Country Profile

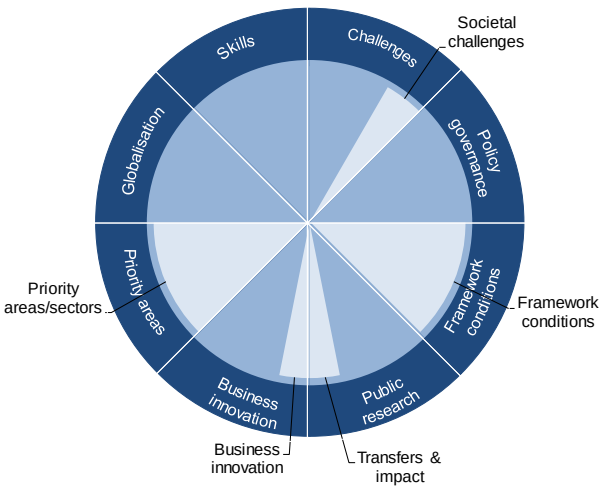
GERMANY

Germany has a major export-led economy driven by a wide range of internationally competitive firms, notably in the manufacturing of machinery and transport equipment, which make up nearly half of all German merchandise exports. The country's economic growth rebounded quickly following the global financial and economic crisis in 2009. Germany performs well on many indicators of economic performance and well-being, including unemployment. In contrast, investment – an important driver of productivity growth – has been slow to recover. In light of weakening growth in labour productivity and an imminent decline in the labour force as a consequence of ageing, Germany needs to promote and invest in productivity-boosting STI policies. In addition, considerable variations related to people's age and socioeconomic background, such as well-being, education and life expectancy, prompted the government to shift the focus of its new High-Tech Strategy (*Hightech-Strategie* – HTS): while initially attending to the market potential of specific technology areas, as of 2010 the HTS has concentrated especially on society's need to develop and implement forward-looking approaches to policies. The third edition of the HTS, adopted in August 2014 (after 2006 and 2010), sees "civil society" as a third actor, alongside industry and research, and focuses on a number of new topics (such as the digital economy and society, a sustainable economy and energy system, the innovative workplace and civil security). New instruments to fund innovation seek to strengthen cooperation between enterprises, universities and research institutions and to enhance society's active involvement in science, technology and innovation. Accordingly, the country's upward trend in R&D expenditure is continuing: in 2014, Germany spent 2.90% of GDP on R&D, up from 2.73% in 2009. GERD is targeted to reach 3% of GDP by 2020. In the current legislative period an additional USD 3.8 billion PPP (EUR 3 billion) is being spent on R&D, despite ongoing fiscal consolidation.

Table 1. Gross domestic expenditure on R&D (GERD)

	DEU	OECD
GERD		
USD million PPP, 2014	108 827	1 181 495
As a % of total OECD, 2014	9.5	100
GERD intensity and growth		
As a % of GDP, 2014	2.90	2.38
(annual growth rate, 2009-14)	(+4.1)	(+2.3)
GERD publicly financed		
As a % of GDP, 2013	0.82	0.61
(annual growth rate, 2008-13)	(+2.7)	(+2.5)

Figure 1. Major STI policy priorities, 2016



Hot issues

Addressing societal challenges (e.g. inclusiveness)

As the national Research Agenda on Demographic Change (The New Future of Old Age) will expire in 2016, the contribution of research and technological development (RTD) activities to managing demographic change will be continued within the Human-Technology Interaction programme (2015-20) of the Federal Ministry of Education and Research (BMBF). This RTD programme will put special emphasis on the implications of technology for improving the quality of life of all generations. In addition, in light of the results of the BMBF Foresight Process II (2012-14), the new HTS gives emphasis to the active participation of society as a central player and to strengthening factors that enable this, such as openness to technology, public participation and social innovation. A number of specific actions to enhance public engagement in S&T and policy are currently being implemented, including: the Years of Science, which aims to establish dialogue with the public in easily understandable language; the FutureFora (*ZukunftsForen*), to support dialogue between scientists, politicians and citizens; Citizens Create Knowledge (*Bürger schaffen Wissen*), a web platform for citizen science projects; and new funding guidelines for citizen science projects with a focus on upcoming societal challenges along the recommendations of the BMBF Process. In 2014, the BMBF set up an agenda in support of the Green Economy (Leitinitiative "*Nachhaltiges Wirtschaften*"), with the aim of shaping a process towards a green economy through application-related research, involving the relevant stakeholders and players from business, science, society and politics in a participatory approach. The new green economy agenda is in line with Germany's strategy for a bioeconomy.

Targeting priority areas/sectors (e.g. new industrial policy, clean tech)

Germany holds an internationally leading position in the establishment of a bio-based and sustainable economy, for which the National Research Strategy BioEconomy 2030 has laid the foundations since 2010. As an interdepartmental strategy, this comprises a series of funding initiatives and programmes set up by Ministries on federal and state levels. Since 2012, the federal government has put forward a cross-departmental policy strategy for achieving greater co-operation, with a Global Bioeconomy Summit held in Berlin in 2015. In addition, the HTS establishes priorities for research and innovation in various fields (i.e. the digital economy and society, the innovative workplace, healthy living, intelligent mobility and civil security), including the sustainable economy and energy systems compatible with this. One priority area, the Energy Transition (*Energiewende*), which pledges the transformation of the energy supply system, continues to be one of the flagships of the federal government's Energy Concept, set out in September 2010, and the energy policy resolutions, adopted by Parliament in 2011. The Energy Concept is to be gradually rolled out up to 2050, and sets goals for electricity, heat and transport. The focus is on two core objectives: 1) energy should be used more efficiently, and 2) energy supplies should be increasingly based on renewable energies. The 10-point energy agenda of the Federal Ministry of Economic Affairs and Energy contains key projects for energy reform during the current legislative term and coordinates the timing and substance of the energy transition projects. The funding programme Smart Energy Showcases - Digital Agenda for the Energy Transition (SINTEG 2016-20) aims to develop solutions for a climate-friendly, secure and efficient energy supply, with high proportions of intermittent power generation on the basis of wind and solar energy. In parallel, the BMBF started the Kopernikus Projects in 2016. These are the most comprehensive initiatives for the energy transition so far. They deal with four areas that have been identified by high-level representatives from over 90 institutions and organisations as being the most important for a successful energy transition: Future Grid Structures; Power-to-X; Industry Processes; and Energy Systems Integration. These projects bring together scientific institutions and universities, private companies, and organised civil society in large consortia to work together for up to ten years to develop technological solutions for the transformation of the energy system. These initiatives have become even more crucial, as environmental performance as measured by GDP per unit of CO^2 has decreased considerably since 2012 (figure 5[b]). The federal government is supporting research for a climate-friendly, secure and efficient energy supply with funding of up to USD 293 million PPP (EUR 230 million) in the period 2016-20. Germany continues to enjoy a technology advantage in environment-related technologies (figure 7).

Improving direct and indirect knowledge transfer

German industry and science have strong links, and a very high proportion of public research is funded by industry (figure 5[o]). The HTS aims to create new instruments to improve regional, national and international networking between science and industry. Initiatives under this policy priority include funding efforts for the internationalisation of clusters, developing technology-specific open innovation research programmes and dual vocational training systems, and creating incentives for public procurement by municipalities. In 2015, a programme (*Validierung des technologischen und gesellschaftlichen Innovationspotenzials wissenschaftlicher Forschung* – VIP+) was launched that is intended to support the validation of the results of basic public research in terms of feasibility and economic or societal impact, open up possible fields of application, and inspire academics concerning the economic and social relevance of their research results. The programme provides grants for projects with a maximum duration of three years. Grants can be up to USD 638 000 PPP (EUR 500 000) per project and year, and a maximum of USD 1.9 million PPP (EUR 1.5 million) per project). About 140 projects have been funded by the preceding pilot measure VIP – the last approved projects will be running till 2017. In 2016, a funding measure *Innovative Hochschule* was launched to support third mission activities at German universities and boost knowledge transfer and innovation. The programme aims in particular at small and mid-size universities and applied sciences universities. It reinforces the strategic development and intensification of collaboration with firms and other societal stakeholders, thereby strengthening the role of universities in the regional innovation system.

Improving the framework conditions for innovation (e.g. competitiveness)

The HTS aims to optimise the framework conditions of the German innovation system by assuring the supply of skilled personnel, the availability of innovation financing and the provision of other societal, technical and legal foundations. As Germany's venture capital (VC) market is at the OECD median (figure 5[h]), VC holding companies investing in young technology-based firms obtain tax relief, and the Investment Grant for Business Angels, started in 2013, reimburses 20% of VC investments that remain in the start-up company for more than three years. This complements existing instruments such as the *High-Tech Gründerfonds* (HTGF) for start-up firms (since 2005), which invests in young, high-opportunity technology companies, aiming to finance start-ups until they are "venture capital capable" or are generating their own turnover.

Targeting innovative entrepreneurship and SMEs

The HTS supports innovation in German industry, and provides special support for small and medium-sized enterprises (SMEs) and technology-oriented start-ups, with a view to enabling such companies to become technology leaders that can shape future markets. Initiatives include the extension of a programme for the funding of cutting-edge research by SMEs to companies counting over 1 000 employees; the improvement of the Central Innovation Programme for SMEs (ZIM), as well as its extension to companies with up to 499 employees; and an increase in funding for international cooperation. In addition, the EXIST programme, which is aimed at improving the entrepreneurial environment at universities and research institutions and at increasing the number of technology and knowledge-based business start-ups, has recently been updated, and the funding and support available has been increased. The EXIST programme comprises three schemes: 1) the EXIST Culture of Entrepreneurship supports universities in formulating and implementing a comprehensive and sustained university-wide strategy for developing an entrepreneurial culture and spirit, 2) the EXIST Business Start-up Grant supports students, graduates and scientists in preparing innovative technology and knowledge-based start-up projects, and 3) the EXIST Transfer of Research funds both the resource development necessary to prove the technical feasibility of start-up ideas based on research as well as the preparation necessary to launch a business. In 2016, the BMBF issued a new SME strategy: Give Way to SME – BMBF's Ten Points Programme for More Innovation in Small and Medium-Sized Enterprises. It contains a number of new measures addressed at SMEs that are less involved with R&D and have less public support, and it is intended to open discussion to a broader range of stakeholders (SMEs, public and private higher education institutions, research institutions and other organisations that are involved with research and development). Its initial measures aim to implement new networks (*Innovationsforen Mittelstand*) and

to make use of existing ones to develop strategic cooperation between SMEs and strong partners (KMU-NetC).

Some key STI performance indicators

Figure 2. Economic performance

Labour productivity, GDP per hour worked, index 2005=100

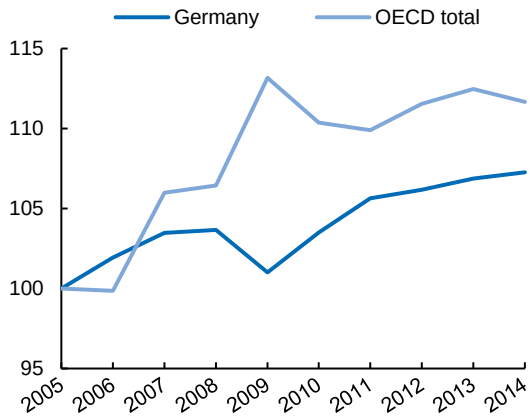


Figure 3. Environmental performance

Green productivity, GDP per unit of CO_2 emitted, index 2005=100

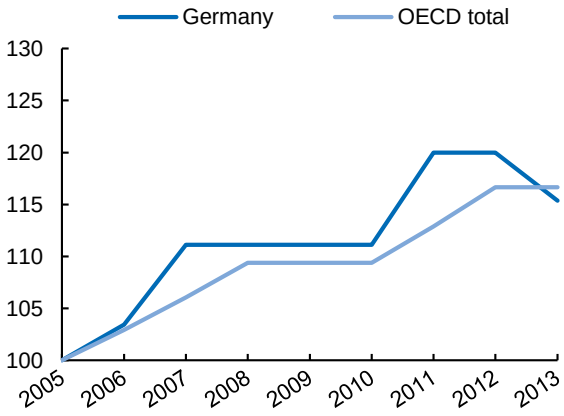
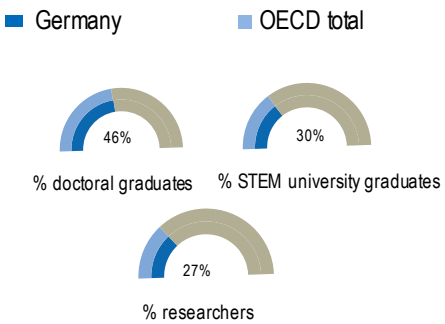


Figure 4. Women in science

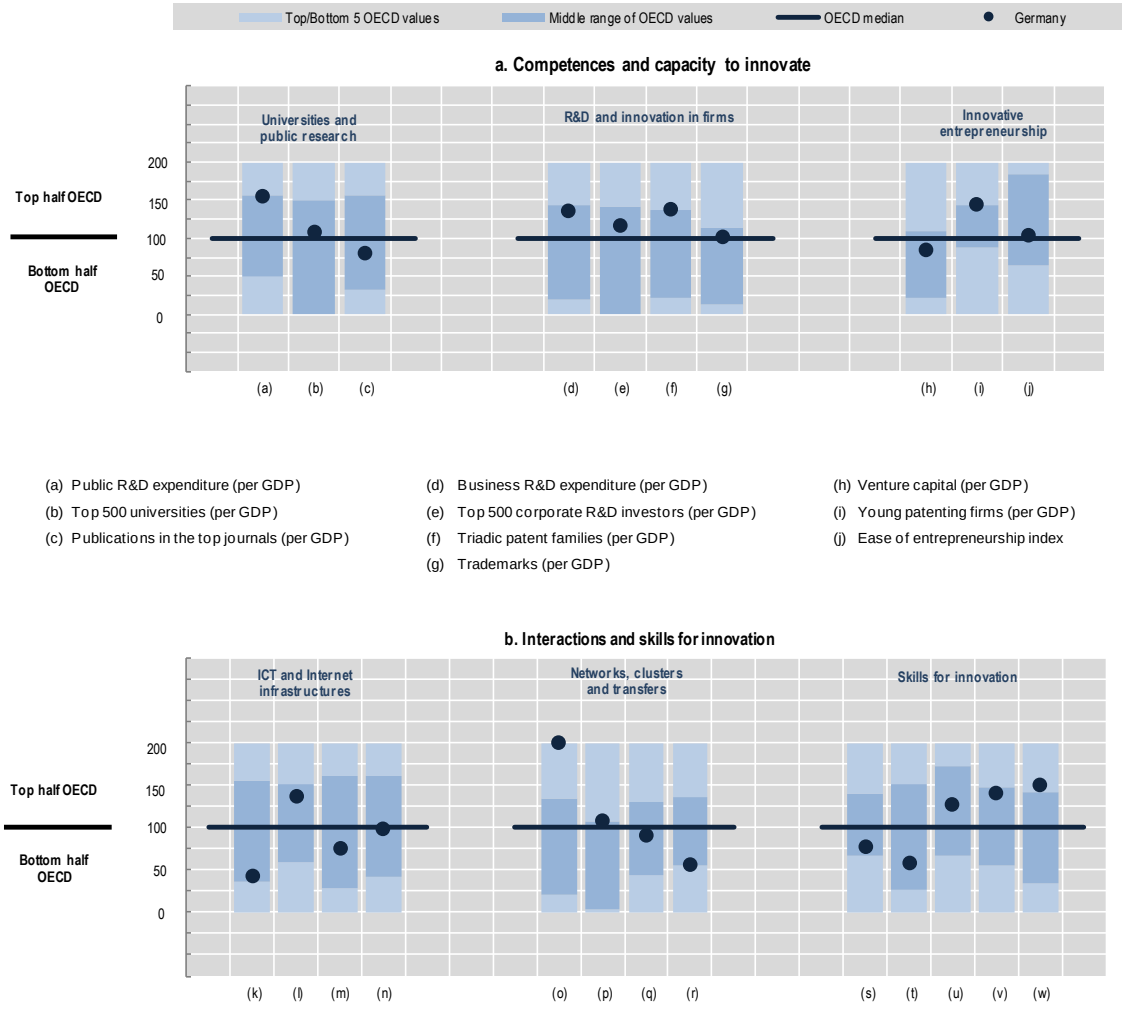
2014 or latest year available



Benchmarking national STI systems

Figure 5. Science and Innovation in Germany

Comparative performance of national science and innovation systems, 2016



(a) Public R&D expenditure (per GDP)
(b) Top 500 universities (per GDP)
(c) Publications in the top journals (per GDP)
(d) Business R&D expenditure (per GDP)
(e) Top 500 corporate R&D investors (per GDP)
(f) Triadic patent families (per GDP)
(g) Trademarks (per GDP)
(h) Venture capital (per GDP)
(i) Young patenting firms (per GDP)
(j) Ease of entrepreneurship index

(k) ICT investment (per GDP)
(l) Fixed broadband subscriptions (per population)
(m) Wireless broadband subscriptions (per population)
(n) E-government development index
(o) Industry-financed public R&D expenditure (per GDP)
(p) Patents filed by universities and public labs (per GDP)
(q) International co-authorship (%)
(r) International co-invention (%)
(s) Tertiary education expenditure (per GDP)
(t) Adult population at tertiary education level (%)
(u) Top adult performers in technology problem-solving (%)
(v) Top 15 year-old performers in science (%)
(w) Doctoral graduate rate in science and engineering (%)

Note: Normalised index of performance relative to the median values in the OECD area (Index median=100).

Highlights of the German STI system

STI policy governance

The federal government considers the HTS to be an ongoing learning process that continually needs to be adapted to new challenges. A consultative body, the High-Tech Forum, which consists of representatives of science, industry and society, has been charged with developing proposals for the strategy's further development and implementation. Advice is being offered to determine suitable funding opportunities at the federal and European level, as well as interdepartmentally.

Universities and public research

Germany has high public spending on R&D at 0.43% of GDP in 2014 (figure 5[a]). GBAORD increased by about 9% between 2011 and 2015, despite fiscal consolidation. Germany ranks fourth globally in terms of publication output and number of citations. Given the size of its GDP, publications in top journals are somewhat below the OECD median (figure 5[c]). In 2014, the heads of the federal government and the *Länder* agreed to renew the Pact on Research and Innovation – which came into force in 2005 – and to increase the basic funding of major public research institutions by 3% annually between 2016 and 2020. This will amount to USD 5 billion PPP (EUR 3.9 billion) of additional funding for R&D. In the current third phase of the Pact, the budgetary increase is being financed by the federal government alone. In 2016, the government decided to convert the Initiative for Excellence, which aims to enhance the international visibility and competitiveness of universities as centres of research, into a permanent support scheme to improve university planning. While support for excellence clusters and institutional strategies will be maintained, the funding for graduate schools can be integrated into the excellence cluster or handled within other funding schemes of the German Research Foundation. In 2016, the federal government and the Länder also decided to further promote junior scholars. A new programme aims to improve the predictability and transparency of career paths by establishing tenure-track professorships at German universities, with federal government funding for 1 000 additional tenure-track professorships. The programme lasts until 2032. In September 2016, the BMBF published its Open Access Strategy to foster open access as a standard model for publishing in Germany. One key measure is the introduction of an Open Access clause in its own funding guidelines. Papers produced from BMBF-funded projects shall be published under green or gold Open Access rules. Several Länder have implemented Open Access strategies as well to promote more inclusive and open participation specifically at the university level.

Innovation in firms

The same time period will see a transition from more supply-side instruments for business R&D and innovation towards more demand-side measures aimed at boosting market opportunities and demand for innovation and encouraging suppliers to meet expressed user needs. Business expenditure on R&D is well above the OECD median, owing to Germany's specialisation in R&D-intensive industries (figures 5[d] and 6). In recent years, many research and innovation activities have been bundled into framework programmes that follow the objectives of the HTS, i.e. focusing research funding on major global challenges. In addition, innovation programmes especially for SMEs have been opened to all topics and technologies, with the aim of enabling companies to innovate according to their business needs and best knowledge of the markets.

ICT and Internet infrastructure

The coverage of fixed and mobile broadband infrastructure is uneven in Germany, the latter being particularly weak by OECD standards (figure 5[l,m]). Germany's Digital Agenda 2014-17 aims to strengthen the security of online services via secured ICT infrastructures and to reinforce the IT security industry. In an attempt to meet the rising need for stronger productivity growth and to fully benefit from digitisation, this Agenda includes initiatives to increase digitisation and automation in manufacturing and measures to promote information on best practices for industry and smart service applications. Moreover, it aims to improve co-ordination and interoperability between key stakeholders and their IT systems and to address

emerging IT security risks related to the increasing digitisation of the healthcare system. Germany lags the OECD median with respect to technological advantage in ICT (figure 5[k]). Recent policy has highlighted the importance of VC investment to support the development of a strong globalised ICT sector, with a particular focus on support for IT start-ups. Specific measures cited in the Digital Agenda 2014-17 include: i) information and advice for founders; ii) improvements to financing through internationally competitive conditions for VC and crowd investments; iii) "matching" start-ups to traditional businesses with related economic activities; iv) targeted support of founders, including their links to other German start-ups; and v) the creation of international start-up "hubs", including incubators.

Globalisation

German researchers are well connected internationally; 44% of scientific articles are published with international co-authorship (figure 5[q]). Germany has several initiatives specifically to support cross-border co-operation within STI programmes. The overarching policy framework is the National European Research Area (ERA) Strategy, adopted in July 2014, and the International Co-operation Action Plan of the BMBF, which provides the basis for Germany's forthcoming Internationalisation Strategy. A major priority of the HTS is the strategic global networking of companies and science in Germany and their integration into global flows of knowledge through international collaboration. Leading-edge clusters, future projects and comparable networks provide an excellent starting point. The funding measure Internationalisation of Leading-Edge Clusters, Future Projects, and Comparable Networks aims to foster respective organisations in strategic internationalisation activities and to build up international R&D co-operation. In 2015, the project EXIST-Start-up Germany-Israel was started, with the aim of connecting the academic start-up scenes in Germany and Israel by supporting the applications of Israeli tech-entrepreneurs to the EXIST Business Start-Up Grant programme. This new support scheme complements the well-established German Accelerator programme, which provides German tech start-ups with mentorship and access to local networks in the San Francisco Bay Area and New York and in Boston/Cambridge for the life sciences.

Skills for innovation

Trends on the German labour market are generally favourable. At over 41 million, the number of employees has never been higher. At the same time, some sectors and regions lack qualified professionals. According to the analytical evidence gathered by Germany, by 2025 demographic changes are expected to result in a shortfall of several million workers, while the effective integration of newly arrived immigrants into the labour market will require a major effort. A number of measures aim to counteract the emergence of shortages of workers with the required skills; these include: i) the National Pact for Women in science, technology, engineering and mathematics (STEM) Careers, which was launched in 2008 and has entered phase three, ii) several new state-level initiatives to promote STEM in secondary schools, and iii) nation-wide school student and youth competitions, which are devised to select the participants in the respective International Olympiads, including in physics, mathematics and chemistry.

Structural aspects and specialisation

Figure 6. Structural composition of BERD, 2013 or latest year available

As a % of total BERD or sub-parts of BERD

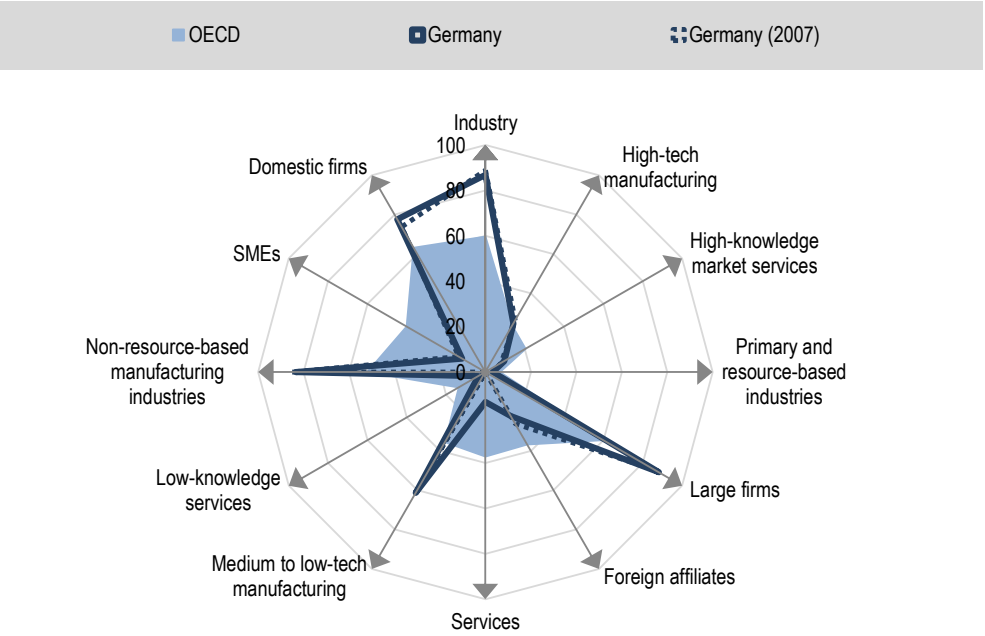
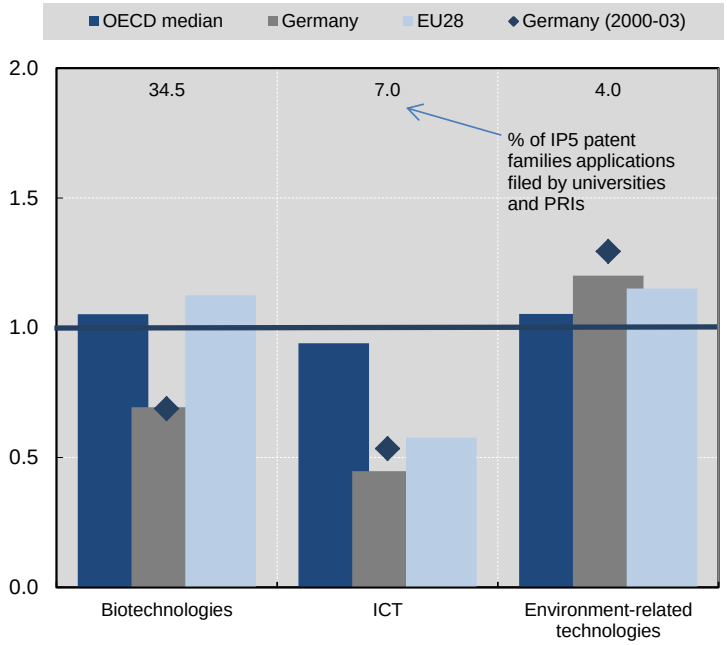


Figure 7. Revealed technology advantage in selected fields, 2011-2013

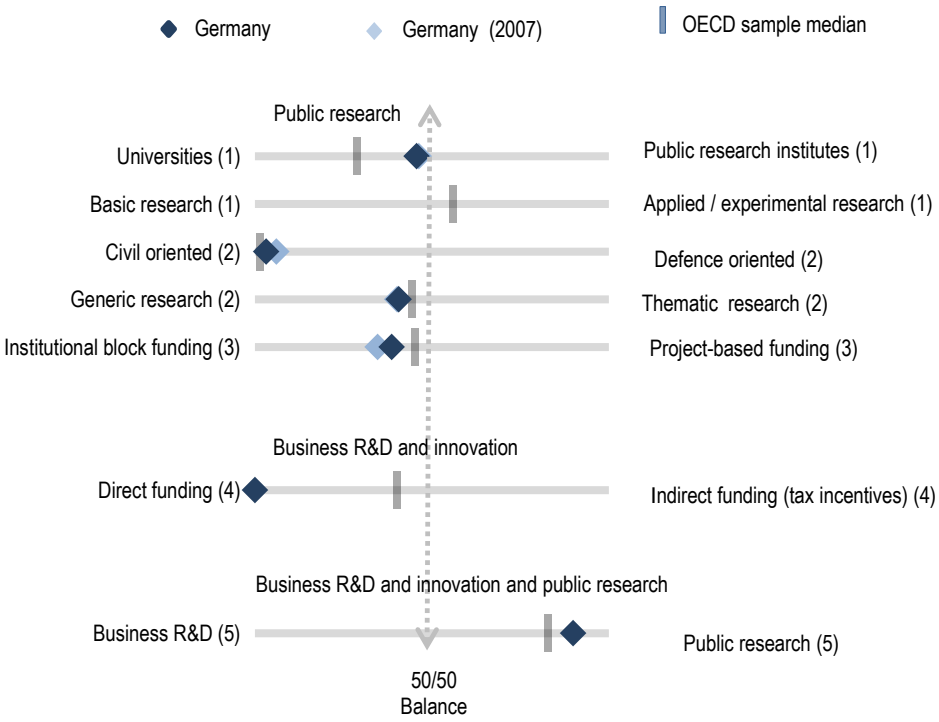
Index based on IP5 patent families applications



National STI policy mix

Figure 8. Allocation of public funds to R&D, 2014 or latest year available

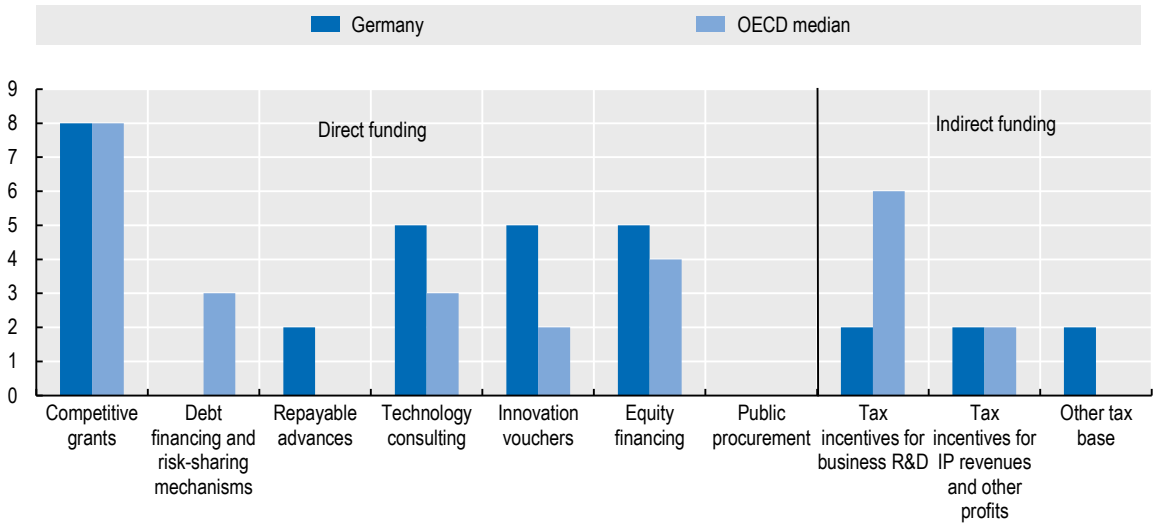
By sector, type of R&D and mode of funding



(1). Balance as a share of both higher education (HERD) and government (GOVERD) R&D expenditure.
(2) Balance as a share of total government budget appropriations and outlays for R&D (GBAORD).
(3) Balance as a share of total funding to national performers.
(4) Balance as a share of both indirect funding (through R&D tax incentives) and direct funding (through grants, procurement, loans, etc.).
(5) Balance as a share of publicly-funded HERD and GOVERD and components of (4).

Figure 9. Most relevant policy instruments of funding for business R&D, 2016

Country self-assessment, index (9 = high and increasing relevance to 0 = not used)



Note: Policy information comes from country responses to the EC/OECD International Survey on STI Policies (STIP) 2016 and 2014. Germany's responses are available in the EC/OECD International Database on STI Policies, edition 2016 at http://qdd.oecd.org/DATA/STIPSurvey/DEU...STIO_2016.

Source: See the reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888933433812

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