4**	**2.7**	**2.4**	**2.8**	**3.3**	**3.0**	**3.0**
low (ISCED 0–2)	2.0	2.0	2.1	1.5	1.4	1.7	2.0	2.1	2.5
medium (ISCED 3–4)	5.9	4.8	4.7	2.7	2.4	2.9	3.6	3.2	2.6
high (ISCED 5–6)	10.7	8.5	7.9	5.2	5.0	5.5	5.2	4.8	6.7
Persons outside the labour force	**4.1**	**3.5**	**3.3**	**1.1**	**0.9**	**0.8**	**0.9**	**0.6**	**0.8**
low (ISCED 0–2)	0.5	0.5	0.6	0.4	0.4	0.4	0.5	0.7	0.7
medium (ISCED 3–4)	5.8	4.7	4.2	1.3	0.9	0.8	0.9	0.4	0.8
high (ISCED 5–6)	8.9	7.4	6.3	2.1	2.0	1.7	2.0	1.1	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: European Labour Force Survey, micro-data 2009 and 2010. Calculations by NIW.

Qualification level of the European workforce in 2010
(figures in percent)

C 1–6

The classification of qualification levels is based on the International Standard Classification of Education (ISCED).[383]
ISCED 3: qualification to study at a university of applied science / university or completion of an apprenticeship
ISCED 4: qualification to study at a university of applied science / university and completion of an apprenticeship
ISCED 5B: Master craftsman or technician training, or equivalent degree from a university of applied science
ISCED 5A: degree from a higher education institution
ISCED 6: completion of doctoral degree



Source: Eurostat, European Labour Force Survey. Calculations by NIW. Figures from Leszczensky et al. (2012).

C 2 RESEARCH AND DEVELOPMENT

In 2010, Germany's overall expenditure on research and development reached a value of EUR 70 billion. Between 2000 and 2010, R&D expenditures increased by as much as 37 percent. With a 2.82 percent share of R&D expenditure of GDP (R&D intensity), Germany is one of Europe's leading research countries, although the three-percent target has not been quite achieved (C 2–1). The front runners in terms of R&D intensity are Finland, Sweden, Japan and Korea, with an R&D intensity significantly above 3.0 percent. Also noteworthy is the development of China, which has increased its R&D intensity from 0.6 to 1.7 percent over the last 15 years.

Figure C 2–3 shows public spending on civilian R&D in selected world regions. On average, expenditures have been increased across OECD countries by a factor of 2.6. Over the same period of time, growth of public R&D expenditure in the EU-15 countries remained below the OECD average. From among the European countries, the Scandinavian countries as well as Belgium, the Netherlands, Austria and Switzerland recorded above-average growth rates in terms of public R&D expenditures. The increase in public R&D expenditure in Germany, however, remained below the average of the EU-15 countries. Noteworthy here is the decline in the share of publicly funded R&D expenditure in the private sector over the last three decades. In the late 1970s, about 14 percent of private R&D in Germany was financed by the public sector. In 1991, this share had decreased to 8.3 percent, and was further halved by 2009 to less than 4 percent.

In Germany, more than two thirds of all R&D funding is allocated to projects in the industrial sector, with a strong focus on manufacturing (C 2–5). Thus, in 2009, a total of EUR 38.7 billion (that is 86 percent) of internal R&D spending was attributable to companies from the manufacturing sector. From among the manufacturing sector, major German export industries continue to play an important role: thus automotive engineering, mechanical engineering, electrical engineering, as well as the chemical and pharmaceutical industries accounted for approximately three quarters of internal R&D expenditures in Germany.

Not least because of the economic and financial crisis, investment activities of R&D heavyweights developed very differently over the past year. Especially automotive engineering displayed a very dynamic development. With an increase of 7.2 percent, this industry sector almost matched its pre-crisis figures. This sharp upward trend is of great importance for Germany, since R&D expenditures in automotive engineering account for almost 30 percent (approx. EUR 15 billion) of Germany's overall R&D volume in the private sector. Mechanical engineering and electrical engineering also showed an upward trend, while the chemical and pharmaceutical industries decreased their R&D efforts compared with the previous year. The negative trend in the chemical and pharmaceutical industries demonstrates how industrial research in Germany is dependent on individual corporations. Thus the decline in R&D spending by some large companies resulted in negative overall results for both industries – despite the fact that the majority of companies developed well with regard to their R&D activities in 2010.

9/10 Transilluminated organic structures
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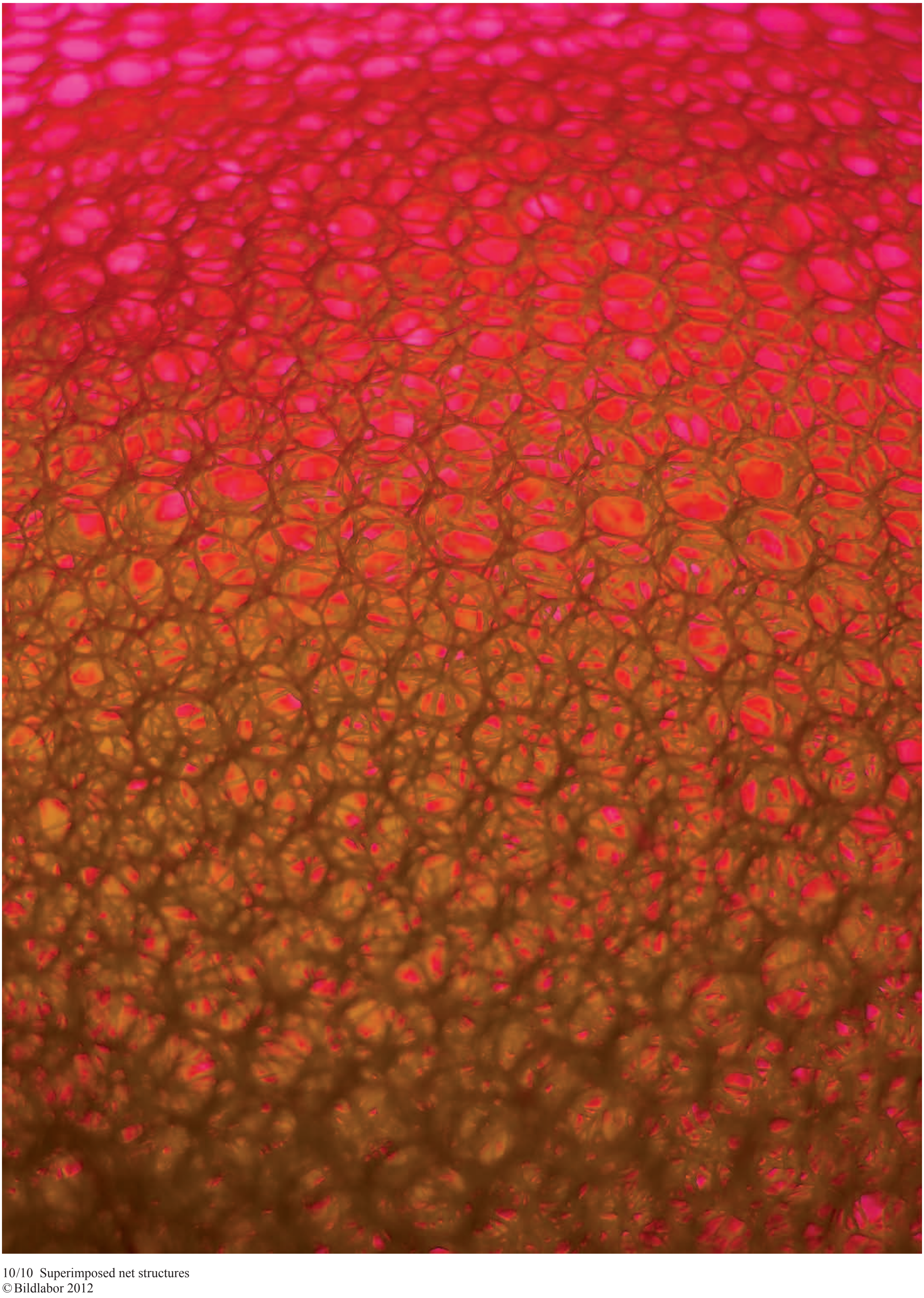

10/10 Superimposed net structures
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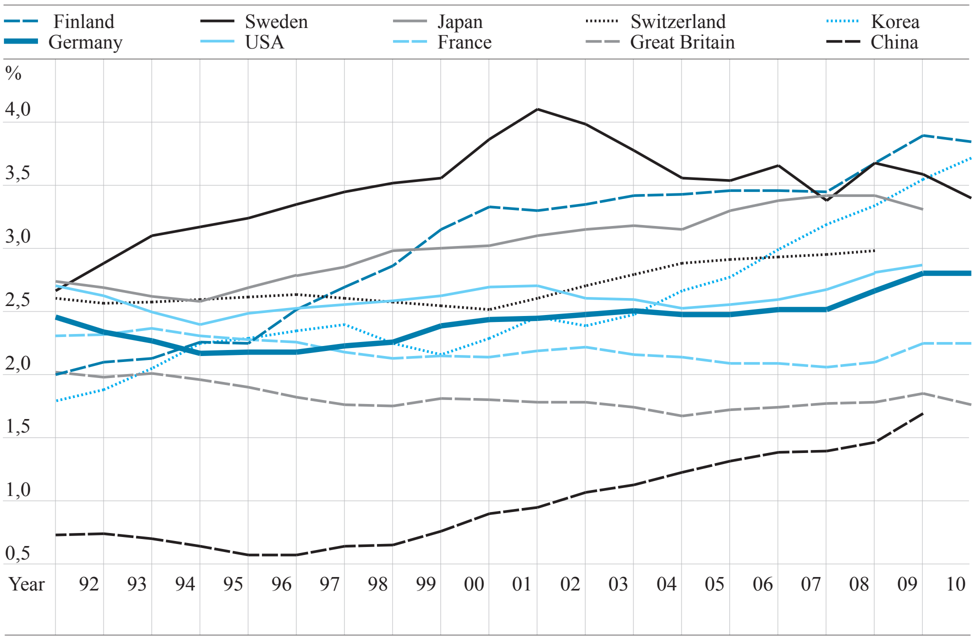
R&D intensity in selected OECD countries
(figures in percent)

C 2–1

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

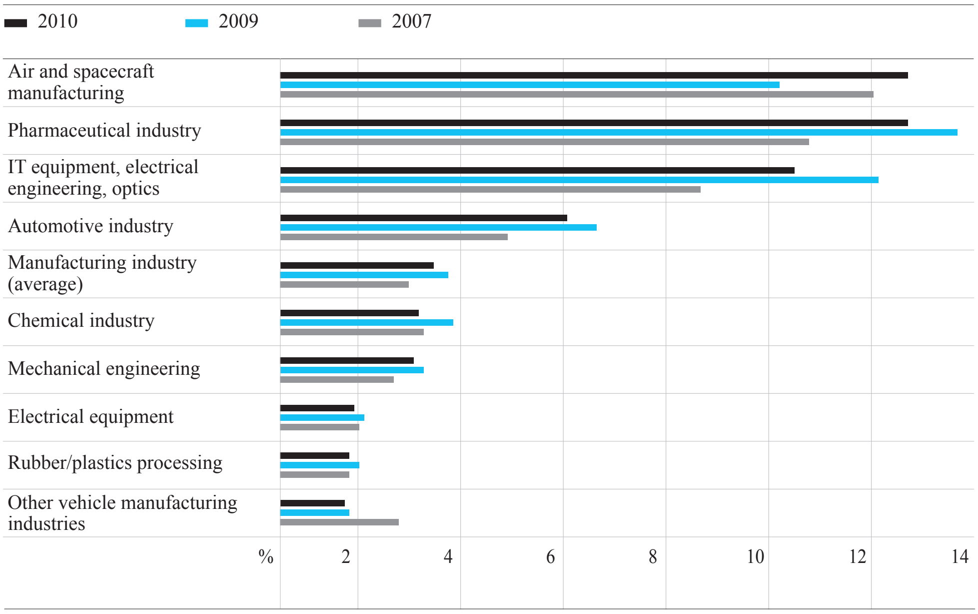


Source: OECD, Main Science and Technology Indicators (2011/1). Eurostat database.
Calculations and estimates by NIW, in: Schasse et al. (2012).

Internal private sector R&D expenditure relative to revenue

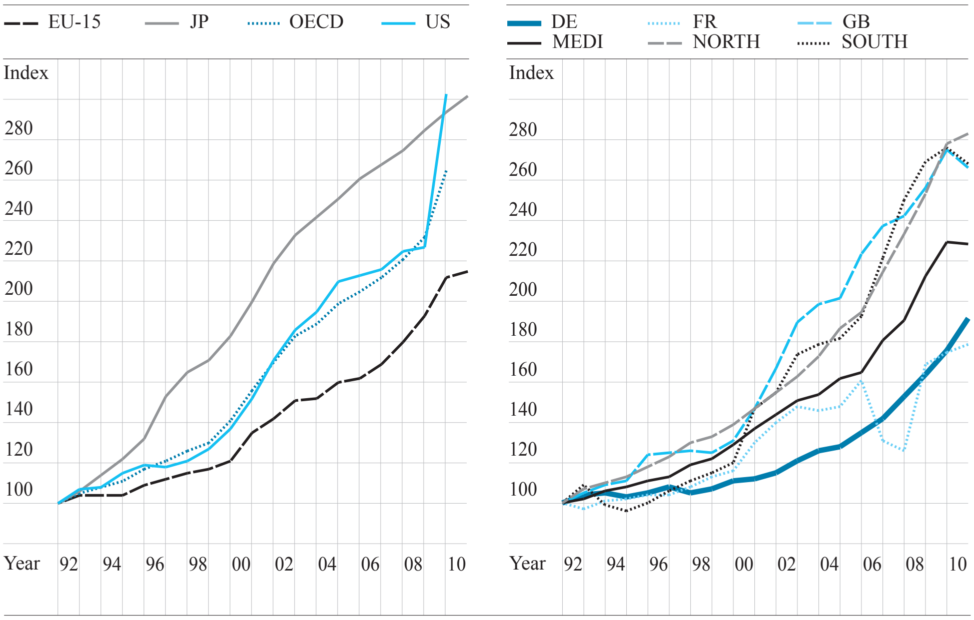
C 2–2

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*. Federal Statistical Office *(Statistisches Bundesamt)*, GENESIS-Online, industrial statistics. Calculations by NIW.

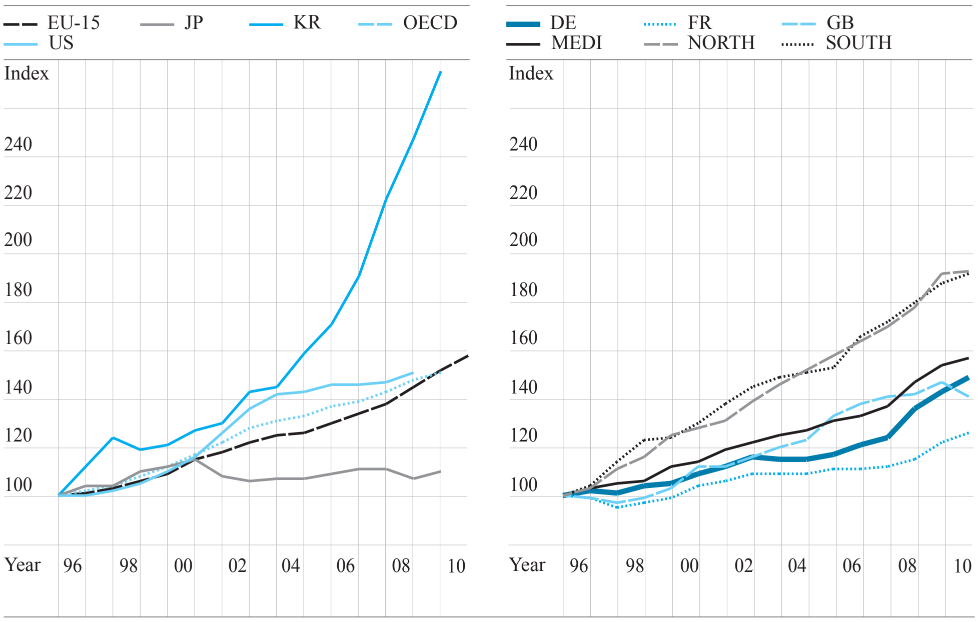
C 2–3 **State budgets for civilian R&D in selected world regions**



Index: 1991 = 100. NORTH: SWE, FIN, NOR, DEN, IRL, ISL. SOUTH: ITA, POR, ESP, GRE. MEDI: BEL, NED, AUT, SUI.
Source: OECD, Main Science and Technology Indicators (2011/1). Eurostat database.
Calculations and estimates by NIW, in: Schasse et al. (2012).

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: 1991 = 100. NORTH: SWE, FIN, NOR, DEN, IRL, ISL. SOUTH: ITA, POR, ESP, GRE. MEDI: BEL, NED, AUT, SUI.
Source: OECD, Main Science and Technology Indicators (2011/1). Eurostat database.
Calculations and estimates by NIW, in: Schasse et al. (2012).

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

Internal R&D expenditures of companies in Germany according to origin of funds, industry, size, and technology classes, 2009

C 2–5

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

Internal R&D expenditures	Total (in EUR)	of this: financed by (in percent)			
		private sector	public sector	domestic	others
Total of companies conducting research	**44,982,742**	**92.9**	**3.6**	**0.1**	**3.4**
Manufacturing sector	38,711,447	94.1	3.0	0.1	2.9
Automotive engineering	15,877,125	91.8	4.2	0.1	3.9
Electrical engineering/electronics	7,148,828	95.3	2.8	0	1.9
Mechanical engineering	4,498,533	95.2	1.8	0.1	2.9
Pharmaceutical industry	3,895,967	99.0	0.5	0	0.6
Chemical industry	3,197,776	97.3	1.4	0	1.3
Manufacturing sector, other	1,752,143	91.8	2.7	0	5.5
Metal production and processing	1,206,447	92.7	6.5	0.1	0.8
Plastics, glass and ceramic industry	1,134,628	94.0	1.7	0	4.2
Other sectors	**6,271,295**	**85.4**	**7.6**	**0.2**	**6.8**
Less than 100 employees	2,371,547	83.2	12.7	0.2	3.8
100 to 499 employees	4,665,044	89.9	4.8	0.1	5.2
500 to 999 employees	2,688,345	92.0	4.3	0.1	3.7
1000 employees and above	35,257,798	94.0	2.8	0.1	3.1
Technology classes within the industrial sector					
Cutting-edge technology (> 7 percent of R&D outlay / turnover)	12,213,754	90.8	6.9	0	2.3
High-value technology (2.5 – 7 percent of R&D outlay / turnover)	22,763,099	96.0	1.0	0.1	2.9

Source: *SV Wissenschaftsstatistik*.

C 3 INNOVATION BEHAVIOUR IN THE GERMAN PRIVATE SECTOR

As defined in the OECD Oslo Manual[384], innovations include the introduction of new or significantly improved products (goods and services), processes, as well as marketing and organisational methods. The figures on innovation behaviour in the German private sector, as depicted in C 3 – 1 and C 3 – 5, are based on the annual innovation survey by the Centre for European Economic Research (ZEW) and the Mannheim Innovation Panel (MIP), a survey that has been conducted since 1993. All figures refer to product and process innovations.[385] In the industrial sector, the innovator rate (C 3 – 1) rose again slightly in 2010, after it had fallen heavily during the 2009 crisis. In knowledge-intensive services, participation in innovation activities declined further and thus returned to the level of 2006.

Continuous R&D activities are usually accompanied by an increase in the innovation performance of companies.[386] The proportion of companies with continuous R&D activities (C 3 – 2) increased in 2010 in both the industrial sector and knowledge-intensive services. While the proportion of companies with occasional R&D activities increased in knowledge-intensive services, it decreased in the high technology sector and in other industries.

In 2010, Germany's innovation intensity (C 3 – 3), which represents the share of innovation expenditures in relation to turnover, slightly decreased in the high technology sector – albeit the fact that innovation expenditures had increased significantly. In other industries, innovation intensity also decreased slightly, while it increased in knowledge-intensive services. In 2010, the percentage of revenue generated with new products evolving from innovation activities (C3 – 4) increased in both industry and knowledge-intensive services, thus returning to the level of 2008.

Only forecast figures are presently available for 2011 and 2012. These have been collected via surveys of businesses, conducted in the spring and summer of 2011 (C3–5). According to these figures, innovation expenditures heavily increased in the industrial sector and mildly increased in knowledge-intensive services in 2011. No further increase in innovation expenditure is planned in either of the two sectors for 2012.

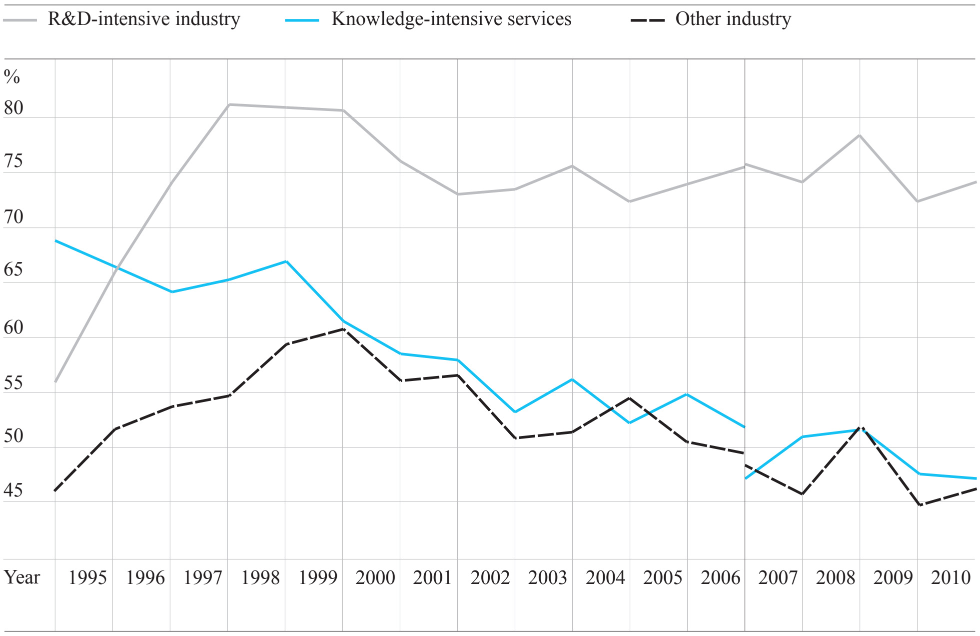
Equity capital is the most important form of financing for companies' innovation activities. According to data from the European Commission's BACH database[387], the capital ratios of small and medium-sized industrial companies in Germany (C 3 – 6) have increased steadily over the last decade. Yet, when compared internationally, German enterprises are not ranked in the top group.
For growth-oriented start-up businesses, the most important form of financing is venture capital. Figures from the European Private Equity & Venture Capital Association (EVCA)[388] demonstrate that the volume of venture capital investments (C 3 – 7) in Germany increased again in 2010, after a dramatic slump in the crisis year of 2009. Still, the level of 2008 has not been achieved yet. When compared on an international scale, it can also be observed that the German venture capital market, despite its recovery in 2010, is still characterised by a very low investment ratio (C 3 – 8). The lack of venture capital continues to be an obstacle for the growth of young businesses in Germany.

More than any other country, Germany contributes to the work of the International Organization for Standardization (ISO). Through its involvement in various ISO committees (C 3 – 9), Germany is able to exert a decisive influence on the global technological infrastructure. This leads to competitive advantages for German companies.[389]

Innovator rate in Germany's industry and knowledge-intensive services
(figures in percent)

C 3–1

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.

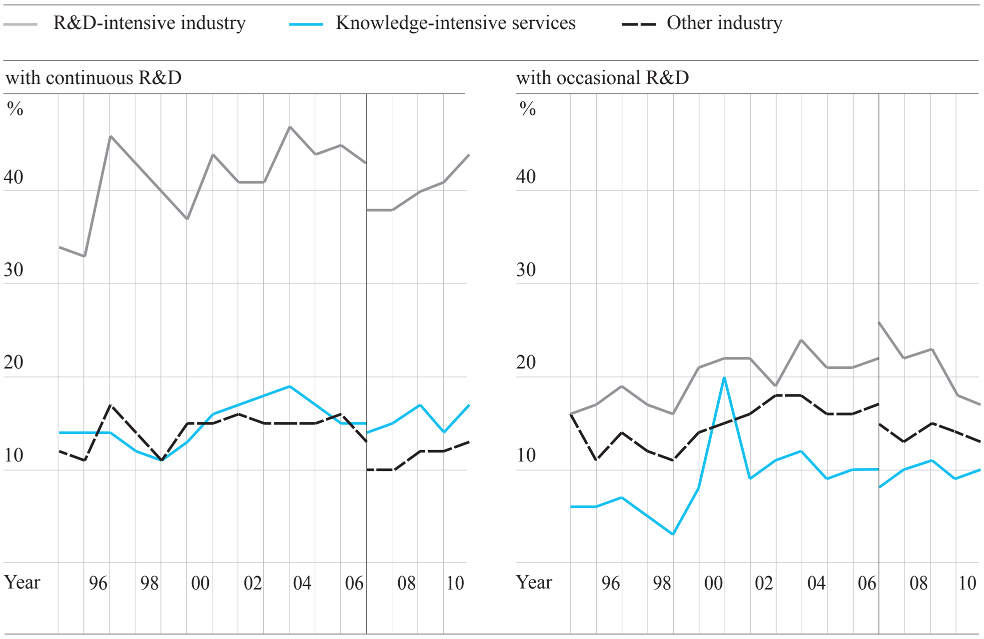


1995 not surveyed for knowledge-intensive services. Break in the time series in 2006. Figures for 2010 are provisional.
Source: Mannheim Innovation Panel (MIP). Calculations by ZEW.

Companies with continuous or occasional R&D activities
(figures in percent)

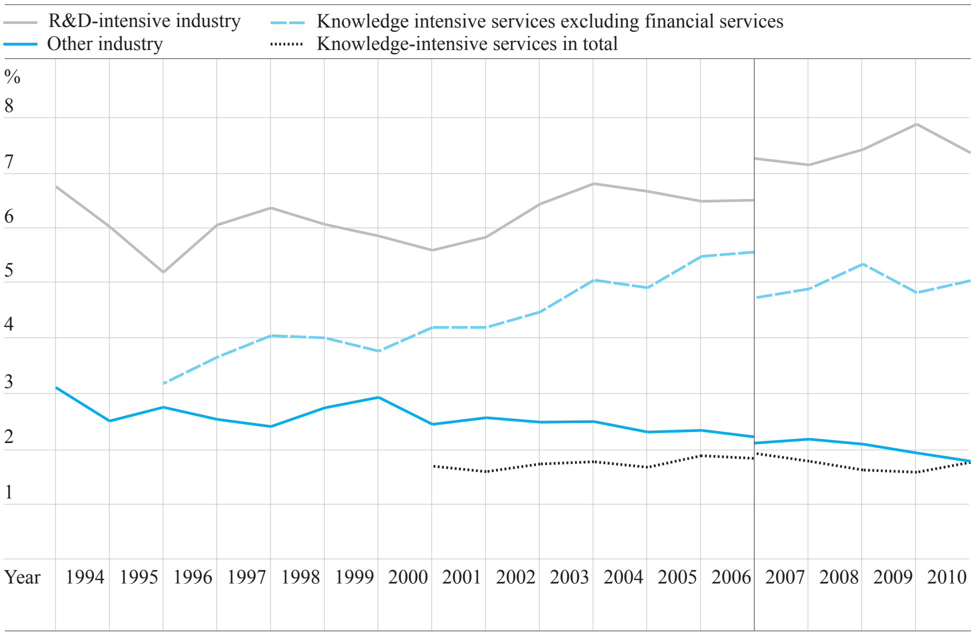
C 3–2

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.



1995 not surveyed for knowledge-intensive services. Break in the time series in 2006. Figures for 2010 are provisional.
Source: Mannheim Innovation Panel (MIP). Calculations by ZEW.

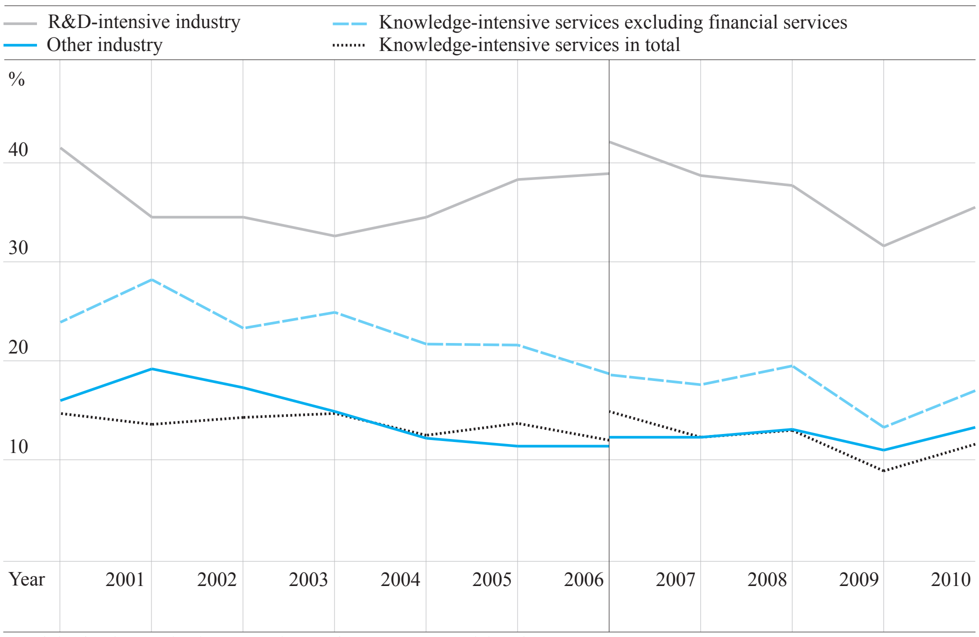
C 3–3 **Innovation intensity in Germany's industry and knowledge-intensive services**
(figures in percent)



Break in the time series in 2006. Figures for 2010 are provisional.
Source: Mannheim Innovation Panel (MIP). Calculations by ZEW.

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

C 3–4 **Proportion of revenue generated with new products in Germany's industry and knowledge-intensive services** (figures in percent)



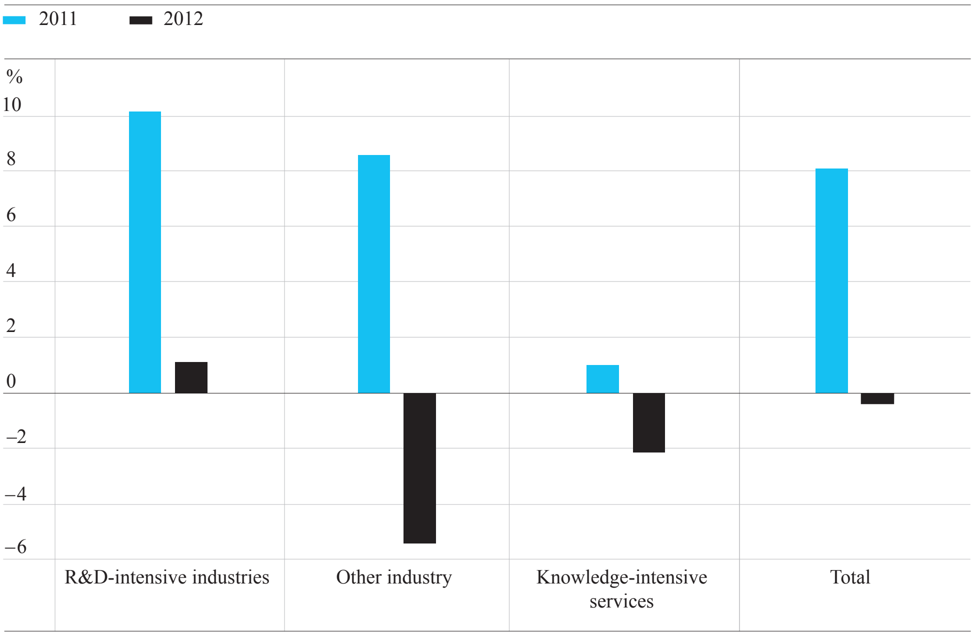
Break in the time series in 2006. Figures for 2010 are provisional.
Source: Mannheim Innovation Panel (MIP). Calculations by ZEW.

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.

Planned changes in innovation expenditures in Germany's industry and knowledge-intensive services (figures in percent)

C 3–5

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

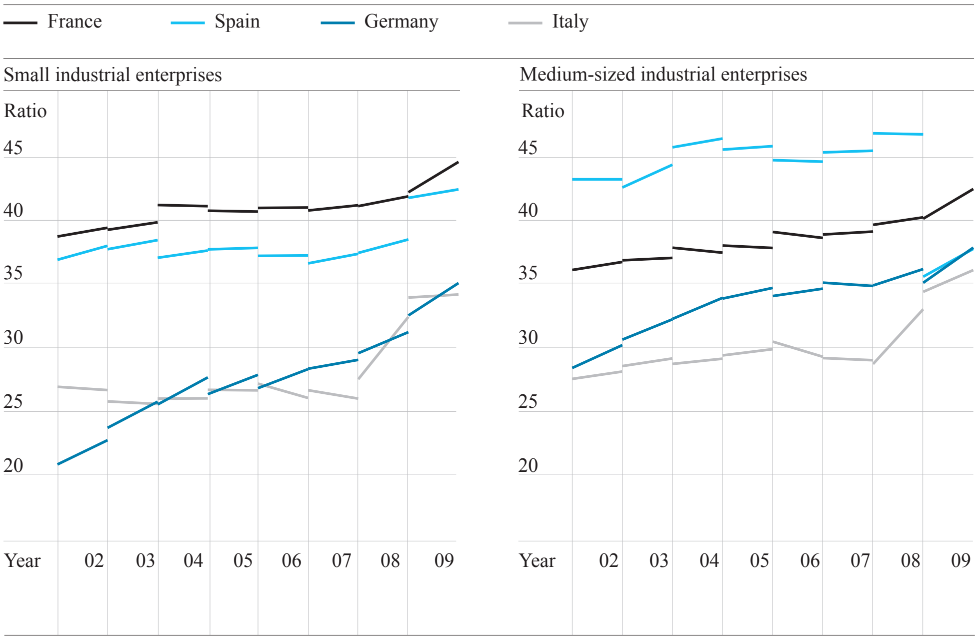


Values based on companies' planning data from spring and summer 2011.
Source: Mannheim Innovation Panel (MIP). Calculations by ZEW.

Equity ratios of small and medium-sized industrial enterprises[390]

C 3–6

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



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

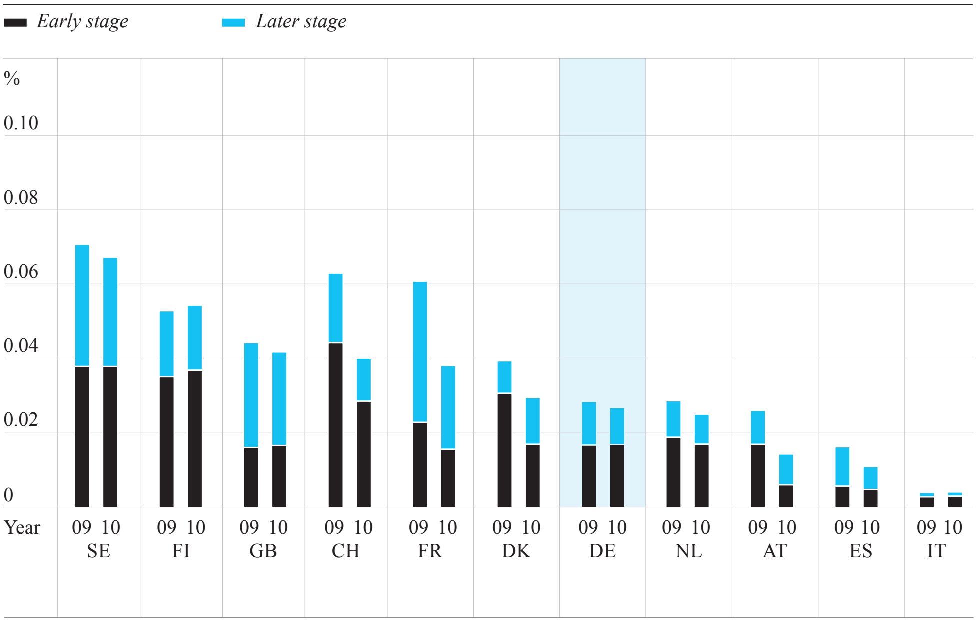
C 3–7 **Venture capital investments**
(investments according to portfolio companies' registered office)

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

	2009				2010			
	Early Stage*	Later Stage*	Total venture capital*	GDP**	Early Stage*	Later Stage*	Total venture capital*	GDP**
Denmark	68,558	19,476	88,033	222,410	39,992	29,433	69,426	234,005
Germany	*412,280*	*233,102*	*645,381*	*2,374,500*	*418,065*	*290,678*	*708,742*	*2,476,800*
Finland	61,153	30,787	91,940	173,267	66,803	31,535	98,338	180,253
France	306,116	534,737	840,853	1,889,231	304,424	436,374	740,798	1,932,802
Great Britain	373,280	398,507	771,787	1,564,476	285,196	428,395	713,591	1,700,145
Italy	44,576	18,313	62,889	1,526,790	48,528	17,389	65,917	1,556,029
Netherlands	108,398	56,295	164,694	571,145	100,752	47,463	148,215	588,414
Austria	46,949	25,095	72,045	274,818	17,630	23,800	41,430	286,197
Sweden	110,912	95,779	206,691	291,347	132,030	101,951	233,980	346,855
Switzerland	157,638	66,551	224,189	354,735	114,543	46,198	160,741	398,878
Spain	61,005	111,272	172,277	1,047,831	51,607	65,120	116,728	1,051,342

* In thousand euro. ** at current prices in million euro. The early stage comprises the "seed" and "start-up" phases.
Source: EVCA (2011). Eurostat. Own calculations. Inaccuracies due to figure rounding.

C 3–8 **Proportion of venture capital investments as a percentage of national GDP**
(Investments according to registered office of the portfolio companies; figures in percent)

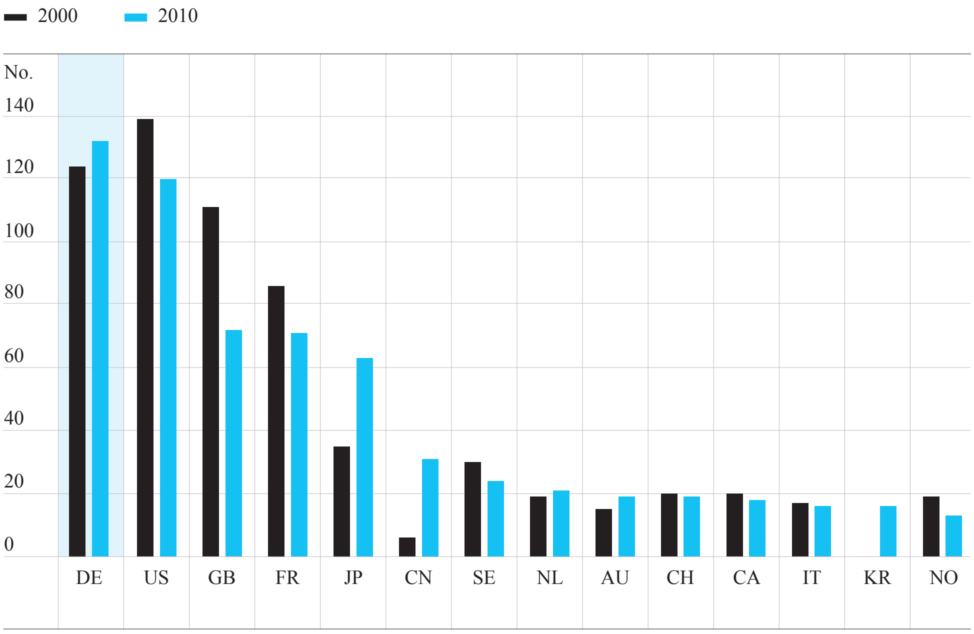


The early stage comprises the "seed" and "start-up" phases.
Source: EVCA (2011). Eurostat. Own calculations.

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

C 3–9

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



Source: ISO (2001 and 2011). Own compilation.

C 4 NEW ENTERPRISES

New findings are used economically by transforming them into innovative products, processes and services, which are then marketed. Here, a particularly sustainable form of knowledge and technology transfer are new enterprises in research and knowledge-intensive sectors.

Graphs C 4–1 to C 4–3, which depict business dynamics in the knowledge economy, are based on figures by the Centre for European Economic Research (ZEW), derived from an evaluation of the Mannheim Enterprise Panel (MUP).[391] In 2010, the start-up rate (C 4–1) in the knowledge economy was 7.3 percent, which represents a slight decrease compared to the previous year. Thus the downward trend in start-up rates, which has lasted for over a decade, continues to prevail. The closure rate (C 4–2) in the knowledge economy was 6.1 percent in 2010, which also represents a decline compared with 2009. Different start-up and closure rates in the various sectors of the knowledge economy reflect sectoral differences in market entry and market exit barriers, as well as differences in (expected) sales opportunities. High-value technology and cutting-edge technology are characterised by low ratios, while values in the IT and telecommunications industry and in business consulting and advertising are relatively high.

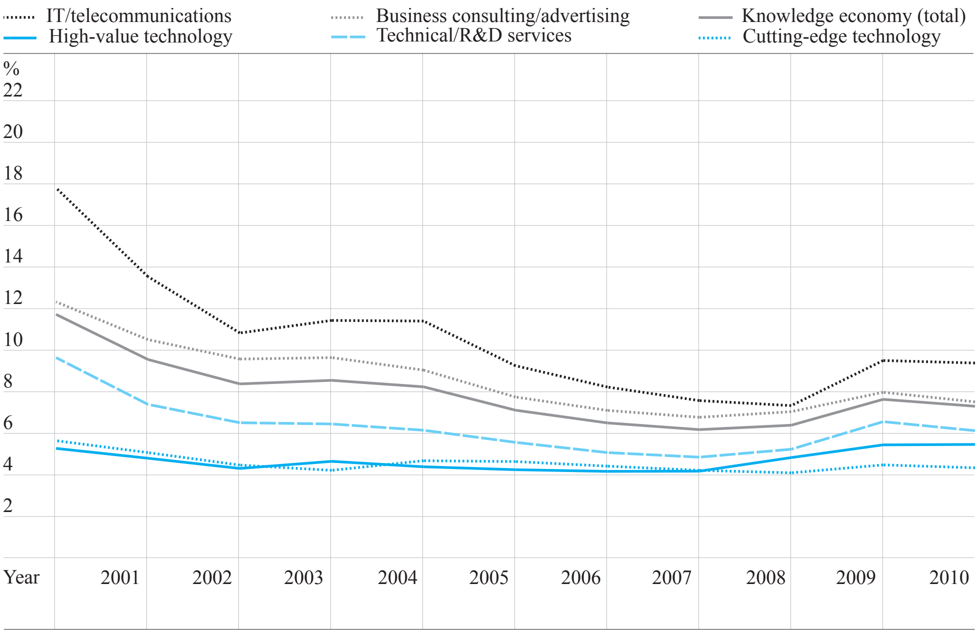
Company dynamics (C 4–3) indicate the direction and intensity of structural change in the business sector. In 2005/2006 and 2009/2010, company dynamics have increased in the knowledge economy. Yet, in most sectors values are significantly lower than those of 2000/2001.

Graphs C 4–4 and C 4–5 represent results from the Global Entrepreneurship Monitor (GEM).[392] The rate of nascent entrepreneurs (C 4–4) is a future-related indicator. It denotes the proportion of the population aged 18 to 64 years that is actively involved in starting up a business. In Germany, this rate had been steadily declining up until 2009. 2010 was the first year that saw an increase in nascent entrepreneurs rate as compared with the previous year, albeit this increase is not statistically significant. But also the opportunity entrepreneurship rate (C 4–5), which represents the proportion of nascent entrepreneurs that start up a business in order to exploit a business idea, has increased in Germany compared with 2009. Both rates, however, are relatively low when compared with the values of the United States, France and Great Britain.

Start-up rates in Germany's knowledge economy
(figures in percent)

C 4–1

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

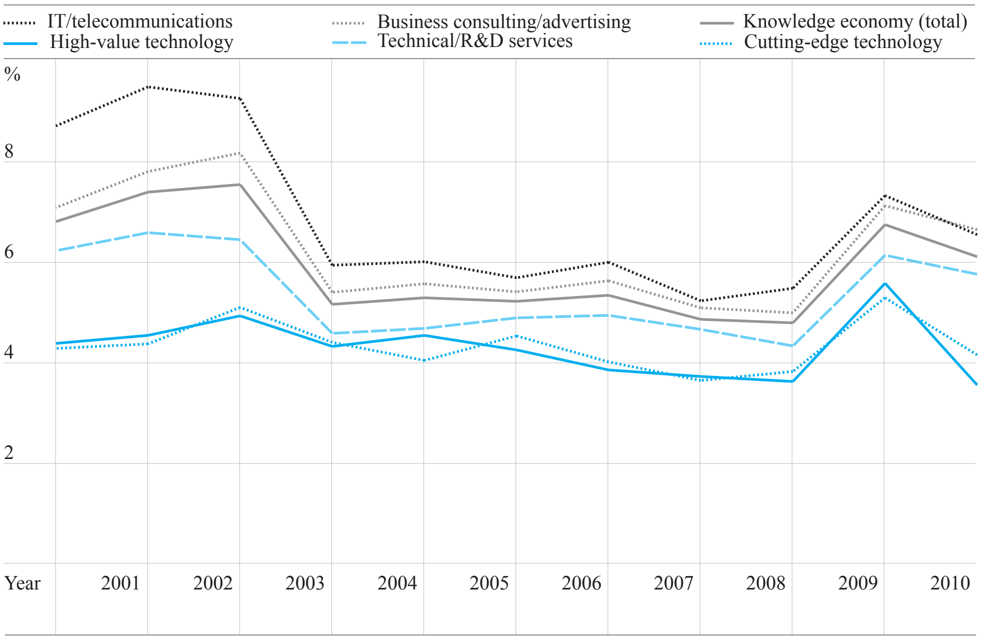


All figures are provisional.
Source: Mannheim Enterprise Panel (MUP). Calculations by ZEW.

Closure rates in Germany's knowledge economy
(figures in percent)

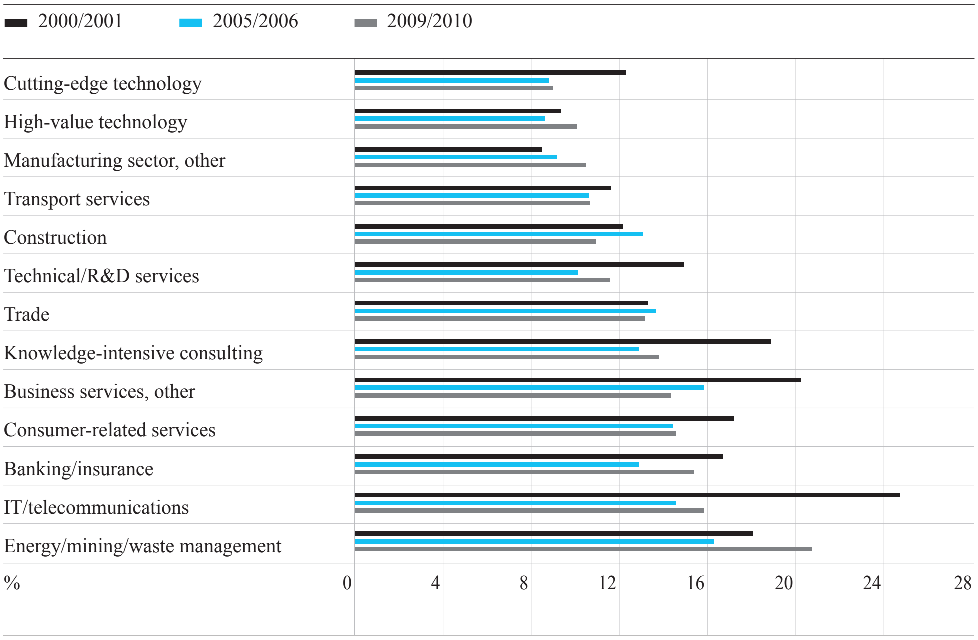
C 4–2

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



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

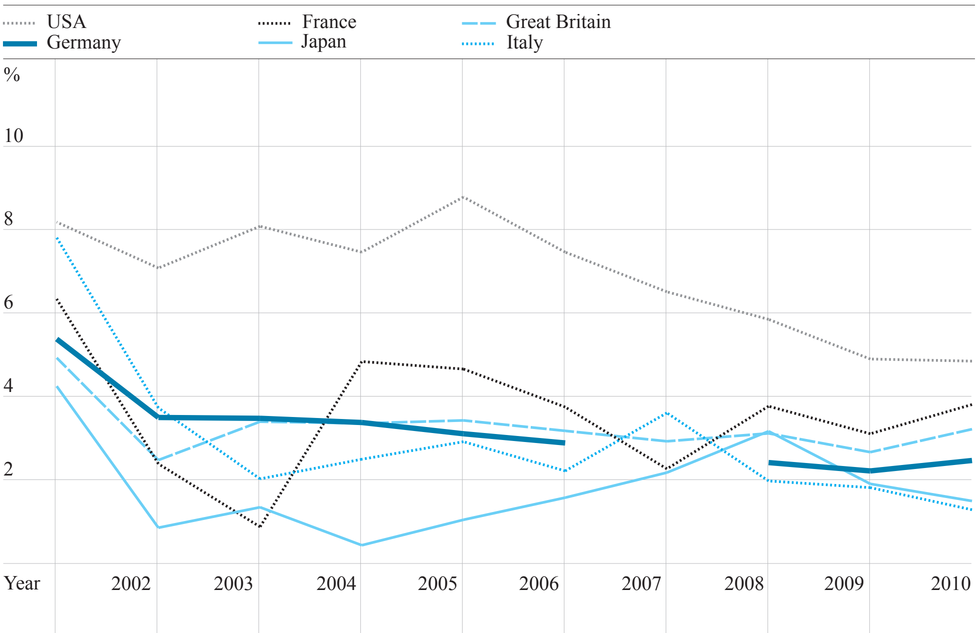
C 4–3 **Company dynamics in Germany according to sector groups**
(figures in percent)



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

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

C 4–4 **Nascent entrepreneurs**
(figures in percent)



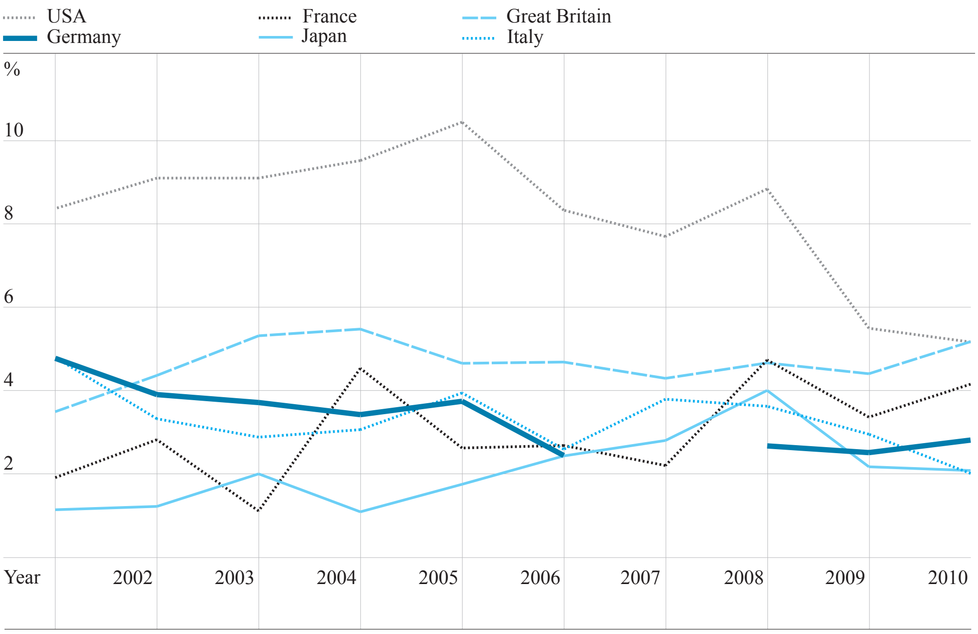
Germany did not participate in GEM in 2007.
Source: Global Entrepreneurship Monitor (GEM), Adult Population Surveys 2000–2010.

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.

Opportunity Entrepreneurs
(figures in percent)

C 4–5

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.



Germany did not participate in GEM in 2007.
Source: Global Entrepreneurship Monitor (GEM), Adult Population Surveys 2000–2010.

C 5 PATENTS IN INTERNATIONAL COMPETITION

Patents protect new technical inventions. Patents provide the patent holder with the spatially and temporally limited exclusive right to dispose of the invention, thereby excluding third parties from utilising the patented invention. Furthermore, when filing the patent application, the holder gives his consent to the publication of his invention. The description of the invention can provide useful guidance to other inventors who are engaged in developing a particular field of technology. Additional information such as details on the inventor and patent applicant, as well as the technical classification of the invention, make it possible to use patent statistics for assessing the technological performance of a country, region or company.

Transnational patent applications are filed either at the European Patent Office or as a Patent Cooperation Treaty (PCT) application[393]. This procedure is usually chosen in cases where a high-quality invention can be marketed internationally. As an innovation indicator, transnational patent applications have the advantage of possessing a qualitative element, while at the same time creating international comparability, which is not the case with national applications.

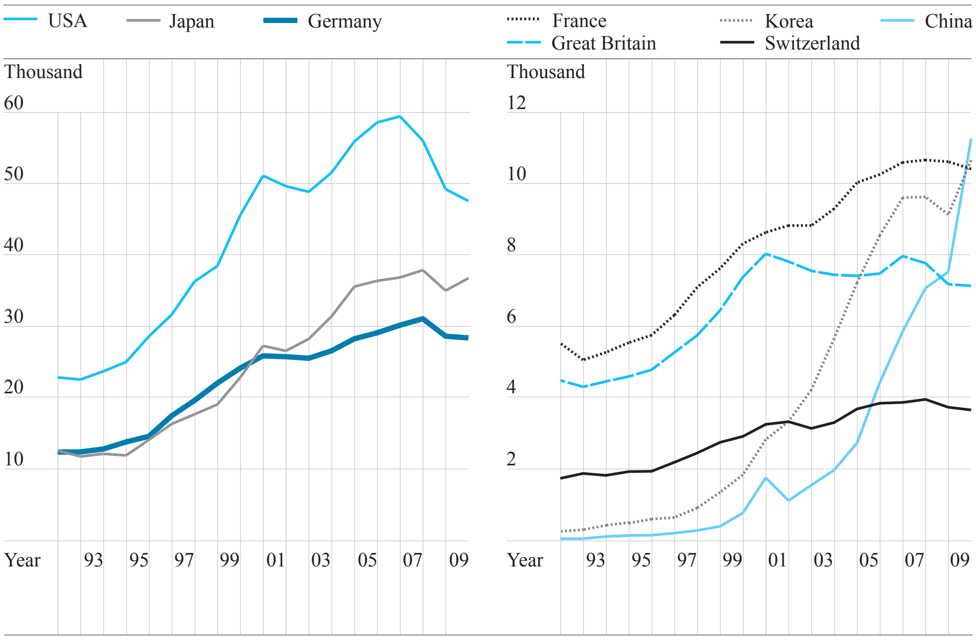
The three main industrial nations, i.e. the United States, Japan and Germany, continue to be the leading countries in transnational patent applications. The greatest dynamics, however, can be observed in the Asian countries of China and Korea (C 5–1). Viewed in absolute terms, the number of transnational applications from China has increased considerably since 2001. In 2009, applicants from China filed more transnational patents than applicants from Great Britain or France. At the same time, there has been a decline in the number of relevant applications from China and Korea in the field of high-value technologies (C 5–3). In this regard, Germany's strong specialisation in high technologies becomes obvious when compared on an international scale. Thanks to the automotive, mechanical engineering and chemical industries, the production of high-value technologies can be considered a traditional domain of German industry. Only Japan has a higher degree of specialisation in this sector. While China, Korea and the United States compensate for their marginal position in high-value technologies by successfully specialising in cutting-edge technology, Germany continues to be badly positioned in the field of cutting-edge technology and is still lagging far behind Japan – a country that has been able to assert itself in both cutting-edge technologies and high-value technologies (C 5–4).

Finally, the number of patent applications per million persons in employment (patent intensity) provides information on the relative innovative strength of an economy, irrespective of its size (C 5–2). When looking at this indicator, it can be observed that the smaller economies of Switzerland, Sweden and Finland are in the top group of the technology-oriented countries surveyed. The fourth and fifth positions are occupied by the leading industrial nations of Germany and, at some distance, Japan. Compared with figures on patent intensity in 2008, Germany was surpassed by Finland in 2009, while Korea has left France and the Netherlands behind.

Development of numbers of transnational patent applications over time, in selected countries

C 5–1

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.



Source: EPA (PATSTAT), calculations by Fraunhofer ISI, December 2011.

Transnational patent applications in the field of high technology: absolute number, intensity and growth rates in 2009

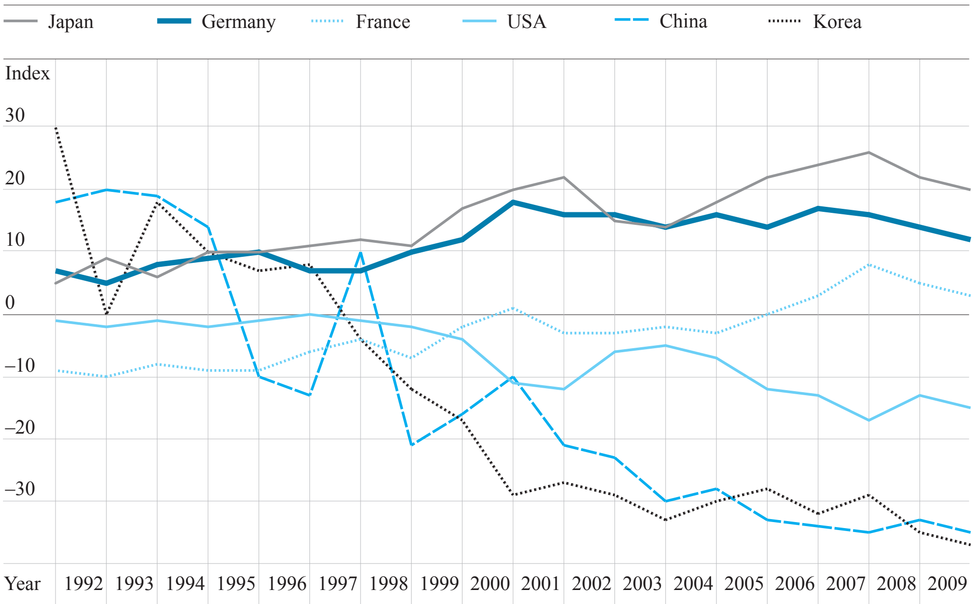
C 5–2

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.

	Absolute	Intensity	Intensity, high technology	Total growth* in percent	Growth* in high technology, in percent
Total	**194,737**	**–**	**–**	**136**	**135**
Switzerland	3,644	804	389	126	130
Sweden	3,339	740	352	112	114
Finland	1,808	736	319	96	96
Germany	*28,321*	*730*	*362*	*118*	*115*
Japan	36,707	585	334	161	163
Korea	10,650	453	236	583	598
Netherlands	3,810	443	211	120	108
France	10,405	395	200	125	129
USA	47,529	340	197	104	104
EU-27	70,169	322	156	121	119
Great Britain	7,125	247	122	97	95
Italy	5,387	234	99	127	128
Canada	3,410	202	99	145	125
China	11,253	14	6	1,488	968

* Index: 1999 = 100.
Quelle: EPA (PATSTAT). OECD (MSTI). Berechnungen des Fraunhofer ISI, Dezember 2011.

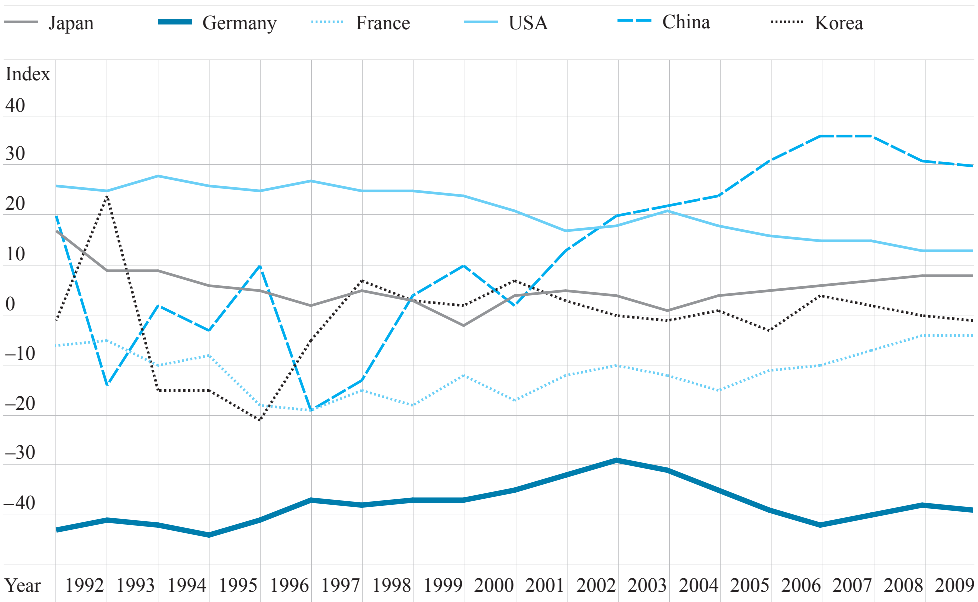
C 5–3 **Development of high-value technology specialisation index over time, for selected countries**



Source: Questel (EPPATENT, WOPATENT). EPA (PATSTAT). Calculations by Fraunhofer ISI. December 2011.

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.

C 5–4 **Development of cutting-edge technology specialisation index over time, for selected countries**



Source: Questel (EPPATENT, WOPATENT). EPA (PATSTAT). Calculations by Fraunhofer ISI. December 2011.

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.

SCIENTIFIC PUBLICATIONS AND PERFORMANCE C 6

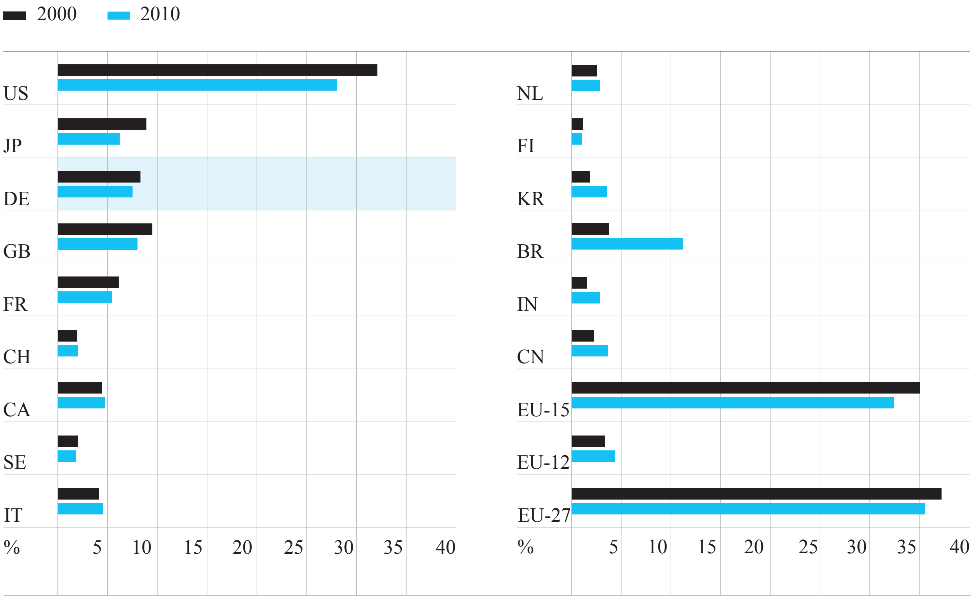
A growing number of technologies and services is knowledge-based and provides the basis of entire industrial sectors. The training of qualified professionals and the creation of an excellent scientific basis for future technological developments are a key contribution of science to the national innovation system. Scientific publications and the frequency of citations are used as indicators for research performance and have been increasingly used in recent years as a means of assessing performance of research institutions and scientists.

When looking at the shares of selected countries and regions in Web of Science (WoS) publications[394], it becomes clear that the major industrialised nations have suffered substantial relative losses in favour of the emerging economies of China, India, Brazil and Korea, as well as the new EU member states (EU-12) (Figure C 6–1). Despite this decline, about one quarter of all publications in 2010, and thus the biggest share of publications, can still be assigned to authors from the United States. In addition to Germany, countries such as Japan, France, Sweden, Finland and Great Britain have also recorded a decline. As opposed to this, publication shares of most emerging economies have at least doubled over the past 10 years. It is also worth noting that Switzerland, Canada, Italy and the Netherlands managed to keep their shares stable or even slightly increased their shares over the same period of time.

However, these significant changes in relation to publication activities become less drastic if one considers the indicators relating to publication quality. Thus, for example, the journal-specific scientific regard (SR) index (C 6–3) suggests that, in terms of quality of publications, the emerging economies and Japan still have a lot of catching up to do to meet the level of Western industrial nations. Nevertheless, considerable progress in quality could be observed in these countries, most notable with regard to Chinese publications. Switzerland remains to be at the forefront, albeit the fact that the quality measured between 2000 and 2008 has decreased marginally. The same can be said for Great Britain, Sweden and Canada. Germany's level of influence is similar to that of these countries, and the positive trend described in the EFI Annual Report 2011 still continued in 2008. In terms of scientific regard, Germany has in fact managed to surpass the United States.

Another quality indicator is the international alignment (IA) index of a country's scientific publications (C 6–2). Here, the current results confirm the dominant role of Switzerland, the United States and the Netherlands, all of which, when compared with the global average, frequently publish in renowned, internationally visible journals. One of the reasons for the increase observed in industrial nations is the fact that in these countries, a publication in eminent journals has become more relevant for academic careers. Here, the emerging countries occupy an unfavourable position compared with the industrial nations. Yet China, India and Korea still increasingly succeed in placing a growing number of publications in internationally visible journals. These countries have already caught up with the EU-12 countries, or have even managed to surpass them.

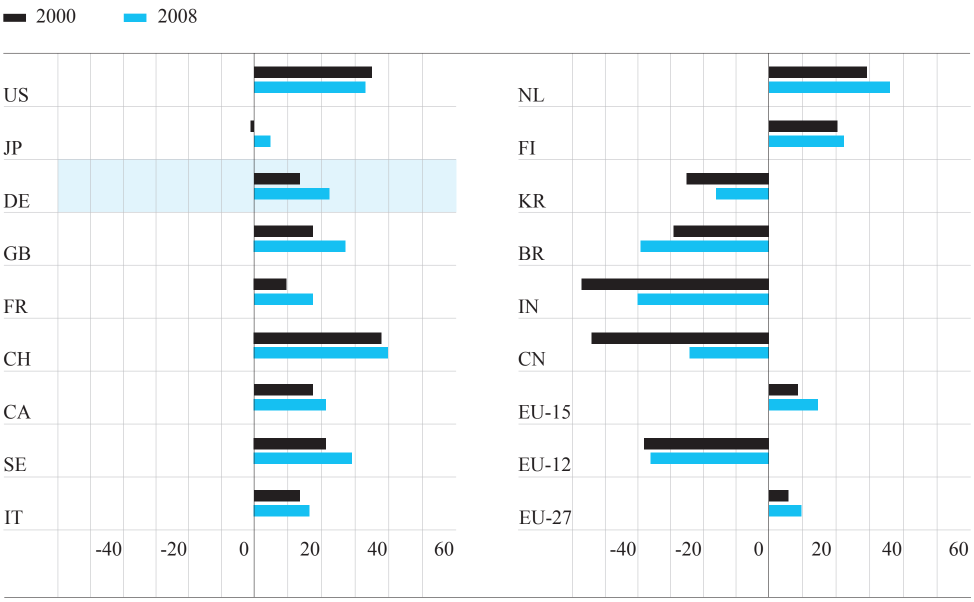
C 6–1 **Shares of selected countries and regions for all Web of Science publications 2000 and 2010** (figures in percent)



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

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

C 6–2 **International alignment of selected countries and regions for Web of Science publications 2000 and 2008**

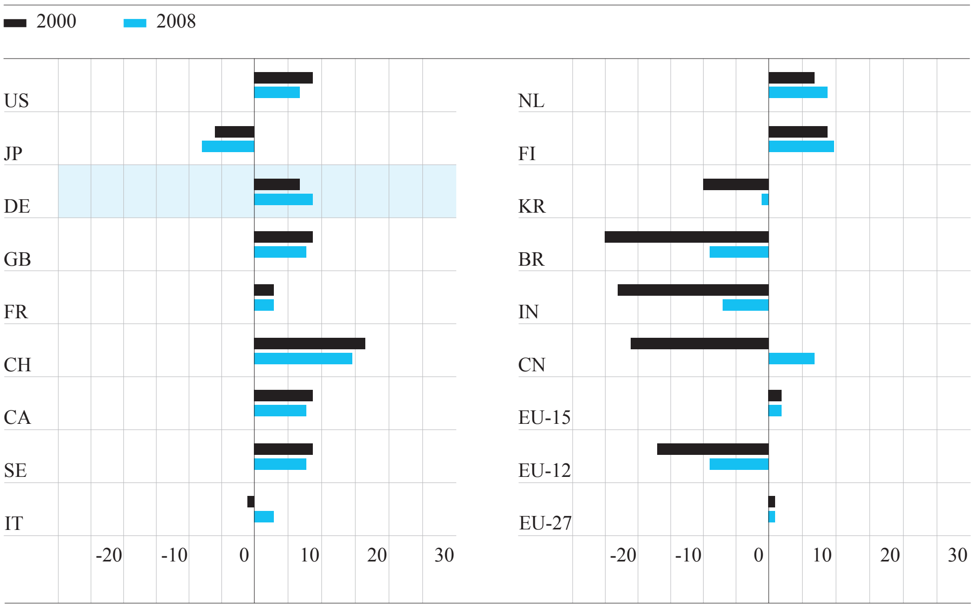


Source: Web of Science (WoS). Research and calculations by Fraunhofer ISI.

The 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.

Scientific regard for Web of Science publications from selected countries and regions 2000 and 2008 C 6–3

The 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.



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

C 7 PRODUCTION, VALUE ADDED AND EMPLOYMENT

The advance of globalisation enables an international division of labour, which means that each country can use its comparative advantages in the production of goods. This has lead to a shift in the production of labour-intensive goods and production processes to developing and emerging countries with low labour costs. Thus the global market share of gross value added in the manufacturing sector has shifted over the last decade, with a significant increase in China's share (C 7–3). In the field of labour-intensive goods, industrialised countries such as Germany are unable to compete internationally and have to specialise in the development and production of high-value and cutting-edge technology. Yet, it should be pointed out that developing and emerging countries do not solely specialise in the production of simple goods, but increasingly focus on the production of R&D-intensive goods as well.

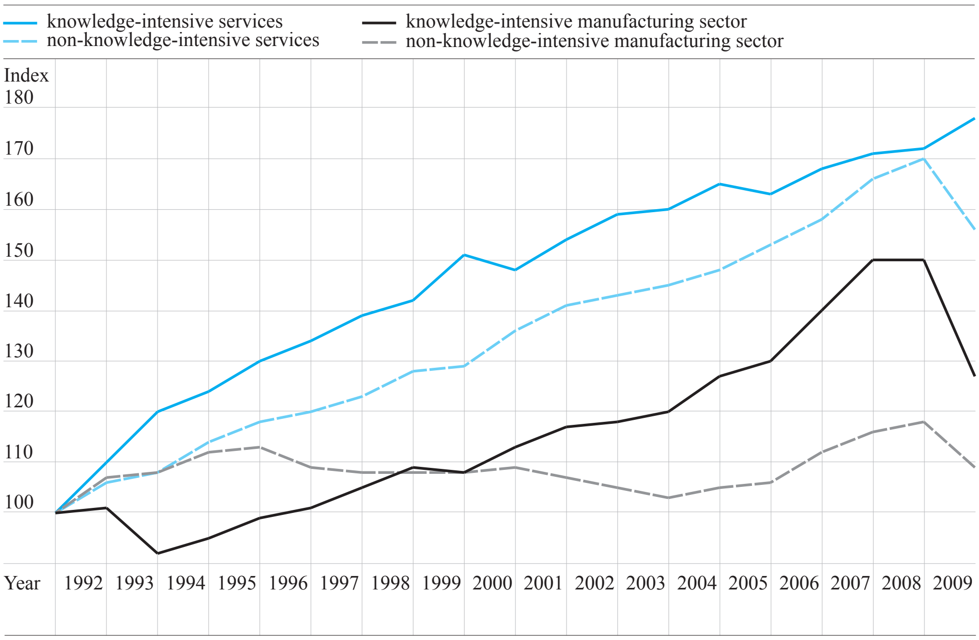
The development of value added in Germany has been hampered by the economic crisis. Thus, in the course of two years, value added in Germany has decreased in the manufacturing sector and in non-knowledge-intensive services, reaching a level similar to that of 2005. Only knowledge-intensive services managed to defy the trend and reported an increase in added value, even during the crisis (C 7–1). A similar trend can be observed in the number of employees subjected to social insurance: while employment in the manufacturing sector has declined in recent years, the services sector reported an increase (C 7–2).

The share of labour input and value added in a country's R&D- and knowledge-intensive industries reflects the relevance of these industries in the respective country. While labour input in R&D-intensive industries has stagnated or declined slightly, labour input increased in knowledge-intensive services in the countries surveyed. A similar trend can be observed in terms of value added: the share of knowledge-intensive services in value added has increased over the past decade. In the R&D-intensive industries, however, these countries do not present a uniform picture (C 7–4 and C 7–5).

But also trade in R&D-intensive goods is no longer solely in the hands of the industrial nations. Emerging economies and developing countries have succeeded in gaining shares in this field as well. While Germany has managed to maintain its global market share over the past 15 years, the United States, Canada and Japan have recorded significant losses in shares. China and Korea, however, have increased their shares in world trade in the field of R&D-intensive goods. Especially noteworthy here is that China – unlike Germany – has built up a positive export specialisation in cutting-edge technologies for several years (C 7–6 and C 7–7).

Shares of gross value added in 2009: knowledge-intensive manufacturing sector, 19 percent; non-knowledge-intensive manufacturing sector, 20 percent; knowledge-intensive services, 30 percent; non-knowledge-intensive services, 31 percent.

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



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

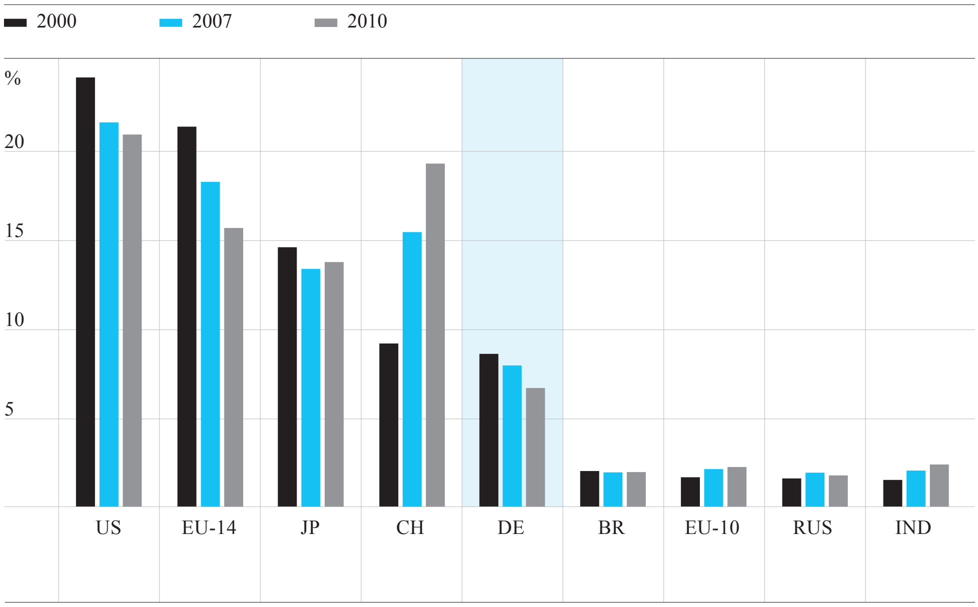
Shares of employment in the business sector in 2010: knowledge-intensive manufacturing sector, 13 percent; non-knowledge-intensive manufacturing sector, 24 percent; knowledge-intensive services, 25 percent; non-knowledge-intensive services, 38 percent.

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

	2008	2009	2010	2008–2009	2009–2010	2008–2010
	in 1,000			annual average changes in %		
Manufacturing sector	**8,625**	**8,472**	**8,394**	**–1.77**	**–0.93**	**–1.35**
Knowledge-intensive sectors	3,083	3,045	2,999	–1.21	–1.51	–1.36
Non-knowledge-intensive sectors	5,543	5,427	5,395	–2.09	–0.60	–1.34
Services	**14,157**	**14,077**	**14,361**	**–0.57**	**2.02**	**0.72**
Knowledge-intensive sectors	5,522	5,569	5,621	0.86	0.93	0.90
Non-knowledge-intensive sectors	8,635	8,507	8,739	–1.48	2.73	0.60
Industry	**22,782**	**22,549**	**22,755**	**–1.02**	**0.91**	**–0.06**
Knowledge-intensive sectors	8,604	8,615	8,620	0.12	0.07	0.09
Non-knowledge-intensive sectors	14,178	13,934	14,134	–1.72	1.43	–0.15

Source: Federal Employment Agency *(Bundesagentur für Arbeit)*. Calculations by NIW.

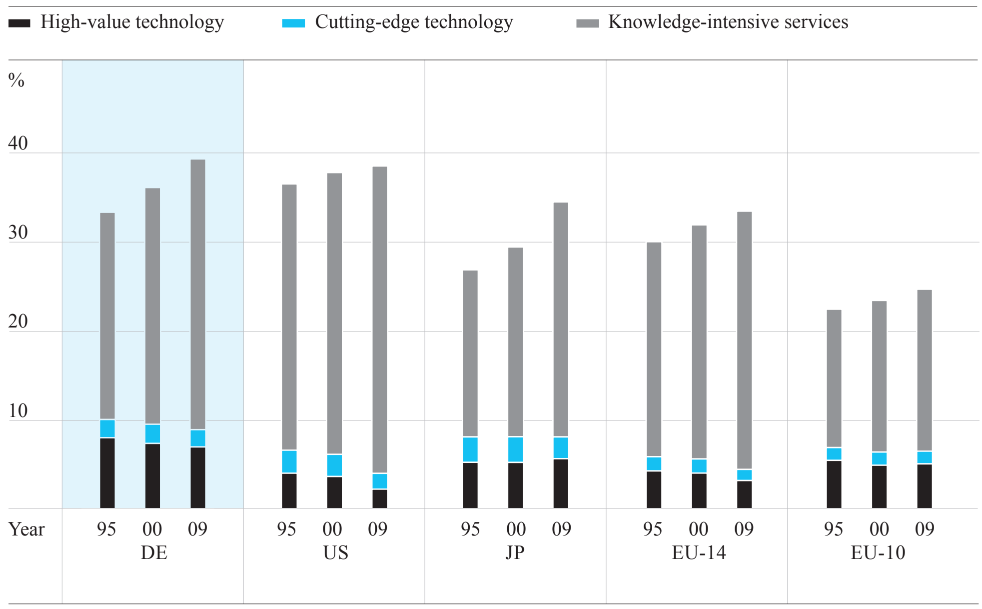
C 7–3 **Countries' and country groups' shares in global value added in the manufacturing sector**
(figures in percent)



Source: United Nations Statistics Division (UNSD 2011). IMF WEO Database (2011). OECD STAN (2011).
Calculations by DIW Berlin.

Global market shares in gross value added of the manufacturing sector have shifted in recent years. China's share in particular has increased significantly.

C 7–4 **Labour input shares of R&D-intensive industries and knowledge-intensive services**
(figures in percent)



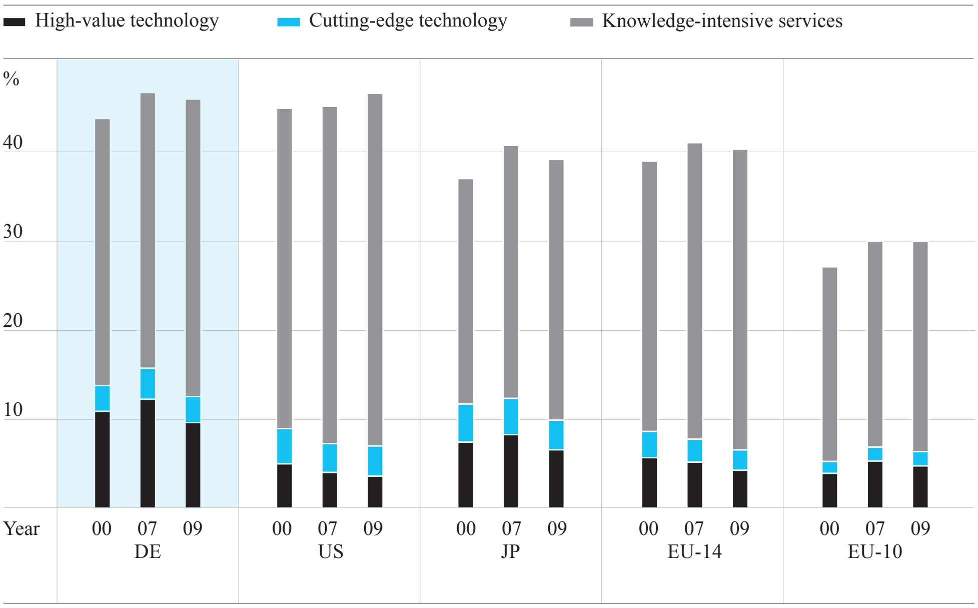
EU-14 refers to the old EU member states, excluding Germany. EU-10 refers to the new EU countries, excluding Romania and Bulgaria.
Source: EUKLEMS database (2011). OECD STAN (2011). Eurostat (2011).
Calculations and estimates by DIW Berlin.

While labour input in R&D-intensive industries has stagnated or decreased slightly, labour input in knowledge-intensive services has increased in the countries surveyed.

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

C 7–5

The share of knowledge-intensive services in value creation has increased over the last decade in the countries surveyed, while the R&D-intensive industries do not present a uniform picture.



EU-14 refers to the old EU member states, excluding Germany. EU-10 refers to the new EU countries, excluding Romania and Bulgaria.
Source: EUKLEMS database (2011). OECD STAN (2011). Eurostat (2011).
Calculations and estimates by DIW Berlin.

Export specialisation (Relative Export Advantage, RXA) of selected countries, for R&D-intensive goods

C 7–6

A positive RXA value means that the share of the world market supply for this product group is higher than it is for processed 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*	9	11	–34	–32	–16	–41	–5	13	–12	10	27	–	–13
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	*34*	5	25	–5	–26	2	–27	10	20	3	16	47	–	–53
Cutting-edge technology														
1995	*–46*	–9	24	–97	–71	–4	–20	–27	–59	–49	55	27	28	–78
2000	*–35*	–10	25	–113	–55	–1	18	–20	–61	–39	39	1	34	–30
2005	*–36*	–15	13	–122	–40	–28	19	–30	36	–58	37	–3	49	36
2010	*–38*	15	–22	–130	–43	–60	–73	–38	–2	–49	–3	–24	–	34

World exports 2010 based on estimates. EU-14 refers to the old EU member states, excluding Germany; 2010 based on estimates.
Source: OECD, ITCS – International Trade By Commodity Statistics, Rev. 3 (various years).
COMTRADE database. Calculations and estimates by NIW.

C 7–7 **Comparative advantages (Revealed Comparative Advantage, RCA) of selected countries, for foreign trade in research-intensive goods**

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	17	–23	–3	–11	–21	3	21	–16	5	42	–	–39
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	8	18	–18	10	75	–	–56
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	10	–83	–14	–30	–11	–9	30	–10	–4	–31	–	–23

EU-14 refers to the old EU member states excluding Germany; only EU-external foreign trade is considered.
1995 excluding Luxemburg.
Source: OECD, ITCS – International Trade By Commodity Statistics, Rev. 3 (various years). COMTRADE database. Calculations and estimates by NIW.

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

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LIST OF ABBREVIATIONS

AIFM	Alternative Investment Fund Manager
ATEM	*Antriebstechnologien für die Elektromobilität* (funding programme of the Federal Ministry of Economics and Technology on the research and development on propulsion systems for electrical and hybrid vehicles)
BAMF	*Bundesamt für Migration und Flüchtlinge* (Federal Office for Migration and Refugees)
BMBF	*Bundesministerium für Bildung und Forschung* (Federal Ministry of Education and Research)
BMELV	*Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz* (Federal Ministry of Food, Agriculture and Consumer Protection)
BMF	*Bundesministerium der Finanzen* (Federal Ministry of Finance)
BMU	*Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit* (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety)
BMW	*Bayerische Motorenwerke*
BMWi	*Bundesministerium für Wirtschaft und Technologie* (Federal Ministry of Economics and Technology)
BRIC countries	Brazil, Russia, India and China
BVK	*Bundesverband Deutscher Kapitalbeteiligungsgesellschaften* (German Private Equity and Venture Capital Association)
BYD	Build Your Dreams (Chinese car manufacturer)
ca.	circa
CASTED	Chinese Academy of Science and Technology for Development
CATARC	China Automotive Technology and Research Center
cf.	confer
CO2	carbon dioxide
CP	Communist Party
CRD	Capital Requirements Directive
CRR	Capital Requirements Regulation
DFG	*Deutsche Forschungsgemeinschaft* (German Research Foundation)
DIW	*Deutsches Institut für Wirtschaftsforschung* (German Institute for Economic Research)
EFI	*Expertenkommission Forschung und Innovation* (Commission of Experts for Research and Innovation)
e.g.	examples given
ERC	European Research Council
ERP	European Recovery Programme
etc.	et cetera
ETH Zürich	*Eidgenössische Technische Hochschule Zürich* (Swiss Federal Institute of Technology Zurich)
EU	European Union
Euroatom	European Atomic Energy Community
EVCA	European Private Equity & Venture Capital Association
EXIST	*"Existenzgründungen aus der Wissenschaft"*, a funding programme of the Federal Ministry of Economics and Technology
FAW	First Automotive Works (Chinese car manufacturer)
FEMTEC	*Hochschulkarrierezentrum für Frauen Berlin* (Higher Education Career Centre for Women)
ff.	and the following

FhG	*Fraunhofer-Gesellschaft*
Fig.	Figure
FiT	*Frauen in technischen Berufen* (women in technical professions)
FZK	*Forschungszentrum Karlsruhe* (Karlsruhe Research Centre)
G8	*Gymnasialzeit von acht Jahren* (upper-secondary school term of eight years)
GDP	Gross Domestic Product
GEM	Global Entrepreneurship Monitor
GG	*Grundgesetz* (German Basic Law)
GIZ	*Gesellschaft für Internationale Zusammenarbeit* (Germany‘s Federal Development Co-operation Agency, previously GTZ)
GRC	Göttingen Research Council
GWK	*Gemeinsame Wissenschaftskonferenz* (Joint Science Conference)
GWp	Gigawatt peak
HDI	Human Development Index
HGF	*Helmholtz-Gemeinschaft deutscher Forschungszentren* (Helmholtz Association of German Research Centres)
HIS	*Hochschul-Informationssystem* (Higher Education Information System)
HRK	*Hochschulrektorenkonferenz* (German Rectors‘ Conference)
IA	International Alignment
IAB	*Institut für Arbeitsmarkt- und Berufsforschung* (Institute for Employment Research)
i.e.	id est (that is)
IP	Intellectual Property
IRIC	Industrial Research and Innovation Council
ISO	International Organization for Standardization
IT	Information Technology
ITER	International Thermonuclear Experimental Reactor
JARA	Jülich-Aachen Research Alliance
KfW	*Kreditanstalt für Wiederaufbau* (KfW banking group)
KIT	Karlsruhe Institute of Technology
MINT	Mathematics, Informatics, Natural Sciences, Technology
MIP	Mannheim Innovation Panel
MOST	Ministry of Science and Technology (China)
MPG	*Max-Planck-Gesellschaft* (Max Planck Society)
MPI	*Max-Planck-Institut* (Max Planck Institute)
MSTI	Main Science and Technology Indicators
MUP	Mannheim Enterprise Panel
NBER	National Bureau of Economic Research (Cambridge, Massachusetts)
n.c.e.	not elsewhere classified
NDRC	National Development and Reform Commission (China)
NVCA	National Venture Capital Association (USA)
OECD	Organisation for Economic Co-operation and Development
p.a.	per annum (per year)
PCT	Patent Cooperation Treaty
PISA	Programme for International Student Assessment
RCA	Revealed Comparative Advantage
R&D	Research and Development
R&I	Research and Innovation
RWTH	*Rheinisch-Westfälische Technische Hochschule* (RWTH Aachen University)
RXA	Relative Export Advantage
SCI	Science Citation Index
SCSTE	Steering Committee of Science, Technology and Education

SERIS	Solar Energy Research Institute of Singapore
SIPO	State Intellectual Property Office
SMEs	Small and Medium-sized Enterprises
SOE	State-Owned Enterprises (China)
SR	Scientific Regard
SSCI	Social Science Citation Index
Tab.	Table
TU9	Germany’s leading institutes of technology: RWTH Aachen, TU Berlin, TU Braunschweig, TU Darmstadt, TU Dresden, Leibniz University Hanover, Karlsruhe Institute of Technology, TU Munich University of Stuttgart
VC	Venture Capital
VDMA	*Verband Deutscher Maschinen- und Anlagenbau* (German Engineering Federation)
WGL	*Wissenschaftsgemeinschaft Gottfried Wilhelm Leibniz* (Leibniz Association)
WoS	Web of Science
WTO	World Trade Organization
WZ 2008	Classification of Economic Activities, Edition 2008
ZEE	*Zentrum für Erneuerbare Energien* (Centre for Renewable Energy)
ZEW	*Zentrum für Europäische Wirtschaftsforschung* (Centre for European Economic Research)
ZIM	*Zentrales Innovationsprogramm Mittelstand* (Central Innovation Programme for SMEs), a funding proramme of the Federal Ministry of Economics and Technology

LIST OF ABBREVIATIONS OF NAMES OF COUNTRIES

AT	Austria
AU	Australia
BE	Belgium
BG	Bulgaria
BR	Brazil
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
LT	Lithuania
LU	Luxembourg
LV	Latvia
MT	Malta
MX	Mexico
NL	Netherlands
NO	Norway
NZ	New Zealand
PL	Poland
PT	Portugal
RO	Romania
SE	Sweden
SG	Singapore
SI	Slovenia
SK	Slovakia
TR	Turkey
TW	Taiwan
US	United States of America

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CLASSIFICATION OF ECONOMIC ACTIVITIES FOR R&D-INTENSIVE INDUSTRY AND KNOWLEDGE-INTENSIVE INDUSTRY SERVICES[395]

R&D-INTENSIVE INDUSTRIAL SECTORS WITHIN THE CLASSIFICATION OF ECONOMIC ACTIVITIES, EDITION 2008 (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 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

Barcelona target:
See three-percent target.

Basic funds:
Basic funds are a higher education institution’s budgetary funds including income from allocations and grants.

Biomass:
Biomass consists of material that is created by or bound within organisms. In energy technology, the term biomass is used when animal and plant products are used to generate heat and electricity, or used as fuels.

Bologna reform / Bologna process:
These are based on the Sorbonne Declaration of 1998, which entered into the EU’s Bologna Declaration 1999. The aim of the reform/process was to harmonise higher education and relevant qualifications by 2010. The central aspects include: achievement of comparable qualifications (two-stage system with Bachelor’s degree and Master’s degree), unified standards for evaluation (credits in keeping with the ECTS system), enhanced mobility via elimination of barriers to mobility, and European co-operation in the area of quality assurance.

Bottom-up processes:
A bottom-up process, for example in political or corporate organisation agreement processes, starts with specific, subordinate units and ends in general, superior units. A top-down process works in the opposite direction.

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

Citation rate:
The number of scientific publications in internationally renowned journals is an indicator of the research output of scientists, research institutes or countries, but it only provides a certain indication of quality. This is why the citation rate is also taken into account, as it is a means of measuring how well scientific articles are received. The citation rate provides information on how often scientific articles have been cited.

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

Convergence regions:
Convergence regions are regions with a gross domestic product per capita of less than 75 percent of the EU-25 average (EU-27 without Bulgaria and Romania). Germany’s convergence regions are the Lüneburg administrative region and the new federal states, excluding Berlin (cf. also “Structural funds”).

Co-operation ban:

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

C remuneration scheme:

The C remuneration scheme was the pay regulation for academic staff at German universities until 2004 and was replaced by pay grade W (see "W remuneration scheme") in 2005. Lecturers already in their posts before 2005 could choose to stay in the old system or transfer to the new one. Under pay grade C, basic salaries increase with length of service.

Cross-licencing:

Cross-licencing is an agreement between two contractual parties (mostly companies) for the mutual use of intellectual property rights, e.g. in the context of patent licencing.

Cutting-edge technology:

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

Demopass:

The "demopass" project carried out by Jacobs University Bremen examines five fields of action that are central to tackling the challenges posed by demographic change. The aim is to develop a demographic match-profile for organisations and thereby optimise how well employee attitudes and competencies, as well as job requirements and the management strategy actually fit.

Dual training:

The dual vocational training system is parallel training in an organisation and a vocational school or academy.

Early-stage financing:

Financing the early-stage development of a company includes the seed and the start-up phase. The seed phase includes development of the business idea, R&D, examining the marketing possibilities, development of a business plan, etc. This is followed by the start-up phase with the actual foundation of the company and the start of business activities.

Econometrics:

Econometrics is a central, empirical discipline in economic science. It uses statistical methods from mathematics to test economic models on the basis of statistical data and to make statistically secure statements about economic relationships.

Educational climber:
Students whose parents do not have an academic background.

Education voucher:
A voucher issued by the public sector to help meet the costs of an educational programme.

Ehegattensplitting (taxation of the total income of a married couple on the basis of equal halves):
A specific procedure at play in the German tax system whereby the income tax of a married couple is calculated by first applying the tax function to half the sum of the spouses' income and then doubling the resulting tax amount. A lower income received by one of the spouses (generally the woman) thereby helps to reduce the higher tax burden of the other spouse, while the spouse with the lower income will be taxed higher on his/her own income.

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.

Equity ratio:
Ratio of a company's equity capital to all of its capital. The ratio is used in assessing the financial stability and independence of companies.

EU-12 countries:
Countries that have joined the EU since 2004 (Bulgaria, Estonia, Latvia, Lithuania, Malta, Poland, Romania, Slovenia, Slovakia, the Czech Republic, Hungary and Cyprus).

EU-14 countries:
The EU-15 countries without Germany.

EU-15 countries:
Countries that were already EU member states in April 2004 (Belgium, Denmark, Germany, Finland, France, Greece, Great Britain, Italy, Ireland, Luxemburg, the Netherlands, Austria, Portugal, Sweden and Spain).

EU-27 countries / EU-27 states:
The EU today is made up of 27 member states (the EU-12 countries plus the EU-15 countries).

EU state aid framework:
In the Community Framework for State Aid for Research, Development and Innovation (in short, the EU state aid framework), which came into force on 1 January 2007, the European Commission sets out, among other things, the requirements under which research institutions are eligible to receive state aid and the conditions under which companies can be recipients of indirect state aid from state-funded research institutes.

Euratom Agreement:
The Euratom Agreement was signed by France, Italy, the Benelux countries and the Federal Republic of Germany on 25 March 1957 at the same time as the Treaty of Rome. It established the European Atomic Energy Community, or Euratom, which still exists virtually unchanged today. Euratom helps to consolidate knowledge and infrastructure in the area of atomic energy, and contributes to pooling financial resources that are required in the field.

Europe 2020 Initiative:

The core aim of the Europe 2020 Initiative is better co-ordination of national and European economic policy. It is the successor programme to the Lisbon strategy (a strategy that aimed to make Europe the world's most competitive and dynamic knowledge-based economic area by 2010) and adopts a more holistic approach in relation to R&D funding, lifelong learning and promoting environmentally friendly technologies.

Excellence Initiative:

An agreement between the Federal and state governments to promote science and research at German higher education institutions and thereby improve international competitiveness. Initiatives are implemented by the German Research Foundation (DFG) and the German Council of Science and Humanities (WR).

Federalism Reform I:

The Federalism Reform I, which came into force in September 2006, reorganised relations between the Federal Government and federal states as regards the balance of legislative power at national and state levels, as well as in relation to the states' responsibilities and participation rights in national government legislation. The aim was to reduce the number of laws that needed 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 Government and states.

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 first Frascati Manual. Since then, the Frascati Manual has been revised several times. The most recent edition dates from 2002 (OECD 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 to manage their financial resources as well as greater freedom in the areas of personnel, co-operation, construction and awarding.

Full-time equivalent:

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

Geothermal energy:

Geothermal energy uses thermal energy created and stored in the earth's interior as an energy source, e.g. for heating purposes or electricity generation. Geothermal plants are best located in areas offering particularly advantageous geological conditions, namely high temperatures in shallow depths.

Global budget:

Global budgets are paid to higher education institutions as total appropriations. Higher education institutions enjoy a large degree of autonomous control over use of these appropriations.

Global Entrepreneurship Monitor (GEM):

The GEM is an empirical research project that is now being carried out in a total of 54 countries. It is co-ordinated by the Global Entrepreneurship Research Association (GERA). The aim of the GEM is to analyse start-up activity, internationally and intertemporally, on the basis of surveys of the public and of experts. In addition, it serves as a vehicle for deriving proposals for optimising policies for promoting and funding start-ups.

Governance:

Governance refers to the control and regulation achieved via relevant structures (structure and process organisation) of a political and societal unit, such as a state, an administration, a municipality, or a private or public organisation. The term is often used to refer to the control or regulation of any sort of organisation (such as a company or a plant).

Hidden labour reserve:

Cf. “Labour potential”.

High-value technology:

High-value technology refers to R&D-intensive goods whose production, on an annual average, requires more than 2.5 percent, but not more than 7 percent, of relevant revenue to be spent on R&D.

Horizontal permeability of the education and training system:

Change from e.g. vocational to general training at the same academic level – or vice versa (cf. also “Vertical permeability of the education and training system”).

Innovation intensity:

Innovation expenditure in relation to revenue.

Joint venture:

Specific form of corporate co-operation involving the creation of a legally independent business unit in which partners invest their own capital and generally bring in the largest share of resources in terms of technology, property rights and technical know-how. The partner companies bear the financial risk of the investment jointly and perform management functions in the joint company.

Labour potential:

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

Leapfrogging:

Term for a supplier’s conscious decision, when developing products, to “jump over” one generation and focus development efforts on future products. Leapfrogging can help suppliers bring a new product onto the market before competitors and assume the role of market pioneer.

Oslo Manual:

The OECD’s Oslo Manual contains specifications for statistically documenting innovation activities. The Oslo Manual moves beyond the R&D concept used by the Frascati Manual (see “Frascati Manual”) as it differentiates between different types of innovation. The Oslo Manual serves as the basis of the Community Innovation Surveys, which have been carried out seven times to date in Europe. The most recent revision of the Manual dates from 2005 (OECD 2005).

Patent-box regulations:
Patent-box regulations, such as those introduced in, for example, 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 intangible assets, such as patents.

Patent family:
A patent family is a group of patent applications and patents granted that are linked together, either directly or indirectly, by a common priority.

Patent thicket:
A patent thicket is a close-meshed network made up of partly overlapping property rights. Patent thickets arise e.g. out of high patenting activity in product areas that have a complex, systemic technological basis. Through the creation of such patent thickets, companies try to develop strong shields for their own technologies and products. For the network developer, this strategy represents effective protection for technological innovations. It is difficult for competitors to battle their way through such patent thickets in order to commercialise their own technologies and products.

PCT application:
The international patent application process was simplified in 1970 with the agreement of the Patent Cooperation Treaty (PCT) under the umbrella of the World Intellectual Property Organization (WIPO), the latter being established in 1969. Inventors from PCT states can submit prior notification of an application to the WIPO, followed by a patent application in the respective treaty country within one year. The priority date is the date the application is submitted to the WIPO.

Portfolio companies:
Portfolio companies are enterprises that receive equity from an investment company (cf. “Venture capital”).

Priority application:
A priority application refers to the first national or international patent application submitted for a particular invention. The date of filing can be used by another patent office within a year. In such a case, the filing date of the first application is regarded as the priority date.

Public-private partnership:
A form of co-operation between public administration and private companies in which the state performs its duties in partnership with the private sector or transfers entire tasks to the latter. Companies benefit from the public administration’s contacts and experience in the respective area, and naturally from the awarding of the contract itself and potential investment opportunities, while public administration can implement particular projects only with financial support from the private sector.

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.

R&D-intensive goods:
R&D intensive goods are made up of cutting-edge technology goods (cf. “Cutting-edge technology”) and high-value technology goods (cf. “High-value technology”).

Recognition Act:

The law to improve the assessment and recognition of foreign professional qualifications (Recognition Act) comes into force on 1 April 2012 to simplify recognition of foreign qualifications.

Renewable Energy Sources Act:

The Renewable Energy Sources Act – in effect the law establishing the priority of renewable energy – came into force in 2000. It regulates the preferred feed-in of electricity from renewable sources into the grid and guarantees electricity producers fixed minimum selling prices for 20 years. The minimum selling prices are adjusted regularly according to the market prices of the relevant energy conversion plant. The additional costs for electricity caused by this law are passed on to consumers.

Research and development (R&D):

The OECD's Frascati Manual defines research and development (R&D) as systematic, creative work aimed at increasing the stock of knowledge – also with the aim of developing new applications.

Research and Innovation (R&I):

Research and development (R&D) and R&I are not used synonymously. According to the OECD's Frascati Manual (cf. "Frascati Manual"), the term R&D comprises the three areas of basic research, applied research, and experimental development, and only forms part of R&I activities. According to the definition in the OECD's Oslo Manual (cf. "Oslo Manual"), innovations include the introduction of new or essentially improved products (goods and services), processes, and marketing and organisation methods. Innovation expenditure covers spending on internal and external R&D, machines and materials for innovations, product design, the market launch of new products and other innovation-related goods and services.

Secondary market:

The secondary market refers to trading in securities or other financial instruments subsequent to the initial public offering.

Spillover effects:

Spillover effects occur in R&I in the form of knowledge transfer, e.g. if a company is in a position to reap economic yields from the R&D activities of another company.

Structural funds:

Alongside cohesion funds, the European Union's structural funds, i.e. the European Regional Development Fund (ERDF) and the European Social Fund (ESF), are central steering instruments in European regional policy. Their main aim is to promote convergence, competitiveness and the employment situation in structurally weak regions, as well as cross-regional partnership working (cf. "Convergence regions").

Subject structure rate:

The subject structure rate gives the proportion of first-degree graduates who have completed their course of studies within a particular department or area of study.

Tenure track:

Tenure tracks are scientific careers that hold out the prospect of permanent positions for young scientists following successful evaluation.

Third-party funding:

Third-party funds are financial resources for higher education institutions and other research bodies that are acquired in addition to the regular budget (basic funding). Third-party funding is obtained from public or private entities.

Three-percent target:

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

Tokamaks and Stellarators:

Two different concepts for fusion reactors. A Tokamak device is currently being assembled as part of the international fusion reactor ITER. The main disadvantage of the Tokamak concept is that it can only operate with short interruptions rather than continuously. Stellarator fusion technologies have been developed in recent years as a prospective alternative to Tokamak, as such technologies can, in principle, operate continuously. The first experimental Stellarator device in Germany, Wendelstein 7-AS, went into operation in Greifswald in 1988. Work is currently underway on Stellarator 7-X, which is expected to start operating in 2014.

Transnational patents:

Inventions that, at the same time, are the subject of at least one application via the PCT process of the World Intellectual Property Organization (WIPO) or an application to the European Patent Office (EPA). Such patents are particularly important for the export-based German economy, as they concern the protection of inventions outside the domestic market.

Triad countries:

At the time the term was first used 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 industrialised East Asian countries (Japan, Taiwan, Korea, Hong Kong and Singapore).

University council:

A body made up of external members and university representatives. It has an advisory or controlling function or takes particular administrative decisions.

Venture capital:

Venture or risk capital is capital provided as initial capital for start-ups and young enterprises. It includes funding used to strengthen the equity capital bases of small and medium-sized enterprises, to enable such companies to expand and carry out 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 risk-capital companies (capital investment companies). Venture capital investments can be divided into the seed phase, the start-up phase, and the later stage.

Vertical permeability of the education and training system:

Move upwards from one level of the education and training system into a higher level (cf. also "Horizontal permeability of the education and training system").

W remuneration scheme:

The W remuneration scheme replaced the C remuneration scheme in 2005 (see “C remuneration scheme”). Remuneration for professors on pay grade W is made up of a basic salary, independent of age, and variable bonus payments.

RECENT STUDIES RELATING TO THE GERMAN INNOVATION SYSTEM

The Commission of Experts for Research and Innovation (EFI) regularly commissions studies on topics that are relevant in terms of innovation policy. All studies can be accessed via the EFI website (www.e-fi.de). The findings of these studies have been integrated into the EFI Annual Report 2012.

1-2012	Leszczensky, M.; Cordes, A. (2012): Bildung und Qualifikation als Grundlage der technologischen Leistungsfähigkeit Deutschlands, Studien zum deutschen Innovationssystem, Berlin: EFI.
2-2012	Heine, C. (2012): Übergang vom Bachelor- zum Masterstudium, Studien zum deutschen Innovationssystem, Berlin: EFI.
3-2012	Cordes, A. (2012): Projektionen von Arbeitsangebot und -nachfrage nach Qualifikation und Beruf im Vergleich, Studien zum deutschen Innovationssystem, Berlin: EFI.
4-2012	Schasse, U.; Kladroba A.; Stenke, G. (2012): Forschungs- und Entwicklungsaktivitäten der deutschen Wirtschaft, Studien zum deutschen Innovationssystem, Berlin: EFI.
5-2012	Belitz, H. (2012): Internationalisierung von Forschung und Entwicklung in multinationalen Unternehmen, Studien zum deutschen Innovationssystem, Berlin: EFI.
6-2012	Rammer, C.; Köhler, C. (2012): Innovationsverhalten der Unternehmen in Deutschland 2010, Aktuelle Entwicklungen – Innovationsausgaben und andere Investitionen, Studien zum deutschen Innovationssystem, Berlin: EFI.
7-2012	Müller, B.; Rammer, C.; Gottschalk, S. (2012): Unternehmensdynamik in der Wissenswirtschaft in Deutschland 2010, Gründungen und Schließungen von Unternehmen – Internationaler Vergleich, Studien zum deutschen Innovationssystem, Berlin: EFI.
8-2012	Frietsch, R.; Neuhäusler, P.; Rothengatter, O. (2012): Patent Applications – Structures, Trends and Recent Developments, Studien zum deutschen Innovationssystem, Berlin: EFI.
9-2012	Schmoch, U.; Michels, C.; Neuhäusler, P.; Schulze, N. (2012): Performance and Structures of the German Science System 2011, Germany in international comparison, China's profile, behaviour of German authors, comparison of Web of Science and SCOPUS, Studien zum deutschen Innovationssystem, Berlin: EFI.
10-2012	Cordes, A.; Gehrke, B. (2012): Strukturwandel und Qualifikationsnachfrage – Aktuelle Entwicklungen forschungs- und wissensintensiver Wirtschaftszweige in Deutschland und im internationalen Vergleich, Studien zum deutschen Innovationssystem, Berlin: EFI.
11-2012	Gehrke, B.; Krawczyk, O. (2012): Außenhandel mit forschungsintensiven Waren im internationalen Vergleich, Studien zum deutschen Innovationssystem, Berlin: EFI.
12-2012	Belitz, H.; Gornig, M.; Mölders, F.; Schiersch, A. (2012): FuE-intensive Industrien und wissensintensive Dienstleistungen im internationalen Wettbewerb, Studien zum deutschen Innovationssystem, Berlin: EFI.
13-2012	Cuntz, A.; Dauchert, H.; Meurer, P.; Philipps, A. (2012): Hochschulpatente zehn Jahre nach Abschaffung des Hochschullehrerprivilegs, Studien zum deutschen Innovationssystem, Berlin: EFI.
14-2012	Egeln, J.; Fryges, H.; Höwer, D.; Müller, B.; Müller, K. (2012): Wachstumsbedingungen bzw. Wachstumshemmnisse für junge Unternehmen, Studien zum deutschen Innovationssystem, Berlin: EFI.
15-2012	Peters, B.; Hud, M; Köhler, C.; Licht, G. (2012): Ökonomische Bewertung von staatlichen Investitionen in Forschung und Innovation, Studien zum deutschen Innovationssystem, Berlin: EFI.

16-2012 Fraunhofer-Institut für System- und Innovationsforschung, Joanneum Research ForschungsgmbH, Stifterverband Wissenschaftsstatistik gGmbH, Wissenschaftszentrum Berlin gGmbH, Zentrum für Europäische Wirtschaftsforschung GmbH (2012): Zur Situation der Forschung an Deutschlands Hochschulen – Aktuelle empirische Befunde, Studien zum deutschen Innovationssystem, Berlin: EFI.

17-2012 Kosmützky, A.; Kretek, P. (2012): Forschung an Hochschulen, Literaturstudie, Studien zum deutschen Innovationssystem, Berlin: EFI.

ENDNOTES

1 In March 2000, the European Council formulated the objective "to become the most competitive and dynamic knowledge-based economic region in the world capable of sustainable economic growth with more and better jobs and greater social cohesion" (cf. http://www.europarl.europa.eu/summits/lis1_en.htm, last accessed on 16 January 2012). Based on this, the European Council decided two years later in Barcelona to raise R&D expenditures within the EU to three percent of the gross domestic product by 2010 (cf. Commission of the European Communities 2002).

2 Cf. Stifterverband für die Deutsche Wissenschaft (2011: 5-7).

3 The average R&D intensity of these countries weighted according to GDP amounts to 3.45 percent (Sweden [2009: 3.62], Finland [2009: 3.96], South Korea [2008: 3.36], Switzerland [2008: 3.00] and Japan [2009: 3.33]). Cf. OECD (2011a).

4 The Federal and *Länder* governments have agreed on a comprehensive national target according to which investments in education and research shall be raised to 10 percent of GDP by 2015. Within the framework of this ten-percent target, 3 percent of GDP shall be allocated to research and development, and 7 percent to education. Cf. BMWi (2011a: 9).

5 In spite of the successes of the German economy in the field of high-value technologies, the Expert Commission has repeatedly pointed to the risks associated with this specialisation pattern. On average, industries relating to cutting-edge technologies display a significantly higher growth than industries relating to high-value technologies. In addition to that, long-term analytical studies demonstrate that other countries are getting more and more competitive in the German domain of high-value technologies. This development is already evident in a gradual decline in the external trade balance for high-value technologies. Cf. EFI (2008: 19 f.).

6 This has been confirmed by numerous scientific studies, e.g. Edwards and Lawrence (2010).

7 Over the last few years, the Expert Commission has been making use of a classification system that divides sectors (and companies) into three different groups. These groups are: cutting-edge technologies, high-value technologies, and one additional group consisting of the non-research-intensive industries. Since 1995, Germany's position within the group of cutting-edge technologies has improved significantly. Value added in cutting-edge technology sectors grew relatively faster than in other sectors of the economy and than in other highly developed economies. In the course of a relatively swift economic structural change, the relevance of these sectors has also increased significantly. Cf. Rammer (2011: 20).

8 When applying the Gini coefficient as an index for measuring income heterogeneity between US states, the value remained steadily between 0.10 and 0.11 throughout the last 15 years. Within the same period, the Gini coefficient for the EU-27 countries amounted to three times the value of the US coefficient and slightly decreased from 0.37 to 0.35. Cf. epp.eurostat.ec.europa.eu/portal/page/portal/national_accounts/introduction (last accessed on 16 January 2012) and www.bea.gov/regional/index.htm (last accessed on 16 January 2012); own calculations.

9 Labour productivity (GDP/hour worked) based on van Ark et al. (2008), as well as Inklaar and Timmer (2008).

10 Available funding (at 2005 prices) from the Structural Funds of 1994 to 2013. Source: European Commission (2008a). Recent studies on the impact of EU funding have come to differing conclusions: while Becker et al. (2010) observe a small positive effect on the GDP growth of the receiving countries, Checherita et al. (2009) cannot detect a significant impact when controlling for the factor of institutional framework conditions.

11 Cf. endnote 8.

12 Data according to Eurostat expenditure on research and development (2010, in percent of GDP).

13 OECD (2011b: Tables 8, 10, 65-68).

14 Yet, the proportion of R&D investments allocated by the public sector is below 5 percent in Denmark and Sweden, between approximately 10 and 15 percent in Central Europe and more than 15 percent in Spain, Greece and the new member states. Source: OECD (2011b: Tables 14, 19).

15 OECD (2011b: Table 64).

16 Gorodnichenko and Schnitzer (2012).

17 Academic Advisory Board at the Federal Ministry of Economics and Technology (2011).

18 The German Council of Economic Experts (2011).

19 Transparency International (2011).

20 World Bank (2010).

21 The survey on technological capacity differentiates between cutting-edge technology goods (R&D share of revenue above 7 percent) and high-value technology goods (R&D share between 2.5 and 7 percent), see Gehrke et al. (2010) as well as the list of industries of R&D-intensive industries and knowledge-intensive commercial services in the Appendix. Germany is becoming more and more successful in the field of high-value technology goods. Yet, when it comes to cutting-edge technologies, major competitive issues can be detected in important areas such as information and communication technology and telecommunications.

22 More recently, the governments of many countries have been focussing on cutting-edge technologies. The 2007 global ranking of the ten leading producers of cutting-edge technology goods featured four emerging countries (China, Korea, Taiwan and Brazil). In addition to the countries mentioned above, the top 25 list of production locations for this class of goods comprised six other aspiring economies, all of which recorded double-digit growth rates each year. These are: Singapore (13th place), Mexico (16th place), Russia (19th place), Malaysia (20th place), India (21st place), and Turkey (25th place). Cf. National Science Foundation (2010).

23 A more recent study by Deutsche Bank Research (2011) points out that “Germany excels in mid-level technology, but is only average in cutting-edge technologies.” Cf. also Gehrke and Krawczyk (2012).

24 Cf. Belitz (2012) and OECD (2011b).

25 In 2005, the relocation of foreign companies’ R&D activities to emerging markets was a key topic of the UNCTAD World Investment Report (2005). Since then, the importance of these aspiring economies as a location for R&D subsidiaries of multinational enterprises has increased continuously.

26 Cf. Belitz (2012: 3).

27 Between 2001 and 2009, the number of R&D personnel of foreign enterprises has been increased by 11,800 to a total of 85,000 (full-time equivalents). In the pharmaceutical industry, 44 percent of R&D staff is attributable to foreign enterprises; in the field of other transport equipment this number even amounts to 81 percent.

28 By far the majority of R&D expenditures in other transport equipment are allotted to air and spacecraft manufacturing, a sector that is largely shaped by EADS – a company that has its registered head office in the Netherlands and key management structures in France.

29 Cf. Kinkel and Maloca (2008).

30 This temporary reduction in foreign R&D expenditures was not only caused by additional management efforts abroad and major co-ordinative issues, but also by a fear of know-how losses and a potential deterioration in quality.

31 Cf. Belitz (2012).

32 Cf. Belitz (2012).

33 Cf. Belitz (2012)

34 Cf. OECD (2010), and, more recently, the French Industrial Association’s analytical study on comparative advantages, with a special focus on tax incentives for R&D.

35 See EFI (2011: Chapter A6).

36 D’Agostino et al. (2010), Ali-Yrkkö and Deschryvere (2008). There is more comprehensive evidence for the migration of jobs and capital investment as a result of international direct

investment. Findings differ however; cf. Muendler and Becker (2010), Desai et al. (2009), Harrison and McMillan (2006), Arndt et al. (2010). Still, an analogy of results regarding R&D activities does not necessarily hold true since Germany, apart from its unfavourable fiscal environment, is generally attractive as an R&D location for foreign enterprises. Hence, it is highly likely that in the course of this international reallocation process Germany will continue to attract further R&D from abroad.

37 Bandick et al. (2010), García-Vega et al. (2011).

38 Lychagin et al. (2010).

39 Griffith et al. (2006) demonstrate that companies from Great Britain particularly benefit from spillover effects if they implement their R&D activities in geographical proximity to US companies.

40 Cf. Håkanson (2004), Gerybadze (2004, 2005) and Ambos (2005).

41 The newly established German-Chinese platforms in the area of innovation research and life sciences may serve as examples for this. Corresponding binational platforms have also been established with other countries such as the United States.

42 Cf. German Bundestag (*Deutscher Bundestag* 2011a).

43 Thus, in the context of EU burden sharing in accordance with the Kyoto protocol, the Federal Government has given a commitment to reduce their production of greenhouse gases between 2008 and 2012 by a total of 21 percent compared with 1990. In addition to that, greenhouse gas emissions are supposed to be reduced by 40 percent by 2020 compared with 1990. Cf. http://www.bmu.de/english/climate/general_information/doc/4311.php (last accessed on 16 January 2012).

44 Given the limited time available, it was not possible for the Expert Commission to provide an extensive account of the situation in the higher education sector and the industrial sector.

45 The statements on the position of the Fraunhofer-Gesellschaft (FhG) are based on a written submission by the FhG from 27 October 2011.

46 Another member of the Fraunhofer Energy Alliance is the Fraunhofer Center for Sustainable Energy Systems CSE, which is located in the United States, cf. http://www.energie.fraunhofer.de/fraunhofer-energy-alliance/member (last accessed on 16 January 2012)

47 The newly established Helmholtz Energy Initiatives are divided into (a) portfolio themes: mobile/stationary energy storage systems, in-system electrochemical storage, sustainable bio economy, gas separation membranes for zero-emission fossil power plants, materials research for future energy supply, and environmentally friendly geo energy; (b) the launch of Helmholtz institutes on "Resources and Resources Research" and "Energy Storage Techniques"; (c) the launch of the Helmholtz Alliance "Future Infrastructures of Energy Supply"; (d) the launch of the Helmholtz Energy Initiative "Swift Expansion of Energy Research". The Helmholtz strategy is based on close collaboration between the Helmholtz centres and between Helmholtz centres and university partners.

48 The statements on the position of the Helmholtz Association (HGF) are based on a written submission by the HGF from 19 December 2011.

49 The statements on the position of the Max Planck Society (MPG) are based on a written submission by the MPG from 28 December 2011.

50 Being an associated member of the Helmholtz Association (HGF), the Max-Planck-Institut für Plasmaphysik (IPP) with locations in Garching and Greifswald receives its basic funding solely from HGF.

51 The statements on the position of the Leibniz Association (WGL) are based on a written submission by the WGL from 30 November 2011.

52 According to the International Energy Agency (IEA)'s Fusion Power Position Paper 2006, it is estimated that the first fusion demonstration plant will go on the grid "in some 30 years". Cf. http://www.iea.org/techno/technologies/fusion/fusion.pdf (last accessed on 16 January 2012).

53 One way of treating vast amounts of high-level radioactive waste consists in "partitioning and transmutation": after long-lived radionuclides have been effectively separated from the high-level radioactive waste, the remaining substances are subsequently transformed ("transmuted") into long-lived nuclides.

54 Cf. BMWi (2011b).

55 Furthermore, it is essential to provide reasonable framework conditions for investments in renewable energy. At this stage, the established energy providers are still very reluctant when investing in this sector. Stimulus for such investments could increasingly come from private equity funds.

56 Cf. Commission of Experts for Research and Innovation (EFI) (2011: 60).

57 No more than half a page of the 6th Energy Research Programme deals with issues concerning fusion research, cf. BMWi (2011b: 120).

58 Research does not however constitute a necessary condition for the emergence of innovations, cf. EFI (2011: Chapter B4). Yet, especially non-technical disciplines in the tertiary education sector can contribute significantly to gaining constructive and critical knowledge in the use of innovative products, services and business models. The recent discussion regarding data protection and the openness of the Internet may serve as an example for this.

59 The Expert Commission shall analyse the important field of academic medicine in one of the next annual reports.

60 The Expert Commission had commissioned a detailed study on key issues relating to academic research so as to base its analysis on current empirical findings. Cf. Brandt et al. (2012) and Berger et al. (2012a and 2012b). This study comprised two surveys: a survey of heads of universities (rectors, vice chancellors, presidents and vice presidents), and a comprehensive survey of professors.

61 The Expert Commission deliberately uses a broad definition of knowledge and technology transfer (cf. EFI 2008). "Knowledge transfer" as used in this report corresponds to what the DFG nowadays refers to as "transfer of findings".

62 These are public institutes, including mostly state-funded not-for-profit scientific facilities as well as private not-for-profit organisations. Cf. Kladroba (2011).

63 The aim of the Federalism Reform was to eliminate excessive links between Federal and *Länder* levels. The proposed legislation of the states of North Rhine-Westphalia, Bavaria, Berlin and Bremen states the following: "The distinct consent powers of the *Länder* via the Federal Council have repeatedly led to cases where important federal legislative initiatives have been delayed, or even prevented, due to differing political majorities between the Federal Government and the *Länder* governments. Furthermore, this has led to compromises that are incoherent as such and barely, or not at all, reflect the respective political responsibilities. Over time, the proportion of laws requiring the consent of the *Bundesrat* has increased significantly, especially due to federal regulations concerning the organisation and procedures of the *Länder* administrations. At the same time, the federal states' legislative powers have been curtailed further and further." Federal Council (Bundesrat 2006: 17).

64 In the following, cf. http://www.hrk.de/de/brennpunkte/110.php (last accessed on 16 January 2012).

65 Cf. http://lexetius.com/GG/91a#2; http://dejure.org/gesetze/GG/91a.html and http://www.bgbl.de/Xaver/start.xav?startbk=Bundesanzeiger_BGBl (last accessed on 16 January 2012).

66 Cf. http://lexetius.com/GG/91b#2 and http://dejure.org/gesetze/GG/91b.html (last accessed on 16 January 2012).

67 The basis for this was laid down with the revision of Article 91a and 91b of the Basic Law of 12 May 1969. In Article 91a, the "expansion and construction of research universities, including university clinics" was now declared a joint task of the Federal and the *Länder* governments. Furthermore, Article 91b was newly added: "In instances of transregional importance, the Federal and *Länder* governments may co-operate, on the basis of agreements, in education planning and the promotion of facilities and ventures of scientific research. The sharing of costs shall be specified in the agreement." The latter regulation established almost equal terms and development opportunities for higher education institutions and non-university research institutions – at least in terms of the federal order and financing patterns between Federal and *Länder* governments.

68 Article 91b, Paragraph 1 as revised in 2006 states: "In instances of transregional importance, the Federal Government and *Länder* governments may co-operate, on the basis of agreements in promoting: 1. facilities and ventures in scientific research outside of the higher education sector; 2. science and research ventures in the higher education sector; 3. research buildings at higher education

institutions, including large-scale equipment. Agreements according to Clause 1, No. 2 require the consent of all *Länder*."

69 Cf. EFI (2011: Chapter B 1).

70 Cf. German Council of Science and Humanities (Wissenschaftsrat 2011a and 2011b), Handelsblatt (2011) as well as Strohschneider (2011).

71 In this regard and in the following, cf. http://www.kmk.org/wissenschaft-hochschule/internationale-hochschulangelegenheiten/bologna-prozess.html (last accessed on 16 January 2012).

72 Cf. BFUG (no year).

73 Cf. http://www.kmk.org/bildung-schule/allgemeine-bildung/sekundarstufe-ii-gymnasiale-oberstufe.html (last accessed on 16 January 2012).

74 Cf. German Bundestag (*Deutscher Bundestag* 2001a).

75 Cf. Schmoch (2007).

76 Cf. Astor et al. (2010).

77 In this regard, cf. Preamble of the Federal-*Länder* Agreement in accordance with Article 91b of the Basic Law (research funding) on the Excellence Initiative by the German federal and state governments to promote top-level research at German universities, http://www.wissenschaftsrat.de/download/Exzellenziniative_Dokumente/BLK-ExIni.pdf (last accessed on 16 January 2012) and in the following, cf. http://www.dfg.de/en/research_funding/programmes/excellence_initiative/index.html (last accessed on 16 January 2012), DFG (2011) as well as http://www.bmbf.de/pubRD/exzellenzvereinbarung_zwei.pdf (last accessed on 16 January 2012).

78 Cf. Schmidtmann (2010) as well as DFG (2011). The distinction between graduate schools and research training groups is as follows: "A graduate school shall support the development of a location's focus by promoting young scientists, thereby creating scientific and structural value added for the university and the subjects involved. Thus in terms of its size and thematic scope, the respective strategies of the university are the guiding principles. There are no strict specifications regarding the size and structure, e.g. in terms of researchers, institutes, or post-graduate students involved. As opposed to this, research training groups pursue a specific research programme, while the number of scientists involved is limited." (http://www.dfg.de/foerderung/faq/grako_faq/index.html (last accessed on 16 January 2012).

79 Cf. Wehrberger (2010), DFG (2011), as well as http://www.dfg.de/en/research_funding/programmes/excellence_initiative/clusters_excellence/index.html (last accessed on 16 January 2012).

80 Cf. DFG (2011), as well as http://www.dfg.de/en/research_funding/programmes/excellence_initiative/institutional_strategies/index.html (last accessed on 16 January 2012).

81 One-year bridge financing was granted to projects from the first round of the first programme phase, the funding period of which expired in October 2011.

82 Cf. European Commission (2006), as well as Meurer and Schulze (2010).

83 In the following, cf. http://www.gwk-bonn.de/index.php?id=192 (last accessed on 16 January 2012), GWK (2011a) and http://www.bmbf.de/en/6142.php (last accessed on 16 January 2012).

84 Cf. GWK (2011a).

85 In the following, cf. http://www.gwk-bonn.de/index.php?id=269 ((last accessed on 16 January 2012).

86 In this regard, and regarding the objectives of the programme, cf. http://www.gwk-bonn.de/fileadmin/Papers/Programm-Lehrqualitaet-Vereinbarung-2010.pdf (last accessed on 16 January 2012), http://www.gwk-bonn.de/fileadmin/Papers/Programm-Lehrqualitaet-Vereinbarung-2010.pdf (last accessed on 16 January 2012) and http://www.bmbf.de/de/15375.php (last accessed on 16 January 2012).

87 The Leuphana University of Lüneburg follows Anglo-Saxon examples of college education. Students from the Bachelor curriculum can choose between nine major subjects, which can then be combined with any of 16 minor subjects. Irrespective of the particular subject combination, students from all disciplines study together throughout the first semester of undergraduate coursework. During this first semester, students attend courses in four thematically related teaching modules.

These modules are: “Science makes History”, “Science uses Methods”, “Science has its Disciplinary Boundaries” and “Science carries Responsibility”. The semester concludes with competitions and a conference organised by students (cf. http://www.leuphana.de/college/bachelor.html, last accessed on 16 January 2012).

88 Federal Statistical Office (*Statistisches Bundesamt*, 2011a).

89 Cf. Brandt et al. (2012).

90 Cf. Berger et al. (2012a) and Berger et al. (2012b).

91 Cf. Brandt et al. (2012).

92 Cf. Polt et al. (2010).

93 Cf. Brandt et al. (2012); Berger et al. (2012a and b); Polt et al. (2010).

94 These revenues are primarily derived from health insurance payments and other payments for providing medical services at university hospitals.

95 In the documentation of staff financed by the Higher Education Pact, a difference is made between the teaching programme line and the programme allowances. Staff that is financed by funds from the Higher Education Pact’s teaching programme line is recorded separately and reported as personnel financed by basic funds. Staff that is funded through the Higher Education Pact’s programme allowances is recorded as personnel financed through DFG funds and is reported as third-party-funded staff (information from the Federal Statistical Office).

96 Source: Federal Statistical Office (Statistisches Bundesamt); own calculations.

97 Source: Federal Statistical Office (Statistisches Bundesamt); own calculations.

98 With regard to DFG funding programmes, the Expert Commission has analysed how funding quotas have changed over time. The funding rate for new applications in individual funding is subject to irregular fluctuations; a particular trend cannot be observed. The same applies to the recommendation rate for special research areas (figures from DFG).

99 Suitable amendments to the German foundation law could significantly increase incentives for foundation funding at German universities. Such amendments include e.g. improved options for reinvestment of the foundations’ endowments in higher education and improved tax deductibility for endowments. Especially with regard to the establishment of “Endowed Chairs” (cf. United States), Germany’s charity law and laws on charitable contributions should be revised in such a way that would increase the maximum deductible amount for donations to foundations’ assets that are aimed at financing endowed professorships. This increase would have to be substantial enough to allow for using the proceeds to cover the maintenance of the chair (cf. Frank et al. 2007 and 2009).

100 This graphical representation does not consider universities of applied sciences *(Fachhochschulen)*, as the potential for measurement errors in recording R&D expenditures of universites of applied sciences is particularly high.

101 In contrast to a comparable figure in the study by Polt et al. (2010: 57), the basis for calculating patent and publication intensity does not comprise the research organisations’ entire personnel, but only academic staff (excluding staff in humanities and social sciences). Furthermore, this figure draws on more recent demarcations of science organisations and different data sources.

102 When measuring publication intensity, only publications in specific journals are being taken into account. Thus academic publishing in engineering disciplines is not fully represented in the SCI. In particular, the publication intensity of the Fraunhofer institutes and the universities tends to be underestimated. While the humanities are excluded from the figure, they still make an important contribution to the knowledge transfer of universities. Patents, on the other hand, are issued for providing solutions to technical problems; hence they have only very limited relevance as performance indicators for basic research and non-technical and non-scientific research.

103 Cf. e.g. https://www.lbf.fraunhofer.de/tud-szm (last accessed on 16 January 2012).

104 E.g. the Lead Discovery Center (LDC), http://www.lead-discovery.de/ (last accessed on 16 January 2012).

105 OECD (2011a: 42).

106 Both rankings are based on the calculation of an overall indicator that merges and weighs several individual indicators. Cf. http://www.timeshighereducation.co.uk/world-university-rankings/2011-2012/top-400.html (last accessed on 16 January 2012) and http://www.shanghairanking.com/ARWU2011.html (last accessed on 16 January 2012). A change in the weighting may have a strong impact on an institution's position in the ranking.

107 Cf. Berger et al (2012b).

108 The expert committee *Aktionsrat Bildung* (2010) analysed the regulatory areas of financial management, human resources and appointments, construction and property management, and the collaboration between state and university regarding teaching and learning in the individual federal states. The highest degree of autonomy was found in North Rhine-Westphalia and Saarland.

109 Cf. Hüther (2010 and 2011).

110 In this regard and in the following, cf. Brandt et al. (2012).

111 Cf. Brandt et al. (2012).

112 Cf. Brandt et al. (2012).

113 Cf. Brandt et al. (2012: Chapter 3.2).

114 Cf. Brandt et al. (2012).

115 Cf. Brandt et al. (2012).

116 Cf. Brandt et al. (2012).

117 Cf. Brandt et al. (2012).

118 Cf. Brandt et al. (2012).

119 In this regard, cf. the qualitative survey "Heads of Universities" (Brandt et al. 2012).

120 In this regard, cf. the quantitative survey "Heads of Universities" (Berger et al. 2012a).

121 In the following, cf. http://www.zee.uni-freiburg.de/ (last accessed on 16 January 2012), http://www.zee-uni-freiburg.de/index.php?id=17 (last accessed on 16 January 2012), http://www.zee-uni-freiburg.de/index.php?id=13 (last accessed on 16 January 2012) and http://www.zee-uni-freiburg.de/index.php?id=14 (last accessed on 16 January 2012).

122 Interdisciplinarity still primarily means that representatives of different disciplines co-operate with each other and initiate e.g. joint research projects. It does not refer to the establishment of interdisciplinary professorships. Cf. Brandt et al. (2012)

123 Cf. Wirth (2011: 112).

124 One example for this is the "50-40-10 process" at the Ludwig Maximilians University Munich: in 2008, the university management initiated a process in the course of which, by 2016, about 50 percent of vacant chairs shall be filled according to their current policy, and 40 percent according to the new approach. Additionally, 10 percent of resources will be allocated to follow-up financing of projects for the continuation of which the university had committed itself as part of the Excellence Initiative. Cf. http://www.en.uni-muenchen.de/about_lmu/research/research_profile/strategy/index.html (last accessed on 16 January 2012).

125 Thus Saxony's Higher Education Act provides that the rector of a university can initiate the associate appointment of a professor "who has proven to have a sustainable impact in his/her field of study", in order to "build, renew or sustainably strengthen a profile-building area of the university" (§ 61 Paragraph 1, SächsHG). Prerequisites for this are a hearing with the senate and the faculty council, as well as the consent of the university council. Cf. http://www.smwk.sachsen.de/download/Hochschulgesetz(3).pdf (last accessed on 16 January 2012).

126 On the amount of the fixed basic salary, differentiated by region, cf. http://www.hochschulverband.de/cms1/fileadmin/redaktion/download/pdf/besoldungstabellen/Tabelle_-_Grundgehaelter_W.pdf (last accessed on 16 January 2012).

127 Cf. http://www.lbv.nrw.de/beztab/besoldung_01012012/beso_abrw_010112.pdf (last accessed on 16 January 2012).

128 Data according to The German Association of University Professors and Lecturers (Deutscher Hochschulverband).

129 Cf. in this regard also Deutscher Hochschulverband (2005).

130 Cf. http://www.aaup.org/NR/rdonlyres/D04D1AAA-4C50-4FDF-A2DB-2EF2014AC96B/0/Tab4.pdf (last accessed on 16 January 2012) and http://chronicle.com/article/Graphic-How-Presidents-Pay/129981/ (last accessed on 16 January 2012).

131 The basic salary for the B10 salary grade is EUR 11,524 in North Rhine-Westphalia. Cf. http://www.lbv.nrw.de/beztab/besoldung_01012012/beso_abrw_010112.pdf, (last accessed on 16 January 2012).

132 Cf. § 33 Paragraph 2 of BBesG, http://www.gesetze-im-internet.de/bbesg/BJNR011740975.html (last accessed on 16 January 2012).

133 The annual salary costs for university teachers at federal and state level shall be kept largely constant (see § 34 of the professor pay scale reform law – ProfBesReformG], see http://www.bmbf.de/pubRD/profbesreformg.pdf (last accessed on 16 January 2012). Although this implies that benefits are actually paid and thus the average income of the professors does not drop; yet this also establishes an upper limit for salary expenditures (cf. German Bundestag 2001b).

134 Cf. Brandt et al. (2012).

135 Cf. http://www.hu-berlin.de/forschung/wiss_nachw/juniorprofessuren/tenure_jp.pdf (last accessed on 16 January 2012).

136 Cf. Brandt et al. (2012: Chapter 3.6.3).

137 SPD Berlin/CDU Berlin (2011: 55).

138 Cf. Brandt et al. (2012).

139 Cf. Brandt et al. (2012).

140 Cf. BMBF (no year).

141 Cf. EFI (2011).

142 Cf. BMBF (no year).

143 Cf. Brandt et al. (2012).

144 Cf. Brandt et al. (2012).

145 Cf. Brandt et al. (2012).

146 Cf. Astor et al. (2010: 114).

147 If an invention is filed with the German Patent and Trade Mark Office (DPMA) or the European Patent Office, it is not disclosed for 18 months. In most cases, the review process is taking place during this time. 18 months after the filing date or the earliest priority date, the invention will be disclosed (i.e. published). The 1.5 year period of confidentiality gives the inventor the opportunity to pursue the application, or cancel it prior to publication. The data in this chart refer to published patent applications only.

148 In the 2011-2013 funding period, the Federal Government and the *Länder* governments are supporting higher education networks which finance patent exploitation agencies' services with EUR 9.1 million and EUR 16.4 million respectively (excluding higher education institutions' own contributions) (information from BMWi). Thus the annual funding volume amounts to EUR 8.5 million. In 2010, commercial exploitation returns amounted to EUR 4.9 million (data: PTJ).

149 Cf. in this regard van Ledebur (2006: 271 f.).

150 In the following, cf. Schmoch (2007) and Cuntz et al. (2012).

151 If academic employees apply their patents as private persons, there can be two reasons behind this. Either the university has released the employee's invention and the inventor can dispose of it freely as he or she will, or the inventor has found it not his duty to register it, i.e. he/she does not inform the university about the employee's invention and applies the patent himself/herself or through third parties. The Expert Commission does not have reliable estimates of how frequently these cases occur.

152 If a market premium is not paid, the transfer of intellectual property rights is considered as consequential government aid according to the EU framework for research, development and innovation. If the company has made a financial contribution towards the tertiary institution's expenses, it may be excluded from the premium (cf. European Commission 2006).

153 Theoretically speaking, it is also possible that the academic inventor did not report his invention to the higher education institution, as required by the employment law, and instead passed it on to the respective company.

154 Data have been provided by Fraunhofer ISI, who used the PATDPA database of the host STN for their research. A search in the STN database will immediately identify the title of professor from among the applicants' and inventors' names. Yet, inventors who are academic staff but not professors, as well as inventors who have not indicated the title of professor, cannot be identified; this number is therefore an estimate by Fraunhofer ISI. The basis of the estimate is an analysis of patent applications by higher education institutions. Here, it has been shown that in the last decade the proportion of inventors who do not hold a professor title was approximately 50 percent. It is assumed that the percentage of non-professors is also considerable in applications by private persons and applications by companies. For the purpose of this analysis, it was assumed to be 40 percent in this group.

155 A proposal for a revised version is: "Federal and state governments may co-operate, pursuant to agreements in cases of national importance, in the promotion of institutions and projects of scientific research." Such a proposal was made by the Minister of Science of the Free State of Bavaria. Cf. http://www.handelsblatt.com/politik/deutschland/ vorstoss-aus-bayern-bund-soll-die-hochschulen-mitfinanzieren-/4231476.html (last accessed on 16 January 2012).

156 Cf. Frank et al. (2007 and 2009).

157 Some of Germany's higher education institutions have established training centres for science management. This has been the case e.g. with the University of Administrative Sciences Speyer.

158 Cf. Börsch-Supan (2009: 26 f.).

159 Cf. Börsch-Supan (2009: 30).

160 The question of whether or not an acute shortage of skilled labour already exists has not been answered quite clearly. Interviews with employers and industry associations suggest that there is growing evidence for a skills shortage. Yet, a study by the German Institute for Economic Research (DIW) (Brenke 2010) concluded that at this stage in time a measurable impact on salaries cannot be detected on the labour market. Regardless of this, it is undisputed that the long-term demographic trend will lead to a shortage of labour supply, albeit the effects will not be equally strong in all sectors and all regions.

161 The necessity to manage demographic change also requires urgent adjustments in other policy areas such as pension schemes and health care. In this report however, we shall concentrate on issues that have a direct impact on the innovative strength of German companies.

162 In this context, the high drop-out rate especially among male students is also a cause for concern. In 2006, the average drop-out rate at universities was 26 percent for men, but only 15 percent for women (cf. Table 8). Thus it seems that the ongoing academisation is challenging for male students in particular. This is especially true for male students in the fields of language and cultural studies and sport sciences. In these fields, the drop-out rate for male university students amounts to 35 percent. But even in mathematics and natural sciences, the drop-out rate for male students is significantly higher (31 percent) than those for female students (24 percent). Even in engineering, a traditionally male domain, the drop-out rate for men (28 percent) is well above that for women (16 percent). Only in mathematics and natural sciences at universities of applied sciences is the drop-out rate for men (25 percent) lower than that for women (32 percent). Yet, this does not apply to engineering courses: also at universities of applied sciences, drop-out rates are higher among men (28 percent) than they are among women (19 percent) (cf. Table 8). It is also striking that the success rates (i.e., the "opposite" of drop-out rates) strongly depend on the federal state that issued the higher education entrance qualification. Thus students who obtained their higher education entrance qualification in Baden-Württemberg and Bavaria (study year of 2001) displayed the highest success rate (82 percent each). The lowest success rate was displayed by students who had obtained their higher education entrance qualification in Bremen and Saxony-Anhalt (67 percent each). Cf. Federal Statistical Office (Statistisches Bundesamt, 2011d).

163 A positive statistical correlation between the percentage of students in engineering or MINT subjects respectively (science, engineering, mathematics, computer sciences) and the economic growth of a country have been confirmed e.g. in an early study by Murphy et al. (1991), but also more recently by Tsai et al. (2010).

164 Cf. Timmermann et al. (2004: 111 ff.).

165 Cf. Messer and Wolter (2009), as well as Schwerdt et al. (2011). These studies indicate that education vouchers are particularly efficient when they refer to clearly defined target groups with substantial educational needs.

166 Cf. Timmermann et al. (2004: 118 ff.), as well as Backes-Gellner et al. (2007).

167 According to calculations by the SME Research Institute, Bonn (IfM), the share of small and medium-sized enterprises of all enterprises amounted to 99.7 percent in 2009. These enterprises employ 60.8 percent of all personnel liable to security contributions. Cf. http://ifm-bonn.org/index.php id=897 (last accessed on 16 January 2012).

168 Cf. Backes-Gellner (2009: 65 ff.).

169 While some countries managed to advance a large proportion of socioeconomically disadvantaged students into the upper third of the PISA ranking (Finland 22.2 percent, Canada 17.1 percent, Japan 17.6 percent, Korea 17.7 percent), this proportion remains to be small in Germany, with only 12.6 percent – a value that is even below the OECD average of 13.0 percent. Cf. OECD (2011C: 88).

170 Cf. OECD (2011c: 31 f., 81).

171 Cf. OECD (2011c: 65).

172 Cf. Spangenberg et al. (2011: 7).

173 Cf. Trautmann et al. (2011: 17 ff.); Börsch-Supan et al. (2009); Schömann and Baron (2009: 31 ff.), Staudinger and Heidemeier (2009).

174 Cf. Backes-Gellner et al. (2009: 40 f.).

175 Cf. Gajewski and Falkenstein (2011).

176 Cf. Staudinger et al. (2011), Staudinger and Bowen (2011).

177 Second careers have often been observed in the Japanese job market (cf. Conrad 2009).

178 Cf. Backes-Gellner (2009).

179 A large gender gap is also apparent in terms of the duration of employment contracts for men and women after the completion of university studies. Compared with their female counterparts, men with a university degree who work in the private sector are much more frequently employed on a permanent contract. The highest proportion of permanent positions is occupied by men with a university of applied sciences degree (55 percent), followed by women with a university of applied sciences degree (42 percent) and men with a university degree (33 percent) (cf. Rehn/Brandt/Fabian/Briedis 2011). The lowest proportion of permanent staff is to be found among women with university degrees: in this group, only 17 percent occupy a permanent position, which means that 83 percent of female university graduates have a temporary position. These gender differences do not apply to employment in the public sector. This may help explain the high preference of women for jobs in the public service.

180 Cf. von der Leyen (2011).

181 FiT: in 1999, the Cologne-based Ford-Werke GmbH initiated the "Women in technical professions" (FiT) programme which aims to considerably increase the proportion of women in vehicle development and production Cf. http://www.ford.de/UeberFord/BerufKarriere/Einstieg/Schuelerinnen_Schueler/Frauen_in_technischen_Berufen (last accessed on 16 January 2012).

182 Cf. http://www.welt.de/print/die_welt/wirtschaft/article13564195/Airbus-plant-hoehere-Frauenquote-bei-Azubis.html (last accessed on 16 January 2012).

183 For an analysis of professional activities and birth rates, cf. OECD (2011e). On the aspect of exploiting the hidden reserve by reconciling family and career, cf. Böhm et al. (2011).

184 In 2000, the proportion of female graduates in engineering was only 3 percentage points below the OECD average; in 2009 the value was even 4 percentage points below the OECD average (cf. Table 5).

185 In 2000, the proportion of female natural scientists in Germany was 8 percentage points below the OECD average; in 2009, this value was in fact 3 percentage points above the OECD average (see Table 5).

186 Over the last decade, the higher education sector has seen an increase in the proportion of female graduates from 45 to 55 percent. This resulted in a relative decline in graduates from engineering courses. A comparison of a selected range of subjects in Germany with the OECD average shows that the increase in women at German universities as compared to OECD figures was largely in favour of "humanities and arts" (subjects that were already disproportionately represented in 2000) and "health and social studies" (subjects that were still underrepresented in 2000 and thus moved closer to the average). But the overall increase in female graduates was also at the expense of "services" degrees, which were significantly overrepresented in 2000 and are now closer to the average. In 2000, "education studies" were below average and were even further below average in 2009 (cf. Table 6).

187 Cf. Spangenberg et al. (2011: 5).

188 Cf. Lörz et al. (2011).

189 FiT: see above. Established in 2001 by the European Academy for Women in Politics and Economics and the Technical University of Berlin, Femtech is a higher education career centre for women. Cf. http://www.femtec.org/content/0/8683/8684/ (last accessed on 16 January 2012). Girls' Campus is a joint programme of the Robert Bosch Foundation and the Bosch Group that offers young female pupils the opportunity to experience science and technology, cf. http://www.bosch-stiftung.de/content/language2/html/11121.asp (last accessed on 16 January 2012).

190 For a more detailed discussion, cf. for instance BAMF (2008).

191 The legislative proposal for the Federal Government's Recognition Act was adopted by the *Bundestag* on 29 September 2011. On 4 November, the Federal Council *(Bundesrat)* gave their consent, and on 1 March 2012, the new law is due to come into force. The Recognition Act includes a new federal law, the Professional Qualifications Assessment Act (*Berufsqualifikationsfeststellungsgesetz,* BQFG), as well as over 60 amendments to existing federal legislation regarding the recognition of qualifications in regulated professions, which include academic and non-academic healthcare professionals and master craftsmen. The *Länder* have also announced plans to amend the legislation governing the professions under their jurisdiction (for example, teachers, engineers, and nursery school teachers) in order to improve the recognition procedure also for these professions. Cf. http://www.bmbf.de/en/15644.php (last accessed on 16 January 2012).

192 Cf. http://www.bmbf.de/de/15644.php (last accessed on 16 January 2012).

193 Cf. German Federal Government (Deutsche Bundesregierung, 2011).

194 Cf. Hochrangige Konsensgruppe Fachkräftebedarf und Zuwanderung (2011: 77 ff.).

195 A study presented by the German Institute for Economic Research (DIW) shortly before 1 May 2011 estimates that in 2011 alone, 466,000 persons migrated to Germany. Cf. Baas et al. (2011: 3).

196 An increase in immigration numbers has been reported with regard to those EU countries that had been hit particularly hard by the financial and debt crisis. Thus in the first half of the year, the number of immigrants from Greece increased by 84 percent (a plus of 4,100 persons) compared with the first half of 2010. Within the same period, immigration from Spain increased by 49 percent (a plus of 2,400 persons). Cf. Federal Statistical Office (Statistisches Bundesamt, 2011c).

197 Interview with Dr. Gunilla Fincke, head of the research department of the Expert Council of German Foundations on Integration and Migration *(Sachverständigenrat deutscher Stiftungen für Migration und Integration)*, Deutschlandradio, 29/11/11. Cf. http://www.dradio.de/dlf/sendungen/wirtschaftundgesellschaft/1616458/ (last accessed on 16 January 2012).

198 In the environment of science funding in Germany, a number of different institutions and programmes for scientists returning from abroad have been developed in recent years. These aim to counteract the permanent emigration of German scientists and facilitate a return to Germany respectively. Among these programmes and institutions are the DAAD programme for winning back German scientists from abroad, as well as the Emmy Noether programme, which was launched by the

DFG and is operated by the DFG and the German Scholars Organization e.V. Cf. http://www.daad.de/ausland/foerderungsmoeglichkeiten/ausschreibungen/10691.de.html (last accessed on 16 January 2012). Emmy Noether programme: cf. http://www.dfg.de/foerderung/programme/einzelfoerderung/emmy_noether/ (last accessed on 16 January 2012). German Scholars Organization: cf. http://www.gsonet.org/index.php (last accessed on 16 January 2012).

199 On deviating projections regarding the supply and demand of labour, see Cordes (2012: 9 ff.). Cf. also Möller (2011).

200 The same applies, mutatis mutandis, for dual vocational training courses, which were also designed to establish a broad basis for a number of subsequent occupations. Yet, even today it has become apparent that in terms of mobility of skilled workers the profession itself is not the decisive factor, but rather the adaptation of a profession to a similar occupational cluster (cf. Backes-Gellner, Geel et al. 2010, Backes-Gellner and Geel 2011). This means that a specialised profession does not have to be a disadvantage as long as it bears enough similarities with professions from occupational clusters that have future potential.

201 Backes-Gellner, Tuor et al. (2010) also show that mixed educational paths offer particularly favourable job market results for entrepreneurs, i.e. the permeability of the education system can foster entrepreneurship indirectly.

202 As regards permeability, it has been shown that e.g. in fields where the combination of professional and academic qualifications is possible, this combination can in fact lead to above-average returns, c.f. Backes-Gellner, Tuor et al. (2010).

203 Fee-based further education programmes for high-ranking managers.

204 Cf. Audretsch et al. (2006).

205 Cf. Amorós et al. (2011).

206 Cf. Aghion et al. (2009).

207 Percentage of individuals aged 18 to 64 years, who started up a business within the last 3.5 years and/or are currently starting up a business. Cf. Brixy et al. (2011).

208 Cf. Chapter C Figure C4 – 4 and Brixy et al. (2011).

209 Cf. Hart and Levie (2010).

210 The knowledge economy comprises research-intensive industries and knowledge-intensive services based on "WZ 2008", a classification scheme for economic activities.

211 12.6 percent of all start-ups were attributable to knowledge-intensive services (information and communication services – software, data processing, IT consulting, telecommunications –, engineering and architectural offices, technical laboratories, R&D services, business, economic and legal consulting, and advertising). 1 percent of start-ups were attributable to research-intensive industries (high technology). Cf. Müller et al. (2011).

212 Cf. Müller et al. (2012).

213 Cf. Bernhard and Wolff (2011), Caliendo et al. (2011).

214 Cf. German Bundestag (Deutscher Bundestag, 2011b).

215 The law was initially referred to the Conciliation Committee. A major reason for this was the controversial reduction of the start-up allowance. Yet, the reduced funding rate was still maintained in the revised act. The law was subsequently adopted by the Federal Council *(Bundesrat)*, despite a request by the states of Rhineland-Palatinate, Baden-Württemberg, Berlin, Brandenburg, Hamburg, Bremen and North Rhine-Westphalia to lodge an appeal against the new law.

216 Cf. Bernhard and Wolff (2011).

217 The European Recovery Programme (ERP) was set up in 1948 as part of the Marshall Plan aid to rebuild the German economy. It later became the Federal Government's ERP Special Fund. Today, the KfW banking group finances several programmes from this off-budget special fund; these programmes are referred to as ERP programmes.

218 Cf. http://www.existenzgruender.de/selbstaendigkeit/finanzierung/foerderprogramme/index.php; www.exist.de; http://www.high-tech-gruenderfonds.de/; (last accessed on 16 January 2012).

219 Cf. Brixy et al. (2011).

220 Cf. European Commission (2008b).
221 Cf. European Commission (2008b).
222 Cf. Council of the European Union (2011).
223 Cf. Brixy et al. (2011).
224 The availability of qualified employees has also been brought up as an issue. Yet it is questionable whether staffing problems can really be so extreme that they can be held responsible for the failure of companies. The insolvency administrators and business consultants interviewed in the context of the ZEW survey expressed their skepticism towards the reasoning of former entrepreneurs and CEOs, according to which a lack in competent staff had been a major reason for closure. Here, interviewees pointed out that many CEOs were in fact “lacking the skills to correctly assess their employees’ competence”. Cf. Egeln et al. (2010), p. 48.
225 Cf. Parker (2004).
226 Cf. Egeln et al. (2012).
227 Cf. Gereffi et al. (2007).
228 Cf. Egeln et al. (2012).
229 Cf. Egeln et al. (2012).
230 Cf. Egeln et al. (2010), Egeln et al. (2012).
231 Cf. Egeln et al. (2010).
232 Cf. Egeln et al. (2010), Egeln et al. (2012).
233 Cf. Müller et al. (2012), p. 33, Figure 18.
234 Cf. Egeln et al. (2010).
235 Cf. Egeln et al. (2012: Fig. 5 – 7).
236 Cf. Egeln et al. (2010).
237 Cf. Egeln et al. (2012).
238 Industries with a high company fluctuation rate are not considered here. These include retail, hotels and restaurants, hairdressers, as well as businesses that conduct administrative work, such as real estate and housing companies and financial holding companies.
239 Cf. Insolvenzordnung § 1.
240 Cf. Egeln et al. (2010).
241 Cf. German Bundestag (Deutscher Bundestag 2011c).
242 The United States’ insolvency law (Chapter XI Bankruptcy Code) served as a model for the legislative proposal. It provides for the reorganisation and maintenance of companies. Cf. http://www.uscourts.gov/FederalCourts/Bankruptcy/BankruptcyBasics/Chapter11.aspx (last accessed on 16 January 2012).
243 Cf. in this regard the recommendations made by Egeln et al. (2010).
244 Cf. OECD (2011).
245 Data refer to the KfW / ZEW Start-up Panel 2007 – 2009 (start-up cohorts 2005 to 2009). Cf. Egeln et al. (2012).
246 In the high-tech industries in the manufacturing sector, 7 percent of companies make use of equity capital; in knowledge-intensive services it is 3.4 percent, and in other manufacturing industries it is 3 percent. Of the companies that had registered a patent even before they launched the business, just under 6 percent made use of equity capital. 4 percent of companies with a market novelty made use of equity capital, and 5 percent of young companies engaging in R&D made use of equity capital.
247 Cf. Egeln et al. (2012).
248 Cf. http://www.high-tech-gruenderfonds.de (last accessed on 16 January 2012).
249 Cf. BVK (2011a).
250 Cf. Geyer and Heimer (2010).
251 Cf. Colombo et al. (2011).
252 Cf. Achleitner et al. (2010).
253 Cf. OECD (2011d), p. 51, Figure 2.8.
254 Cf. OECD (2011d).

255 Cf. Mason (2009).

256 Cf. Harrison and Mason (2000).

257 Cf. European Commission (2009: 24).

258 To a limited extent, the HTGF funding programme also allows for co-investments by business angels.

259 The European Investment Fund (EIF) is currently planning to launch a co-investment facility that shall be implemented in collaboration with the *Business Angels Netzwerk Deutschland*. The EIF will focus on selecting suitable business angels rather than selecting eligible investment projects. This new pilot project will be launched in Germany and, in the event of success, shall be extended to other European countries. Cf. Kraemer-Eis and Schillo (2011).

260 Based on a survey conducted among 33 out of 38 German business angels networks, Redweik (2012) describes the activities of these networks. The figures provided in this report are based on this study.

261 Detailed information on the EIS can be found at http://www.hmrc.gov.uk/eis/ (last accessed on 16 January 2012).

262 Investments comprise both early stage and later stage investments. Cf. National Venture Capital Association, VC Industry Statistics, German Private Equity and Venture Capital Association (Bundesverband Deutscher Kapitalbeteiligungsgesellschaften, 2011a).

263 Between 2006 and 2010, only six funds with a volume of over EUR 100 million were launched in Germany. Cf. http://www.gruenderszene.de/finanzen/venture-capital-szene-deutschland (last accessed on 16 January 2012).

264 Cf. Arjan et al. (2009).

265 On the development of venture capital investments in Germany over the last decade, cf. BVK (2011a), p. 28, Table C3.

266 Cf. Erhart and Zimmermann (2007).

267 Cf. BMF (2004).

268 Cf. Deloitte (2009).

269 Cf. European Commission (2011a).

270 As part of the Enterprise Europe Network, the EU has established 600 contact points, 33 of which are located in Germany. In the state of Baden-Württemberg alone, seven contact points have been affiliated to local chambers of industry and commerce. It is questionable whether these decentralised institutions will be able to build up sufficient expertise in the field of venture capital and start-up financing. It might be more efficient if these tasks were taken on by business angels networks, venture capital providers and specialised consulting companies, as all of these carry expertise in this field.

271 In 2010, the Basel Committee on Banking Supervision published its “Basel III” set of regulations, for the implementation of which the European Commission proposed a Directive (the Capital Requirements Directive), as well as a Regulation (the Capital Requirements Regulation) in 2011.

272 The Directive 2011/7/EU of the European Parliament and European Council of 16 February 2011 to combat late payment in commercial transactions applies to payment claims between enterprises, and between enterprises and public sector bodies. The aim is to harmonise terms and rights of creditors. The member states have to implement the Directive by 16 March 2013.

273 The Enterprise Europe Network was established by the European Union. It is an agency that comprises chambers of industry and commerce, technology centres, research institutions and development agencies that support small businesses in the EU internal market.

274 Cf. European Commission (2011a).

275 In Germany, a financing gap exists particularly between 6-digit and low 7-digit number amounts.

276 Cf. EVCA (2008).

277 However, it should be taken care to avoid incentives that would prompt small investors to choose risk-intensive investment strategies.

278 Cf. Deloitte (2009).
279 Cf. Deloitte (2009).
280 These include e.g. managers of hedge funds, buyout funds and venture capital funds.
281 European Commission (2011b). http://ec.europa.eu/internal_market/investment/venture_capital_en.htm (last accessed on 16 January 2012).
282 If a lender declares that, in the event of insolvency, he/she will subordinate his/her claims to those of all other creditors involved, the loan is thereby transformed into quasi-equity.
283 Cf. European Commission (2011b), Article 5 (portfolio composition).
284 Article 6 (eligible investors) stipulates that qualified funds can only be marketed to investors who are recognised as professional investors according to Directive 2004/39/EC. Marketing to other investors such as certain high-net worth individuals is only allowed if they commit a minimum “ticket” of EUR 100,000 to the fund, and meet other conditions specified in the proposal.
285 This also applies to funding measures such as the discussed venture capital guarantee facility.
286 Cf. Hall et al. (2009), Guellec and van Pottelsberghe de la Potterie (2001).
287 On correlations between R&D investments and growth, see OECD (2010: 21 f.), Sveikauskas (2007) as well as Duval and de la Maisonneuve (2009).
288 The remainder is attributable to other sources of funding (e.g. foundations) as well as financing from abroad.
289 Cf. Kladroba et al. (2012).
290 Cf. ibid.
291 Cf. Arrow (1962), Nelson (1959).
292 Cf. Pavitt (1990).
293 Cf. Lane (2009), Lane and Bertuzzi (2011).
294 A comprehensive analysis of the knowledge exchange between university and non-university research and industrial companies has been provided by Cohen et al (2002). The results of this study confirm that, from the point of view of companies, informal contact with scientists from research institutions is considered a far more important aspect of collaboration than e.g. prototypes and patents. Meyer-Krahmer and Schmoch (1998) also examined the connection between universities and the industrial sector, while also including the perspective of academic researchers. Their findings illustrate that, also in the view of university-based scientists, the exchange of knowledge is regarded as highly relevant. These scientists refer to knowledge transfer as “the lowest common denominator” for the balancing of interests between academia and industry.
295 Cf. Gibbons and Johnston (1974), Martin and Irvine (1983).
296 Cf. Czarnitzki and Hussinger (2004), Hussinger (2008), Klette and Møen (1998), Hennigsen et al. (2011).
297 To ensure that this finding was supported by a broad literature analysis, the Expert Commission had commissioned a detailed study on the topic. As part of this study, Peters et al. (2011) analysed a number of evaluation studies. 12 of 14 of the reviewed studies rejected the idea of a total knock-on effect and instead reported that public R&D funding in fact stimulated private-sector activities, cf. Peters (2011: 32, 54).
298 Peters et al. (2012:127).
299 Cf. Peters et al. (2009:12).
300 ibid., p. 89.
301 Cf. Segerstrom (2000).
302 Cf. Lane (2009).
303 Generally speaking, a differentiation between incremental and volume-based promotional policies exists. An incremental approach aims to decrease the proportion of taxable income that exceeds a certain threshold in qualified R&D expenditures. This approach is practiced in the United States and Ireland. In contrast to this, the volume-based approach supports all qualified R&D expenditures over a period of one year. In a number of countries, this type of policy is enjoying increasing popularity, among them Great Britain, Canada, Australia, France and Italy. But

also mixed forms of both approaches exist; these can be found e.g. in Portugal, Spain and Japan. Norway provides this form of indirect R&D funding with a ceiling in order to support SMEs in a more targeted way.

304 For Great Britain cf. Bond and Guceri (2011), for France cf. Ientile and Mairesse (2009).

305 Cf. Spengel and Wiegard (2012).

306 In its Expert Panel Report, the Industrial Research and Innovation Council (IRIC) confirms the relevance of R&D tax credits as an important supplement to project funding. For the purpose of gradually simplifying tax-based R&D support, the IRIC calls for a decrease in the tax burden exclusively attributable to labour costs for R&D personnel. Cf. Industrial Research and Innovation Council (2011: 12).

307 Cf. Industrial Research and Innovation Council (2011).

308 Cf. Geyer and Tiefenthaler (2011:13).

309 Cf. Höfer and Welling (2009: 5).

310 A study has shown that France was able to advance to the position of Europe's most competitive country due to the introduction of R&D tax credits and a subsequent reduction in research investments by companies. Cf. http://www.anrt.asso.fr/fr/espace_europe/pdf/ANRT_CIR_couts_du_chercheur_GrandsGroupes_2010.pdf (last accessed on 16 January 2012).

311 Cf. Spengel and Wiegard (2012).

312 According to this, 10 percent of R&D expenditures would be deducted from the amount of tax to be paid.

313 The authors of the study estimate an internal rate of return of 25 percent for R&D. As regards the external rate of return, a value of 30 percent is assumed. Other assumptions refer to additional burdens and the enforcement costs of the measure. Cf. Spengel and Wiegard (2012).

314 Spengel and Wiegard (2012), p. 46.

315 A general problem of impact analysis in innovation research is the fact that it remains difficult to draw conclusions on the counterfactual situation. This means that it is close to impossible to discuss the question of how funded companies would perform had they not received funding. This can only be done by systematically comparing a group of funded companies with a suitable control group. In combination with information on different funding instruments, this would allow for securing conclusions on the effectiveness of these instruments for individual groups of businesses.

316 Cf. Geyer and Heimer (2010).

317 Cf. Barasinska et al. (2011).

318 In addition to using existing R&D funding data sets, it is also recommended to link these records with data from other institutions. A linking of these data sets with individual wage data (e.g. from the Institute of Employment Research), would allow for e.g. an analysis of the effects that R&D funding has on employment and productivity growth. It is often assumed that additional R&D expenditures via public funding would also lead to the creation of new jobs. Yet, studies from the United States and the Netherlands show that an increase in R&D spending does not necessarily lead to an increase in employment and productivity. Rather, it could be shown that parts of funding simply "evaporate" due to higher wages for R&D professionals. This effect has not been adequately analysed for Germany yet. A combination of data sets could therefore resolve deficits in academic research.

319 Cf. Lane (2009) as well as Lane and Bertuzzi (2011).

320 This decidedly anticyclical growth in 2009 and 2010 was largely influenced by the launch of a comprehensive economic stimulus programme by the Chinese government.

321 Data up until and including 2010 by IMF (2011: 183). Data on the growth of GDP in 2011 are based on a publication of the Chinese National Bureau of Statistics from 17/01/12, quoted in the *Frankfurter Allgemeine Zeitung*, 18/01/12.

322 Cf. China hat Deutschland überholt, *Frankfurter Allgemeine Zeitung*, 17 July 2007.

323 Cf. Finn Meyer-Kuckuck: Ehrgeiziges China überholt Japan, *Handelsblatt*, 16 August 2010.

324 Cf. OECD (2008a). As part of these reforms, state-owned enterprises were given the opportunity to produce beyond the quota determined under the planned economy, and market these surpluses independently.

325 Cf. Schüller (2011: 33 – 45).

326 This transition towards the idea of "indigenous innovation" is a key aspect of China's research and innovation strategy and shall be examined in more detail in this report. Cf. also Schwaag Serger and Breidne (2007: 135 ff.) and Schwaag Serger (2006: 227 ff.).

327 Cf. Deutsche Bank Research (2010).

328 Cf. Jannsen and Wu (2011).

329 Cf. World Bank (2009: 33).

330 The Gini coefficient or Gini index is a statistical measure for the distribution of inequality in income or wealth. The Gini coefficient can display any value between 0 (the assets of a country are evenly distributed between all residents) and 1 (all of the country's assets are owned by a single resident). The closer the Gini coefficient is to 1, the greater the inequality (e.g. in terms of income distribution). In 2007, the Gini coefficient for Germany was 0.28.

331 Cf. Peterskovsky and Schüller (2010: 2).

332 Between 1981 and 2005, the headcount index declined from 84 to 16.3, cf. Peterskovsky and Schüller (2010: 2).

333 The Human Development Index (HDI) rose from 0.36 in 1980 to 0.66 in 2010. The Human Development Index is a welfare indicator that has been published by the UNDP since 1990. It comprises three main indices: income per capita, life expectancy, and education. Cf. UNDP (2011, 1990).

334 In order to highlight its changing character to the larger public, the 11th Five-Year Plan was renamed and is now referred to as the Five-Year Programme. Cf. Schucher (2011: 2).

335 On the reasons for the failure of China's readjustment of national policy, see Schucher (2011: 3).

336 Schucher (2011: 6).

337 Expenditure in US dollars at current prices, converted into purchasing power parities. Cf. OECD (2011b: 24).

338 This would largely correspond to the level implemented in Germany in 2007.

339 All data in US dollars based on purchasing power parities. Yet, based on currency parities, China would still be ranked fourth due to the clearly underevaluated Yuan.

340 A very significant proportion of the growth in private R&D expenditures is also due to different definitions in comparison with the OECD, as well as different ways of Chinese companies' recording certain activities as "R&D". Especially the huge tax incentives that are granted in China for R&D have resulted in the fact that many activities are labeled as R&D that in other countries would be subsumed under other operating areas such as construction, production preparation, training, etc.

341 While in 1990, China still occupied the 8th position in the ranking of high-tech producers (with a share of only 2 percent in worldwide production); this is another area in which China has outperformed former leading countries. Thus, by 2000, China had surpassed Korea, France and Italy, and subsequently surpassed Germany, Japan and Great Britain.

342 However, a large part of China's exports in the area of high technology is heavily dependent on importing specialised primary products. For example, China exports computers, but largely relies on semiconductor components imported from the US, Korea and Taiwan. Thus the strong growth in exports in the high technology sector has been traded for a high degree of dependency.

343 In addition to this, some of the leading Chinese companies successfully went public, especially on the New York Stock Exchange.

344 GWp: rated power of a photovoltaic installation. The rated power is similar to that of peak power on a sunny day. The average power is about one-sixth of rated power (GW = one billion watts).

345 In 2010, Germany produced 10 percent of the world's photovoltaic modules installed. Of these, 80 percent went to the European market, 10 percent to the United States, and 10 percent to Asia –

whereas China supplied 48 percent of the world market. Of these, 65 percent were exported to Europe and 25 percent to the United States; only 10 percent went to the Chinese market. It can be assumed that the internal Chinese photovoltaics market will continue to grow strongly in the coming years: in 2011, China introduced a market launch programme based on the German feed-in tariff model. Estimates on the part of the Chinese suggest that in five years' time, around 50 percent of the world's photovoltaic systems production will be installed in China.

346 Cf. BMWi (2011b: 92).

347 According to VDMA, a German industry association, the total revenue of German machine and plant manufacturers in the photovoltaic sector amounted to EUR 2.5 billion in 2010. The export ratio was 85 percent, while 74 percent of exports went to Asia alone. However, German mechanical engineering in the field of photovoltaics is currently experiencing a dramatic slump in orders caused by global overcapacities.

348 This situation will lead to a worldwide consolidation in this market segment. At present, several large, financially strong multinationals are entering the photovoltaic production market with new production facilities, among them Bosch, General Electric (via Primestar), Showa Shell (via Solar Frontiers), and Panasonic. One of the objectives here is to achieve significant cost decreases by achieving economies of scale, and with the help of new production technologies.

349 The price-experience curve (also known as learning curve) displays the average world market prices as a function of installed power accumulated over time.

350 Cf. Gehrke and Krawczyk (2012: 13).

351 Van Gerth (2011) subsumes: "As China goes, so goes the world". In his book of the same title, van Gerth describes important consumption patterns that, starting in China, are being transferred to emerging Asian economies and other world regions.

352 Cf. OECD (2011b), as well as calculations by CASTED on the shares of foreign investors in R&D expenditures of the Chinese economy.

353 If one counts in investors from Taiwan and Hong Kong, the share of foreign investor groups even increases from 20 to 26 percent.

354 Cf. UNCTAD (2005).

355 At the forefront of this are the leading technical universities, as well as selected institutes of the Chinese Academy of Sciences (CAS).

356 Yet, collaboration between foreign companies (MNCs) and state-owned enterprises (SOEs) in China is not always free of conflict, especially when it comes to co-operations in the field of R&D. As a result, many MNCs limit the scope of collaboration to joint production and marketing activities. R&D tends to be excluded due to concerns that know-how and technologies are transferred too quickly to SOE.

357 Cf. Belitz (2012), Gerybadze and Merk (2012).

358 Cf. AHK Greater China (2011).

359 In 2007, published estimates reported a total of 600 R&D subsidiaries of foreign corporations in China. Recent estimates suggest that this number has increased to between 1,200 and 1,500 subsidiaries in 2011.

360 Emissions occur outside of the cities in cases where electricity is not generated from emission-free sources such as hydro power, wind energy and solar energy.

361 "A lead market is characterised by a high domestic demand for innovative products or services that spreads over time to other markets. Demand is determined both by the preferences of consumers and the framework conditions for businesses. If successful, the establishment of a lead market can result in significant positive welfare effects." BMBF (2011: 4).

362 In autumn 2011, the following premium model was in place: manufacturers of electric vehicles were granted the equivalent of EUR 6,000 per vehicle. Additionally, in some of the cities, the purchaser also received a premium of EUR 6,000. In Beijing, the secured admission to e-mobile traffic has a value of approx. EUR 5,000. Thus anyone who purchases an electric car will not have to participate in auctions or lotteries for a traffic licence.

363 BYD is a car manufacturing company from Shenzhen. The acronym BYD stands for Build Your Dream; the acronym FAW stands for First Automotive Works. The company's head office is located in Changchun.

364 BYD produces its own lithium iron phosphate high-voltage batteries. BYD is probably the world's largest battery manufacturer in the area of electric mobility.

365 TU9 is an amalgamation of the following universities: RWTH Aachen, TU Berlin, TU Braunschweig, TU Darmstadt, TU Dresden, Leibniz University Hanover, Karlsruhe Institute of Technology, TU Munich, and University of Stuttgart.

366 The China Automotive Technology and Research Center CATRAC was founded in 1985 and today employs 2,000 staff, including 850 scientists.

367 Leapfrogging strategies are focussed on "jumping over" a technology generation in cases where a company (or an up-and-coming country) joins the competition at a later stage, thereby surpassing the previous technology leader. Thus Apple for instance managed to push former leading companies such as Nokia and Motorola to rear ranks when they introduced their new generation of smartphones.

368 This has also been referred to as "the construction of the national innovation system", which is planned to be implemented via ten different categories of innovation policy measures. Cf. Xu (2011).

369 Enhanced efforts by the central government and the provinces shall ensure that the proportion of public expenditure on R&D increases both in absolute and relative terms. In 2010, this proportion had reached 0.4 percent. By 2015, it is supposed to increase to 0.55 percent. (Compared with this, the OECD countries are currently at 0.65 percent, while Germany reaches a value of 0.76 percent.)

370 All data in US dollars based on purchasing power parities at current prices. Cf. OECD (2011b).

371 This is supported by publication and patent analyses, which place around 50 percent of authors and/or employees from elite universities and CAS institutes in their top 10 lists of authors.

372 In 1995, the Chinese Ministry of Education launched its Project 211, a programme that aims to strengthen the country's top 100 universities. The focus of research funding is concentrated on these universities, which receive around 70 percent of the research budget allocated to the higher education sector. The list is updated regularly on the website of the Ministry of Education of the People's Republic of China. Cf. OECD (2008a).

373 Cf. Schmoch et al. (2012).

374 Cf. Xu (2011).

375 One of the consequences of this is a brain drain to the private sector and abroad. To overcome this problem, the Chinese government has initiated its "1000 Talents Programme", offering promising career opportunities to top researchers from abroad. Yet, a few exceptions aside, the effectiveness of this measure has to be put into relation to the status of advanced research in China, which is still not always positioned at the forefront when compared by international standards.

376 Cf. OECD (2008b).

377 There are numerous initiatives in Germany, the United States, and also at an EU level. In the United States, a high-level position has been created that reports directly to the President. Between 2006 and 2011, the European Union set up a delegation that was engaged in negotiations on patent protection in China, which has led to important improvements in the field.

378 Particularly since 2006, legal foundations and guidelines for patent protection and its implementation have taken shape, and new institutions have been launched. China's medium and long-term plan 2006 devotes central passages to the importance and future development of the patent system. In 2008, China specified its national IP strategy. Since 2009, a number of government decrees have been published. Patent applications receive considerable attention and are fostered by a variety of promotional activities and political campaigns.

379 While in 2009 the ratio of patents granted to patents filed was 74 percent for foreign enterprises, Chinese applicants only achieved a patent grant rate of 29 percent. Strictly speaking, the patent grant rate should be calculated by taking into account time delays; yet the results would not lead to major changes in these findings.

380 Recommendations of the Standards and Conformity Assessment Working Group, cf. European Chamber of Commerce (2011: 75 ff).

381 See the position paper on *"Organisationsübergreifende Strategien der Internationalisierung der Forschung"*, cf. Joint Science Conference GWK (2011b). Here, Germany's major scientific organisations (DFG, FhG, HGF, MPG, and WGL) present their positions on internationalisation. Yet, the position paper suggests that the basis for a common strategy is rather thin.

382 The National Platform for Electromobility was launched by the Federal Government on 3 May 2010 as an advisory body for issues relating to electromobility. Platform members are leading representatives from industry (10 persons), politics (6), science (3), associations (3) and unions (1). The Platform has been established to identify Germany's opportunities and strengths in the area of electromobility, across sectors and across disciplines. In addition, the National Platform for Electromobility makes concrete suggestions for achieving the objectives specified in the National Development Plan for Electromobility. Questions regarding e.g. drive and battery technology, charging infrastructure and network integration are discussed in seven thematically structured working groups. An initial progress report was published on 30 November 2010, followed by a second report on 16 May 2011.

383 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 this 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 higher education institution (*Diplom* certificate, university) and respective final examinations).
ISCED 6 – completion of doctoral degree.
Cf. Normann Müller (2009): Tertiary education in Germany – Blind spots in the OECD's international comparison, 2/2009, http://www.bibb.de/en/51670.htm
For further information, see OECD (2011): Education at a Glance, as well as the Federal Statistical Office *(Statistisches Bundesamt)*: http://www.destatis.de/jetspeed/portal/cms/Sites/destatis/Internet/DE/Content/Statistiken/WirtschaftsrechnungenZeitbudgets/PrivateHaushalteInfoGesellschaft/Begriffserlaeuterungen/Bildungsstand,templateId=renderPrint.psml.

384 Cf. OECD (2005: 46).

385 The MIP surveys legally independent firms from the industrial and service sectors with five or more employees. These are interviewed with regard to their innovation activities. The MIP is the German contribution to the European Commission's Community Innovation Surveys (CIS). As regards the MIP survey wave 2009, several adjustments have been made owing to the transition to the new economic sector classification scheme (WZ 2008, cf. Federal Statistical Office, 2008). Furthermore, 2009 was the first year in which the statistical offices' company registers could be used as a basis for projections. Both factors have led to a revision of data that goes back to the review period 2006. Further adjustments were made to the surveys of 2010 and 2011, also in the context of the transition to the WZ 2008 scheme and the use of company registers as a projection basis. The values presented below are based on this revision; hence, deviations may occur when comparing these values with the figures provided in the Expert Commission's 2010 and 2011 reports. In the following, cf. Rammer and Köhler (2012), a study that considers product, service and process innovations, but not marketing and organisational innovations.

386 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, namely basic research, applied research and experimental development.

387 The European BACH database (BACH: Bank for the Accounts of Companies Harmonised) is hosted by the Banque de France. It allows for determining the capital-to-assets ratio of companies (excluding the financial sector) for various European countries. Cf. http://www.bachesd.banque-france.fr/?lang=en (last accessed on 16 January 2011).

388 Cf. EVCA (2011).

389 Cf. Blind (2002).

390 Figures are based on samples that consider corporations only and are not representative. The samples are always identical in only two consecutive years (two-year sliding samples).

391 The MUP, which also includes the former ZEW Start-up Panel, is a panel data set of businesses in Germany, provided by the ZEW. It is prepared in collaboration with Creditreform, Germany's largest credit information bureau. The term enterprise, as used by the MUP, refers to economically active enterprises only, while the term start-up refers only to original newly formed companies. 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 carried out on the basis of the new classification scheme for economic activities (WZ 2008, cf. Statistisches Bundesamt 2008), as was the case in the previous year. The procedure for documenting company closures is continuously being developed, and because of this, both the values relating

to closures and the values relating to the number of companies have been revised retrospectively to 1995. For the definition of R&D-intensive industries, the revised list of research-intensive sectors has been employed (cf. Gehrke et al. 2010). In the following, cf. Müller et al. (2012).

392 GEM is a project that has been running since the late 1990s. In 2010, the GEM compared entrepreneurial activities in 59 countries regarding their scope, development, framework conditions and motives. The GEM survey based its data on interviews with a representative sample of citizens and experts. Cf. in the following Brixy et al. (2011).

393 PCT: Patent Cooperation Treaty.

394 The Web of Science (WoS) database by THOMSON Scientific is frequently used as the data basis for bibliometric analyses.

395 Cf. Gehrke et al. (2010).

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Published by
Commission of Experts for Research and
Innovation (EFI), Berlin
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Translation
Michael O’Sullivan, Ingrun Wenge, Berlin

Cite as
Commission of Experts for Research and Innovation (EFI)
(ed.) (2012): Research, innovation and technological performance in Germany – EFI Report 2012, EFI, Berlin.

Design and Imagery
Kognito Gestaltung, Berlin
Production: Buch- und Offsetdruckerei H. Heenemann
GmbH & Co. KG, Berlin

ISBN 978-3-00-038185-0

Editorial deadline: 16 January 2012

ISBN 978-3-00-038185-0