G20 INNOVATION REPORT 2016

Report prepared for the G20 Science, Technology and Innovation Ministers Meeting

BEIJING, CHINA,
4 NOVEMBER 2016

OECD
BETTER POLICIES FOR BETTER LIVES

This report of the Organisation for Economic Co-operation and Development has been prepared at the request of G20 Leaders (Hangzhou Summit Communique, 4-5 September 2016). An initial prototype was prepared for the Third G20 Sherpa Meeting in Xiamen, China, 23-25 June 2016.

This report is based on material from the OECD's *Science, Technology and Industry Scoreboard 2015* (with data updates where available) and the forthcoming *Science, Technology and Innovation Outlook 2016*. The latter publication benefits from policy information gathered via the joint European Commission/ OECD International Survey on Science, Technology and Innovation Policy (STIP).

TABLE OF CONTENTS

Part 1

SELECTED INNOVATION INDICATORS

The indicators presented here of science and innovation in the global economy highlight G20 economies' performance in a selection of areas, and track discussions and comments made by the G20 Innovation Task Force. They are mainly based on indicators contained in the *OECD Science, Technology and Industry Scoreboard 2015*. The next *OECD STI Scoreboard* publication will be released in 2017.

Indicators are presented for the following topics:

- Emerging players in the science landscape
- Monitoring STI performance and progress
- Funding long-term, higher-risk research
- Innovation for global challenges
- Enabling the Next Industrial Revolution
- Addressing common challenges through international co-operation in science and innovation
- Raising the quality of science
- Promoting excellence
- Nurturing talent and skills
- Investing in scientists and engineers
- Promoting student exchanges
- Facilitating researcher mobility
- Promoting collaboration in innovation among firms
- Supporting business innovation
- Fostering entrepreneurship
- Empowering society with science and technology

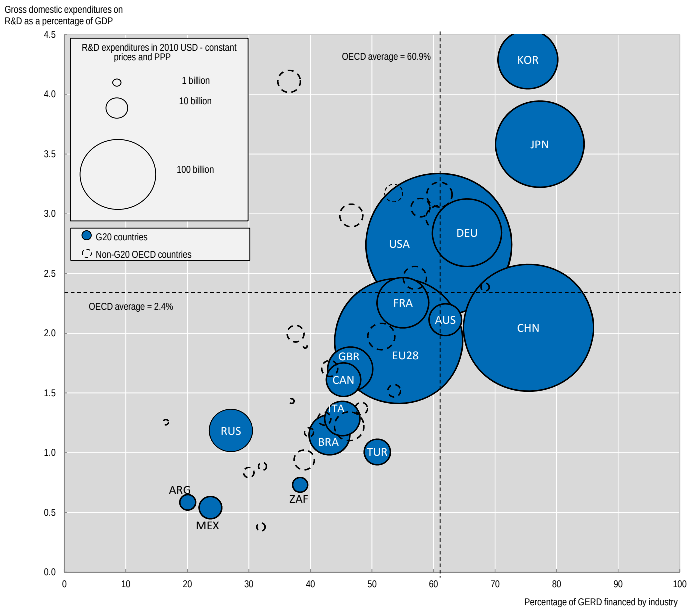
Emerging players in the science landscape

Faced with major economic, societal and environmental challenges at a time when budgets are under pressure, policy makers look for evidence to help them guide efforts to ensure that investments in science and research help improve people's lives.

The United States is the world's largest R&D performer, with nearly USD 433 billion of domestic R&D expenditures in 2013. This exceeds by about one-quarter the amount of R&D performed in the People's Republic of China (hereafter "China"), the second-largest performer, which is broadly on par with the combined EU28 area. Among the G20, Korea has the highest ratio of R&D expenditures to gross domestic product (GDP) owing to rapid increases in recent years. Emerging G20 economies account for a growing share of the world's R&D.

Increasing national investment in R&D requires the combination of public and private efforts. In the more developed economies, the business sector accounts for the largest share of R&D spending. Here, it is mostly directed towards developing new products and processes to introduce in the market, building on existing and developing new knowledge. Governments and higher education institutions play a key role in developing both fundamental and applied knowledge that provides the basis required for major, paradigm-changing breakthroughs. However, excessive reliance on public sector investment can prevent economies from reaping the economic benefits of knowledge investments. Overall, the cross country relationship between R&D intensity and business financing of R&D expenditure suggests that high levels of economy wide R&D investment are not attainable without a strong private sector commitment.

Figure 1. R&D in selected G20 economies, 2013



Sources: OECD, *Main Science and Technology Indicators* database, January 2016, www.oecd.org/sti/msti.htm; data for Brazil from UNESCO Institute for Statistics, November 2015.

WHAT DO WE MEAN BY R&D?

As defined in the OECD's *Frascati Manual* (http://oe.cd/frascati), R&D comprises basic research (aimed at creating new knowledge with no specific application in view), applied research (new knowledge towards a specific practical aim) and experimental development (to develop new products or processes). OECD data show that businesses are far more likely to invest in development than in research. The *Frascati Manual* recommends reporting separately the performance and funding of R&D, grouped by "broad" sectors that include business, higher education, government and other non-profits. Business or industry funding of R&D comprises the portion of R&D carried out within any sector of the economy that is directly funded by resident businesses. Typically, the share of R&D financed by industry is less than the share of R&D performed by firms in this sector, but this excludes the financing of R&D performed abroad, including by affiliates.

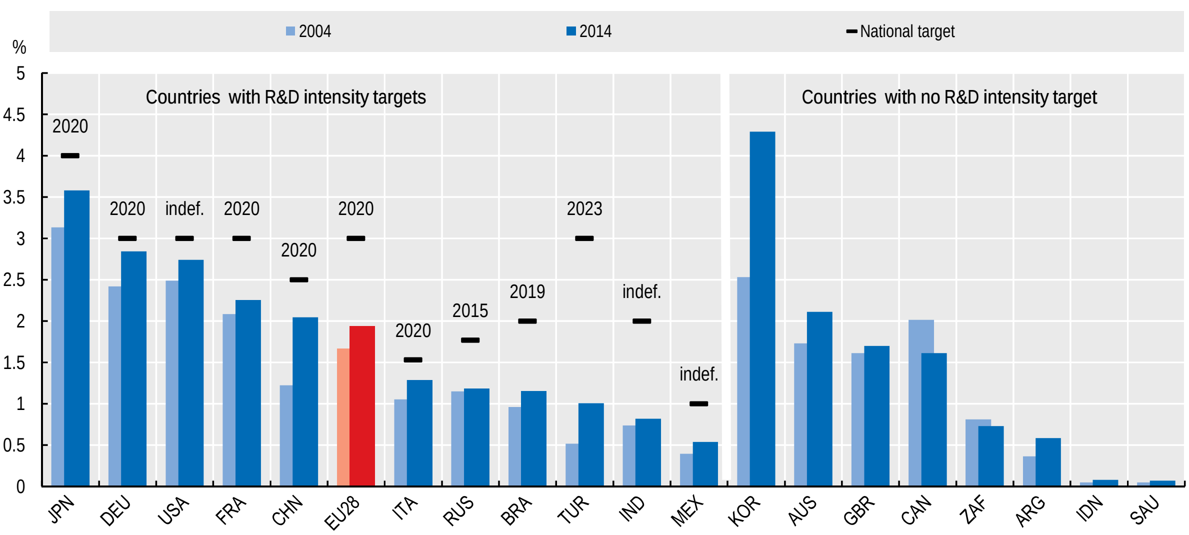
Monitoring STI performance and progress

Many OECD countries and G20 economies have adopted quantitative targets to benchmark their science, technology and innovation (STI) performance and progress, especially through targets for R&D spending. The target volume of R&D expenditure is often expressed as a percentage of GDP.

With STI budgets under pressure, many governments' capacity to drive further increases in domestic R&D expenditure is limited. The gap between overall strategic R&D spending targets and current R&D expenditure in most cases remains too large to be closed by the foreseen date. The relevance and feasibility of targets also largely depends on the structure of economies and their positioning in global value chains, as industries differ in their propensity to carry out R&D. In the G20, the industrial structure varies considerably from service-based economies to manufacturing or resource-based ones. The innovation potential of economies with different sectoral profiles may be more responsive to forms of knowledge-based capital, i.e. innovation assets beyond R&D, thus limiting the potential relevance of the R&D intensity target.

Figure 2. National R&D expenditure targets and gap with current levels of GERD intensity, G20 economies, 2014

As a percentage of GDP



Note: "indef." is an abbreviation for indefinite or no fixed end date for reaching the target.

Sources: OECD, *Main Science and Technology Indicators* database, www.oecd.org/sti/msti.htm, January 2016; data for Brazil, India, Indonesia and Saudi Arabia from UNESCO Institute for Statistics, November 2015; data on national R&D targets from country responses to OECD STI Outlook policy questionnaire 2014 and national sources (Brazil).

R&D TARGETS

Information on R&D targets is derived from information collected through the questionnaire for the *OECD Science, Technology and Innovation Outlook*. Gross domestic expenditure on R&D (GERD) is the main aggregate used for international comparisons of R&D expenditures. For comparisons and target setting, GERD is typically normalised by the level of economic activity as percentage of GDP, and this is referred to as the R&D intensity of an economy. Data on GERD are collected through surveys of R&D performing institutions and firms. Despite common reference reporting guidance – the OECD's *Frascati Manual* – national R&D surveys often follow different sampling and estimation methods.

Funding long-term, higher-risk research

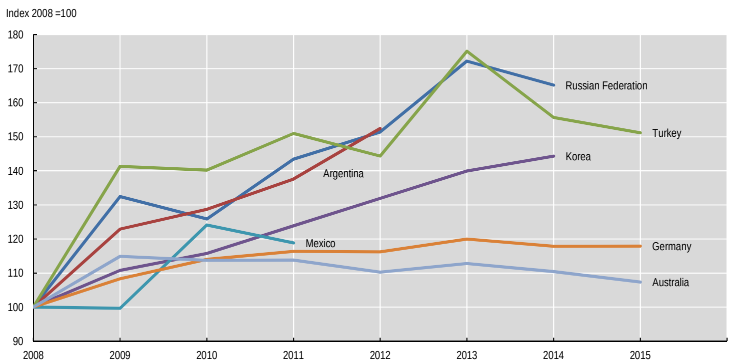
As with other types of investment, expenditures in R&D and innovation are pro-cyclical – they are positively related to an economy's level of activity. In recent years, government budgets for R&D have started to level off or even decline in many OECD and G20 economies. In some cases, this has been partly due to the re-orientation of public support to other innovation support instruments, such as R&D tax incentives.

Rapid increases in public R&D funding, potentially followed by periods of rapid cuts, may have a deleterious impact on the performance of the science system by creating adjustment problems and discouraging long-term planning. Severe adjustments can have a particularly marked impact among younger and non-tenured research personnel, especially if there is limited absorptive capacity in the private sector. Research activities subject to merit-based competitive funding can bear a disproportionate share of cuts when there are rigidities in public research systems, which can then compromise scientific excellence.

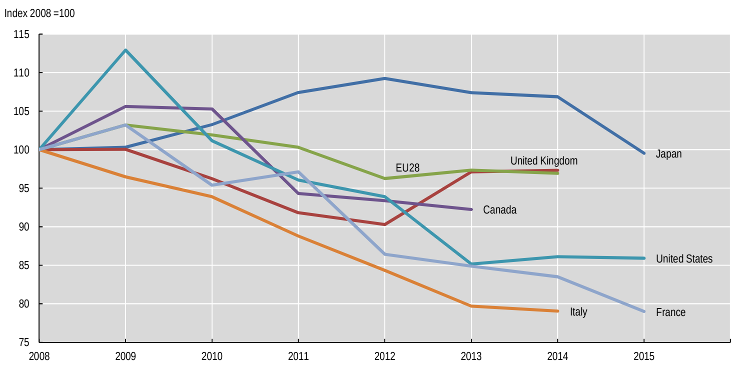
Figure 3. Government R&D budgets, selected G20 economies, 2008-2015

Index 2008 = 100

PANEL A: Countries where government-funded R&D has grown since 2008



PANEL B: Countries where government-funded R&D has declined since 2008



Source: OECD, calculations based on *Main Science and Technology Indicators* database, www.oecd.org/sti/msti.htm and *Research and Development Statistics* database www.oecd.org/rds, January 2016.

HOW DO WE MEASURE GOVERNMENT DIRECT SUPPORT TO R&D?

Government budgets for R&D provide timely estimates of government direct support for R&D as recognised in budgetary information. Funding may be allocated for R&D to be carried out in subsequent years. For a number of G20 economies (such as China) it is not possible to report budgetary support for R&D separately from other public investments in STI. Detailed data on budgets from R&D, also by socio-economic objectives, are available from the OECD's *Research and Development Statistics* database (www.oecd.org/sti/rds.htm).

Innovation for global challenges

Long-term, higher-risk research leads to the development of frontier technologies and data-driven applications that are needed to help tackle global challenges. Recent technology developments have focused on global issues (climate change, ageing societies, food security), on productivity growth (e.g. new manufacturing processes), and on environmental and social concerns that raise specific challenges and opportunities for STI policies.

While the United States and the European Union (EU) continue to play a leading role in health innovation, ageing-related challenges have led to increases in patent filing in this area in Japan and most G20 Asian economies, including Korea, China and India. For environmental technologies, EU countries increased their patenting activity and accounted for 28% of total applications in 2010-13, while Japan and the United States experienced a relative decline in the field, linked to increased activities in Asia, especially in Korea and China. The G20 accounted for over 90% of world health-related and climate change mitigation technologies IP5 (see below) patent families in 2010-13.

Figure 4. Health-related patents, 2000-03 and 2010-13, G20 economies

Share of G20 economies in IP5 patent families

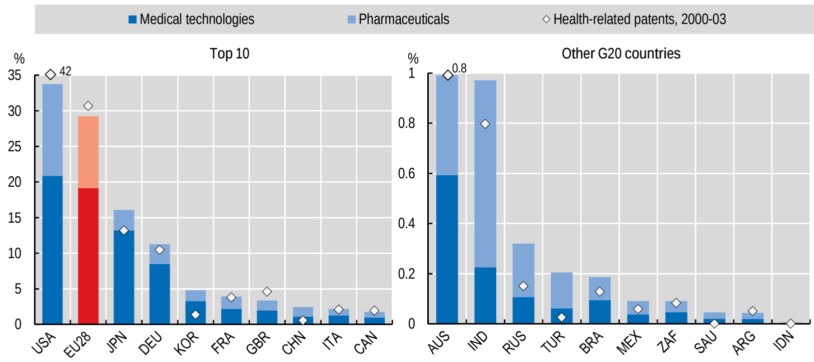
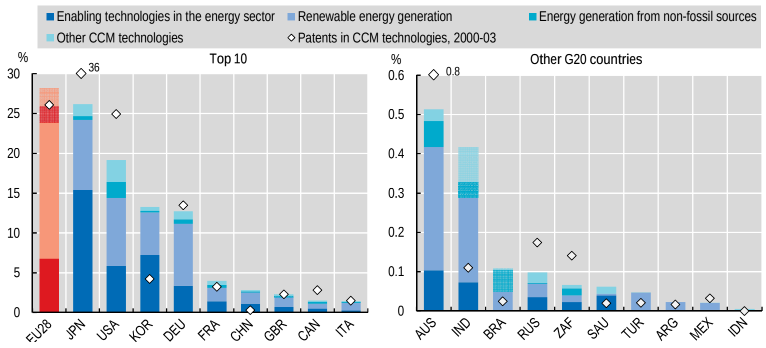


Figure 5. Patents in climate change mitigation (CCM) technologies, 2000-03 and 2010-13, G20 economies

Share of G20 economies in IP5 patent families



Source: OECD, *STI Micro-data Lab: Intellectual Property* database, http://oe.cd/ipstats, June 2015.

DEFINING THE TECHNOLOGIES

Data supplied by different patent authorities can be used to follow the development and diffusion of key enabling technologies. Statistics are compiled using information on patent families within the Five largest IP offices (IP5, i.e. USPTO, EPO, SIPO, JPO and KIPO), with patent family members filed at the European Patent Office (EPO) or US Patent and Trademark Office (USPTO) and attributed to economies on the basis of location of the patent owner. This approach maximises comparability in terms of the prospective value of inventions.

Health-related patents are identified in line with the 2013 WIPO concordance. Pharmaceutical patents are filed under Class A61K of the International Patent Classification (IPC), excluding A61K8/* (cosmetics). Medical technology patents relate to IPC Classes A61 (B, C, D, F, G, H, J, L, M, N) and H05G. *Environmental technology patents* are identified using refined search strategies based on the IPC and the Cooperative Patent Classification (CPC), and draw upon the expertise of patent examiners at the EPO, as described at www.oecd.org/env/consumption-innovation/indicator.htm.

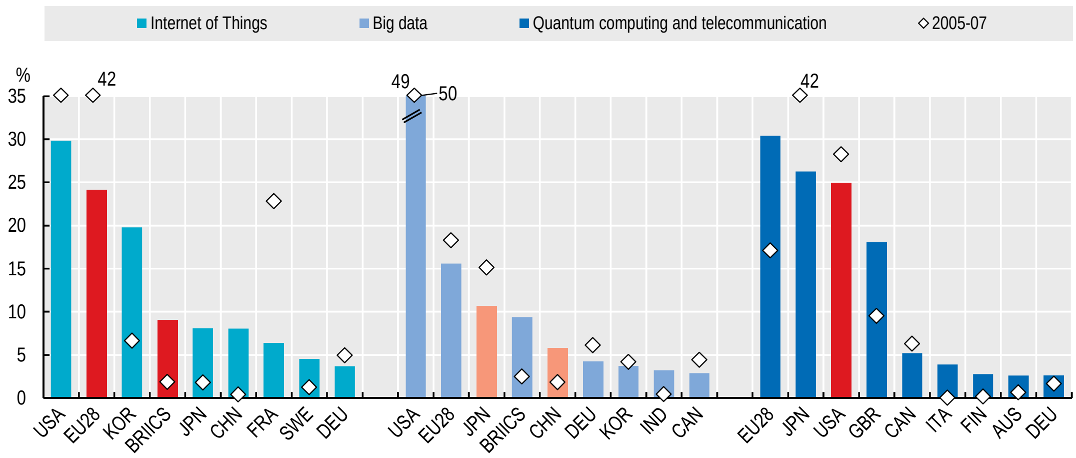
Enabling the Next Industrial Revolution

The Next Industrial Revolution refers to a range of new technologies and applications – advanced robotics, additive or 3D printing, factories embedded with sensors ("industrial Internet") – as well as new techniques like big data analytics. A range of disciplines will need to be mobilised in a way that can harness the changes to multidisciplinary research brought about by the Internet and IT and apply them to a range of fields.

Disruptive technologies displace established ones and affect production processes, the entry of new firms, and the launch of ground-breaking products and applications. Examples of such technologies include sensors, computers and experimental gene therapies. Many of the most exciting or useful products available today owe their existence, performance, efficacy and accessibility to the recent development of disruptive technologies in fields such as advanced materials, information and communication technologies, and health-related technologies. The United States alone contributed 36% of all inventions patented in the case of a new generation of ICTs (i.e. technologies related to the Internet of Things [IoT], big data and quantum computing and telecommunication). Both the European Union and the United States saw their relative share of IoT inventions diminish as G20 Asian countries, in particular Korea, China, and Japan gained ground and contributed about 36% of inventions in Internet of Things-related technologies over 2010-12.

Figure 6. Top players in IoT, big data and quantum computing technologies, 2005-07 and 2010-12

Economies' share of IP5 patent families filed at USPTO and EPO, selected ICT technologies



Notes: The indicators presented here rely on patent families within the Five IP offices (IP5) with patent family members filed at the EPO or USPTO by first filing date and according to the applicant's residence using fractional counts. The distribution of economies reflects the location of patent assignees. The UK government has identified a number of technologies as potential sources of future growth and mapped inventive activity in these technologies over the period 2004-13 through examination of patent documents published worldwide.
Among the identified technologies were a number of enabling technologies that form the basis of the new generation of ICTs, as well as advanced materials and health-related technologies. The new generation of ICT technologies includes quantum computing and telecommunication, the IoT, and big data and energy-efficient computing. Quantum technologies harness quantum physics to acquire functionalities or improve the performance of existing technologies (e.g. microprocessors with more effective computation, leading to patents related to encryption, as well as transmission systems and components). Big data and energy-efficient computing relates to data having such magnitude (typically several petabytes) and high processing speed requirements that require innovative approaches to handling and manipulation. The Internet of Things (IoT) refers to networks of everyday physical objects that can be accessed through the Internet and are able to automatically identify themselves to other devices. Examples include remote control appliances, traffic congestion optimisation, e-health and industrial auto-diagnosis.
Further details on IPO's patent landscape can be found in the *Eight Great Technologies* report (October 2014), www.gov.uk/government/publications/eight-great-technologies-the-patent-landscapes.

Source: OECD calculations based on IPO (2014), *Eight Great Technologies: the Patent Landscapes, United Kingdom*, and *STI Micro-data Lab: Intellectual Property* database, http://oe.cd/ipstats, June 2015.

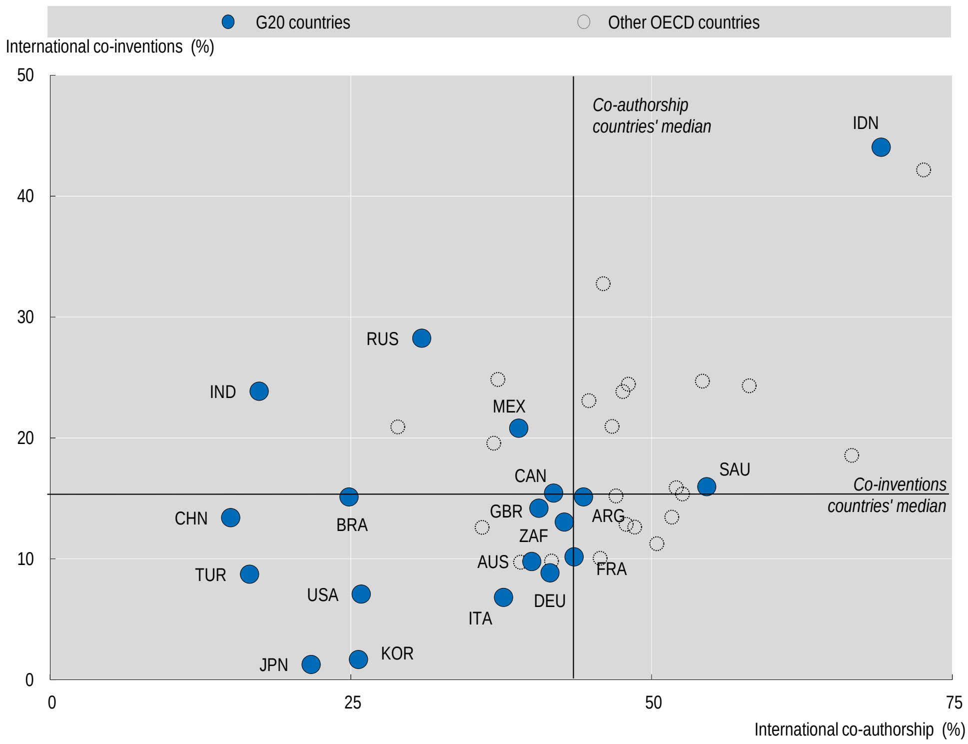
Addressing common challenges through international co-operation in science and innovation

Meeting global challenges is not a one-country endeavour. Co-operation and knowledge flows help address common challenges and empower society.

Collaboration within and across countries is a pervasive feature of research and innovation activities worldwide. This can be documented by tracking the affiliation and geographic location of co-authors of scientific publications and co-inventors of patented inventions. With the exception of Indonesia, most of the G20 economies (blue circles) have lower than median international collaboration, both in scientific production and in inventive activities. While exhibiting similar levels of engagement in international co-authorships, highly innovative economies such as Japan, Korea and the United States present different levels of co-patenting, with Asian inventors being relatively more engaged in within-country collaboration. Factors such as scientific and technological specialisation, collaboration opportunities, and geographical and institutional proximity may contribute to explaining these patterns.

Figure 7. International collaboration in science and innovation, G20 economies, 2003-12

Co-authorship and co-invention as a percentage of scientific publications and IP5 patent families



Notes: "International co-inventions" are those that include at least one foreign co-inventor in total patents invented domestically. Data refer to IP5 patent families with members filed at the European Patent Office (EPO) or the US Patent and Trademark Office (USPTO), by first filing date and according to the inventor's residence using whole counts.

"International co-authorship" of scientific publications is measured in terms of the share of articles featuring authors affiliated with foreign institutions (from a different country or economy) in total articles produced by domestic institutions. Most G20 economies fall in the bottom left quadrant, indicating a relatively low share of both international scientific co-authorships and patented co-inventions. For Japan, scientific co-authorship just exceeds 20%; however this is higher than the level of international patent co-invention, which stands at less than 2%.

Sources: OECD, *STI Micro-data Lab: Intellectual Property database*, http://oe.cd/ipstats, June 2015; OECD and SCImago Research Group (CSIC) (2015), *Compendium of Bibliometric Science Indicators 2014*, http://oe.cd/scientometrics.

Raising the quality of science

Co-operation and knowledge flows also help raise scientific quality and innovation capabilities. Production of scientific knowledge has shifted progressively from individuals to groups, from single to multiple institutions, and from the national domain to the international arena. Scientific researchers increasingly network across national and organisational borders. Single authors affiliated to a single institution currently account for less than 15% of scientific publications. The proportion of documents involving international collaboration in some form has nearly doubled since 1996, reaching close to 20% in 2013, although most scientific collaborations are still of a domestic nature. Estimates suggest a positive relationship between measures of scientific research collaboration and citation impact. This relationship appears to be stronger in economies with lower levels of scientific production, highlighting the importance of scale, which smaller economies attempt to overcome by participating more intensively in global networks. However, several larger G20 economies still lie in the quadrant corresponding to lower levels of scientific collaboration and lower level of scientific impact.

Figure 8. The citation impact of scientific production and the extent of international collaboration, G20 economies, 2003-12

Notes: Scientific collaboration is defined as co-authorship involving different institutions. International collaboration refers to publications listed in the Scopus database that are co-authored among institutions in different countries. Estimates are computed for each country by counting documents for which the set of listed affiliations includes at least one address within the country and one outside. The normalised impact measure is derived as the ratio between the average number of citations received by the documents published by authors affiliated to an institution in a given economy and the world's citation average, over the same time period, by document type and subject area. A similar pattern arises if one looks at measures of scientific excellence (e.g. the percentage of domestic documents among the world's 10% top-cited) instead of average citation impact.

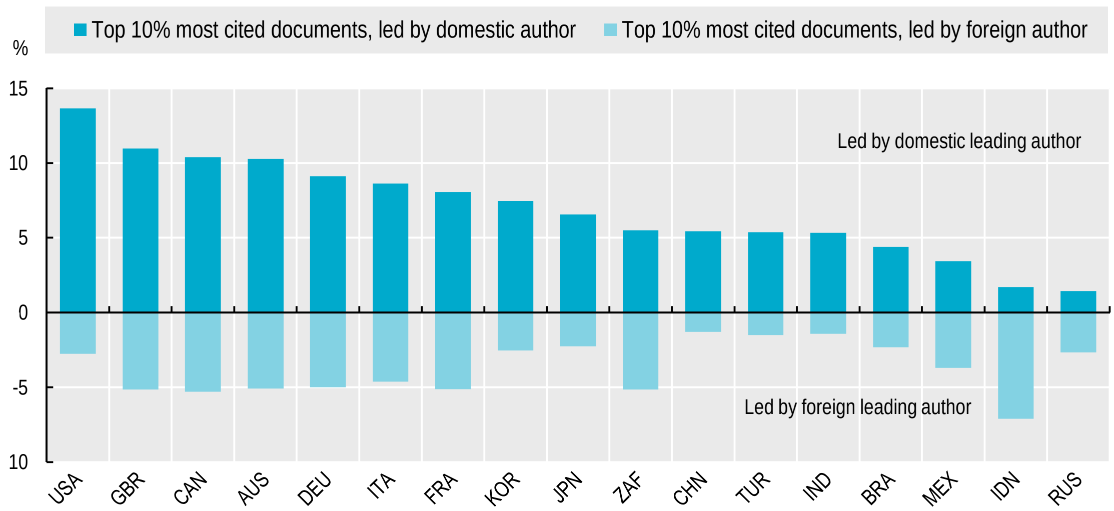
Source: OECD and SCImago Research Group (CSIC) (2015), *Compendium of Bibliometric Science Indicators 2014*, http://oe.cd/scientometrics.

Promoting excellence

How do countries benefit from international scientific collaboration? International collaboration allows authors in different countries to partner with leading experts elsewhere, sharing knowledge, costs and rewards. Combining the analysis of excellence and leading authorship (i.e. the affiliation of the leading author) can provide further insights into the source of a country's highly-cited publications. In the United States, for example, 17% of publications are among the top 10% most cited globally, of which 14% had a US-based author listed as the leading author, while only 3% are led by authors with affiliations abroad. Accordingly, while the United States has levels of "scientific excellence" similar to the ones of the United Kingdom, as measured by this indicator, the United States has the largest share of top-cited publications led by domestic authors among the G20 economies. Other countries with higher overall excellence rates display lower levels of leading excellence because of the higher importance of collaborative articles led by authors from other countries. For example, while Japan and Indonesia display an equal share of top 10% cited scientific publications, scientific leadership in Indonesia is much lower than in Japan.

Figure 9. Top 10% most cited documents and scientific leading authorship, selected G20 economies, 2003-12

As a percentage of all documents, whole counts



Notes: The indicator of scientific excellence indicates the percentage of a unit's scientific output that is included in the global set of the top 10% of cited papers in their respective scientific fields. This indicator can be used in combination with information on the affiliation of the corresponding author, domestic or based abroad, to better describe the role of international collaboration as a driver of scientific excellence. The concept of leading authorship can obey different norms within scientific groups and disciplines. The leadership criterion for attribution gives no weight to other contributors not listed as leading, so it should be interpreted carefully in conjunction with other indicators. Scientific leadership indicators help explain the role of a given institution or country in collaboration activities, as reflected in publication output. In this case, the lower part of the chart documents the contribution of foreign-led documents to the overall excellence rate for documents involving authors from the reference economy. Among the G20 economies for which data are available, this component is largest in the case of Indonesia and smallest for the United States.

Source: OECD and SCImago Research Group (CSIC) (2015), *Compendium of Bibliometric Science Indicators 2014*, http://oe.cd/scientometrics.

Nurturing talent and skills

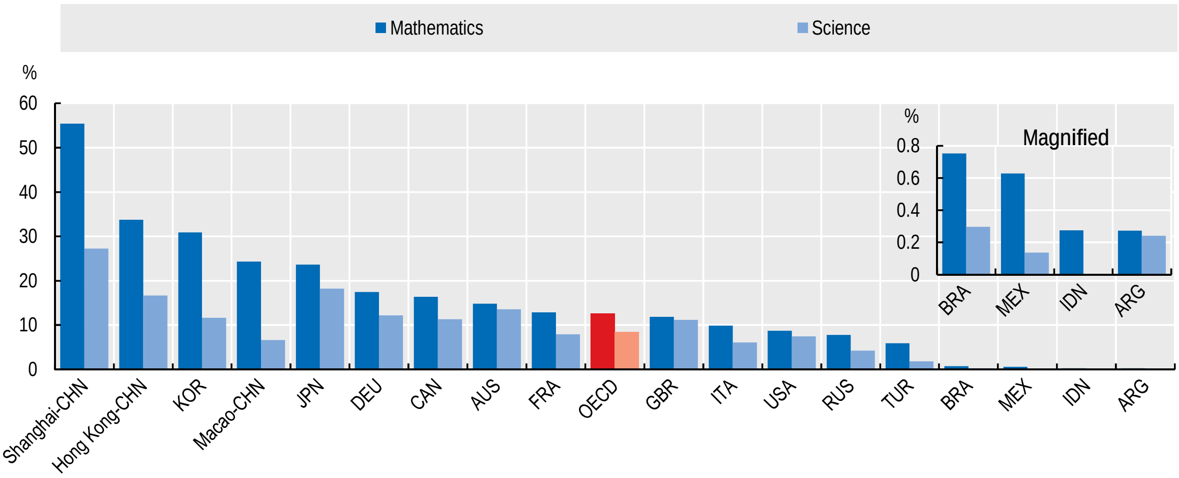
Education systems play a broad role in supporting innovation as knowledge-based societies rely on a highly qualified and flexible labour force in all sectors of the economy and society. Innovation requires the capacity to continually learn and upgrade skills.

While basic competencies are generally considered important for absorbing new technologies, high-level competencies are critical for the creation of new knowledge and technologies. Emphasis is increasingly placed on capabilities for adapting and combining multidisciplinary knowledge and performing complex problem-solving. The acquisition of such skills starts at a very early age.

A focus on top-performing students allows for a better understanding of proficiency patterns among 15-year-olds. Data from the OECD's Programme for International Student Assessment (PISA) show that in all G20 economies, the share of top performers was higher in mathematics than in science. However, the variability in the proportion of top performers across countries suggests differences in countries' potential capacities to staff future knowledge-driven industries with home-grown talent.

Figure 10. Top performers in mathematics and science, selected G20 economies, 2012

Percentage of students reaching the two highest levels of proficiency



Notes: The OECD PISA programme assessed in 2012 the skills of 15 year-olds in 65 economies. Around 510 000 students participated, representing 28 million 15 year-olds globally.

"Students" assessed by PISA are between the ages of 15 years 3 months and 16 years 2 months. They must be enrolled in school and have completed at least 6 years of formal schooling, regardless of the type of institution, the programme followed, or whether the education is full-time or part-time.

"Top performers in science" are students proficient at Levels 5 and 6 in the PISA 2012 science assessment (i.e. they have obtained scores higher than 633.3 points). "Top performers in mathematics" are students proficient at Levels 5 and 6 in the PISA 2012 mathematics assessment (i.e. with scores higher than 607.0). These students are expected to be at the forefront of a competitive, knowledge-based global economy. They are able to draw on and use information from multiple and indirect sources to solve complex problems.

Source: OECD (2014), *PISA 2012 Results: What Students Know and Can Do – Student Performance in Mathematics, Reading and Science* (Volume I, Revised edition, February 2014), OECD Publishing, Paris, http://dx.doi.org/10.1787/9789264208780-en.

Investing in scientists and engineers

Societies require a wide array of skills and assets to achieve progress. Tertiary education has expanded worldwide to support the supply of highly educated individuals and meet rising demand. Policy makers are particularly interested in the supply of scientists and engineers because of their direct association with technological progress, industrial performance and economic growth. The supply of graduates in the natural sciences and engineering (NS&E) may relate to opportunities in labour markets and their ability to absorb highly specific skills, both at home and abroad.

The proportion of NS&E graduates among the subpopulation of doctorates is higher than for other tertiary levels, reaching an average of approximately 40% for a sample of G20 economies. The natural sciences account for almost 50% of new doctoral degrees awarded in France. Engineering represents more than 50% of new doctoral degrees in Korea and Japan.

Figure 11. Tertiary education graduates in natural sciences and engineering, selected G20 economies, 2013

As a percentage of all tertiary graduates, based on ISCED-11

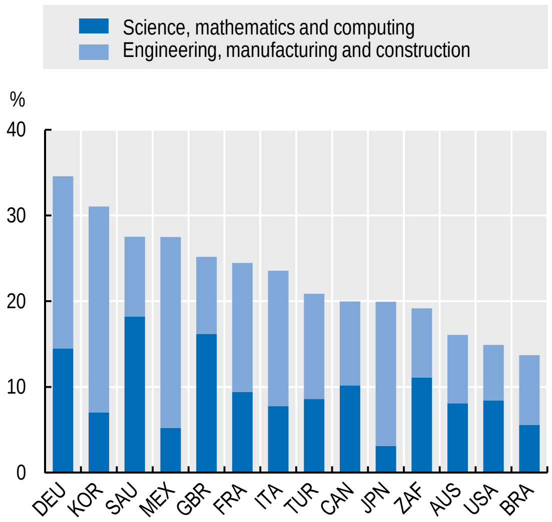
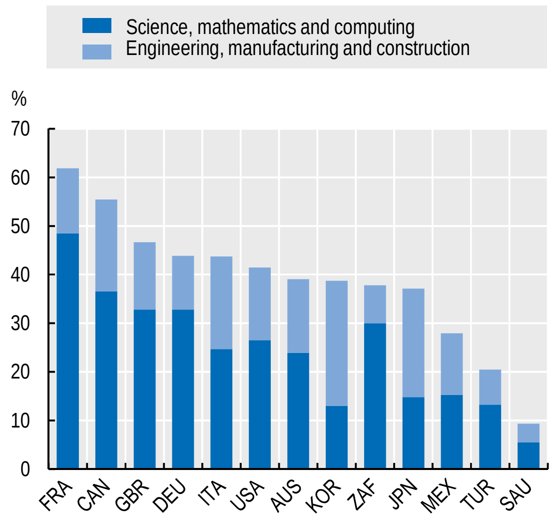


Figure 12. Graduates at doctorate level in natural sciences and engineering, selected G20 economies, 2013

As a percentage of all graduates at the doctorate level, based on ISCED-11



Notes: The "natural sciences" and "engineering fields" of education correspond to ISCED-11 fields 4 and 5, with 4 being for science (comprising the life sciences, physical sciences, mathematics and statistics and computing) and 5 for engineering, manufacturing and construction. The science category in ISCED-11 corresponds broadly to the concept of natural sciences used in the OECD Fields of Science and Technology classification (2007).

A "graduate" is defined as a student who has successfully completed all requirements of a particular programme of study. "Graduates at the tertiary level" are individuals that have obtained a degree at ISCED-11 Levels 5, 6, 7 or 8. "Graduates at the doctorate level" are those tertiary graduates who have completed the second stage of university education and obtained a degree at ISCED-11 Level 8. These graduates have successfully completed an advanced research programme and been awarded an advanced research qualification (e.g. a PhD or equivalent).

Data on graduates by field of education are computed on the basis of annual data jointly collected by UNESCO-UIS/OECD/Eurostat. This data collection aims to provide internationally comparable information on key aspects of education systems in more than 60 countries worldwide (www.oecd.org/education/database.htm). The International Standard Classification of Education has been recently revised (ISCED-11) and implemented in the UNESCO-UIS/OECD/Eurostat data collection. A particular feature of the revised classification is the provision of more detailed information on the broader community of graduates at tertiary level.

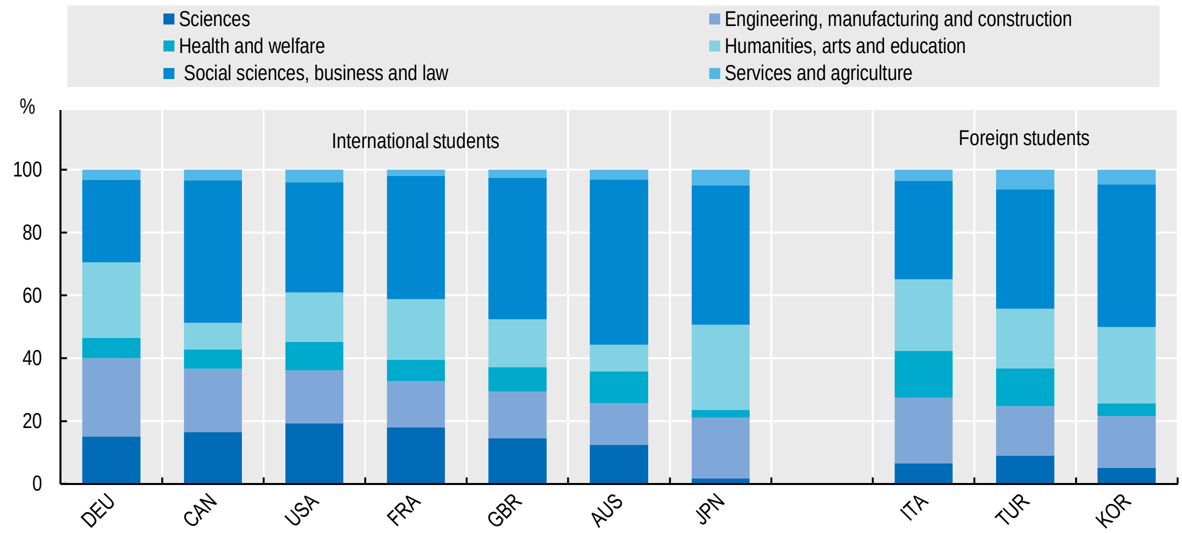
Source: OECD, *Education Database*, April 2016.

Promoting student exchanges

International mobility among highly educated individuals at different stages of their personal development and professional careers constitutes a key driver of knowledge circulation worldwide. For example, students in higher education that study or spend some time in a foreign tertiary-level institution build links with other individuals and acquire competencies which will be carried over to other places during their working lives. The United States attracts the largest absolute number of international students, followed by the United Kingdom, France, Australia and Germany. The majority of international students specialise in subjects outside the natural sciences and engineering.

Figure 13. International and foreign students enrolled in tertiary education, selected G20 economies, 2013

Total and breakdown by field of education



Notes: "International students" are students that have crossed borders expressly with the intention to study. The UNESCO Institute for Statistics, the OECD and Eurostat define international students as those who are not residents of their country of study or those who received their prior education in another country. "Foreign students" are defined according to their citizenship.
The 2014 UNESCO-OECD-Eurostat (UOE) collection of education statistics is the primary source of data on tertiary enrolment by source and destination country. When data on international students are not available, data on foreign-born students are used to obtain a more complete picture. However, numbers of international students is more directly relevant for the analysis of mobility.

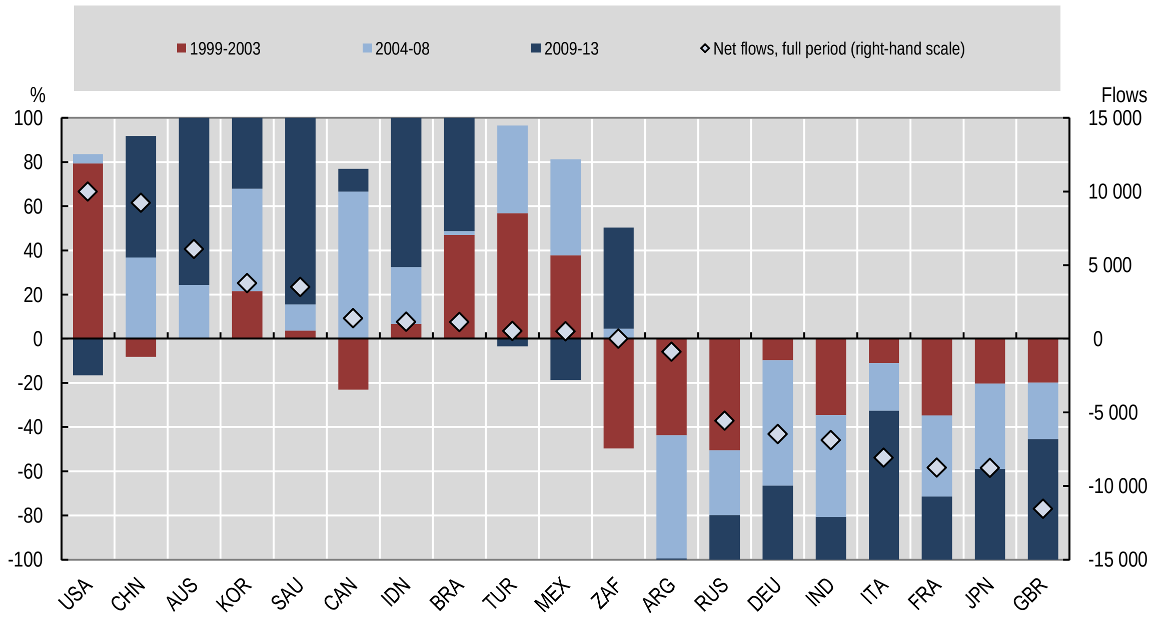
Source: OECD calculations based on OECD (2015), *Education at a Glance: OECD Indicators*, OECD Publishing, Paris, http://dx.doi.org/10.1787/eag-2015-en.

Facilitating researcher mobility

While published scientists are only a subset of the highly skilled, they represent a particularly important portion given their high level of training and proven contribution to scientific knowledge and its circulation. Indicators of international mobility based on changes in author affiliations can be used to investigate the net entry or exit flow of scientific authors over time for different economies. The timing and intensity of these flows can be related to relevant policies adopted by countries, for example concerning the funding of scientific research, support for international mobility, or the role played by migration policies. Countries such as Australia and China owe most of their overall positive net inflow to recent trends. China reversed what were net outflows experienced in the late-1990s into a significant net inflow of authors in the last few years, while India experienced persistent net outflows until 2013 when a net inflow was first recorded. In the United States, a positive balance involves substantial net inflows in the early part of the 1999-2013 period, combined with a net outflow in more recent years. While the scientist population in the United Kingdom is among the most mobile, it also has the largest net outflow over the period. In the case of Italy there appears to have been an acceleration of net outflows in the latter period. The major EU countries appear to be rather stable net providers of scientific authors to the rest of the world, a likely outcome of the attractiveness of their higher education systems at the degree level. This is reflected in the EU net cumulative outflows (diamond at -35 000); a value that nets out intra-EU researcher flows and shows the European Union as an important node of trained scientists for the rest of the G20 economies.

Figure 14. International net flows of scientific authors, G20 economies, 1999-2013

Difference between annual inflows and outflows, as percentage of cumulative net flows



Notes: This figure decomposes the overall net flow of scientific authors across different years for G20 economies over the period 1999-2013, expressed in relative terms. This helps to identify the timing and intensity of different phases of net entry and net exit from the perspective of a given country. For example, the United States and China experience similar net inflows over the entire period (see the diamond) but the timing and trends are rather different. In the case of the United States, the net flows turn from being positive in the early 2000s to negative in more recent years, while for China the pattern is exactly the opposite.

It is difficult to capture consistently the movement of scientists through statistical surveys which are national in scope. Monitoring changes in scientist affiliations in global repositories of publications provides a complementary source of detailed information but these are limited to authors who publish, and moreover who publish regularly: otherwise their affiliations cannot be detected and timed in a sufficiently accurate way. Mobility can only be computed among authors with at least two publications. These indicators are likely to understate flows involving moves to industry or organisations within which scholarly publication is not the norm.

Source: OECD calculations based on Scopus Custom Data, Elsevier, version 4.2015, http://oe.cd/scientometrics, June 2015.

Promoting collaboration in innovation among firms

Collaboration is a key conduit for innovation-related knowledge flows both for firms that use R&D (either internally developed or externally acquired) and for those that are not R&D-active. Patterns of collaboration differ in terms of possible partners' and firms' own characteristics. Collaboration with higher education or public research institutions constitutes an important source of knowledge transfer for large firms. In most countries such firms are usually two to three times more likely to engage in this type of collaboration than small and medium-sized enterprises (SMEs).

International collaboration plays a very important role by allowing firms to gain access to a broader pool of resources and knowledge at lower cost and to share risks, integrating in global value chains. International innovation collaboration rates vary widely across countries. In some small, open economies collaboration is heavily skewed towards foreign partners. This may reflect factors such as sectoral specialisation, limited opportunities for domestic collaboration and, in some cases, proximity to external centres of knowledge. Size also appears to be a strong determinant of international collaboration on innovation, especially in the case of Brazil.

Figure 15. Firms collaborating on innovation with higher education or research institutions, by firm size, selected G20 economies, 2010-12

As a percentage of product and/or process-innovating firms in each size category

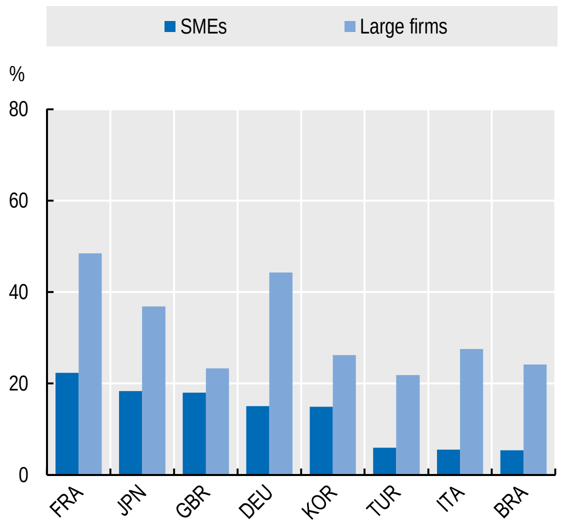
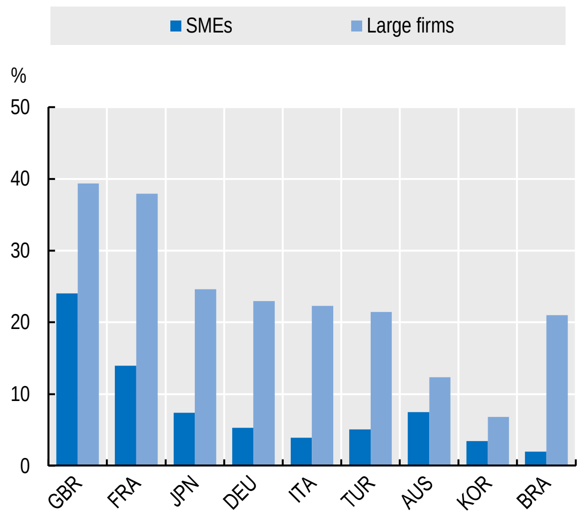


Figure 16. Firms engaged in international collaboration for innovation, by firm size, selected G20 economies, 2010-12

As a percentage of product and/or process-innovating firms in each size category



Notes: Collaboration involves active participation in joint innovation projects with other organisations but excludes pure contracting out of innovation-related work. It can involve the joint implementation of innovations with customers and suppliers, as well as partnerships with other firms or organisations. International collaboration on innovation refers to active cross-border participation in innovation collaborations. International comparability of innovation data may be limited due to differences in innovation survey methodologies and country-specific response patterns. Data on collaboration with different partners and in different locations are obtained from surveys of firms using questions based on the OECD/Eurostat *Oslo Manual* on measuring innovation (see www.oecd.org/sti/oslomanual). Design features such as question order, scope or combination with other types of surveys may influence answers to questions on innovation activity and collaboration with other parties.

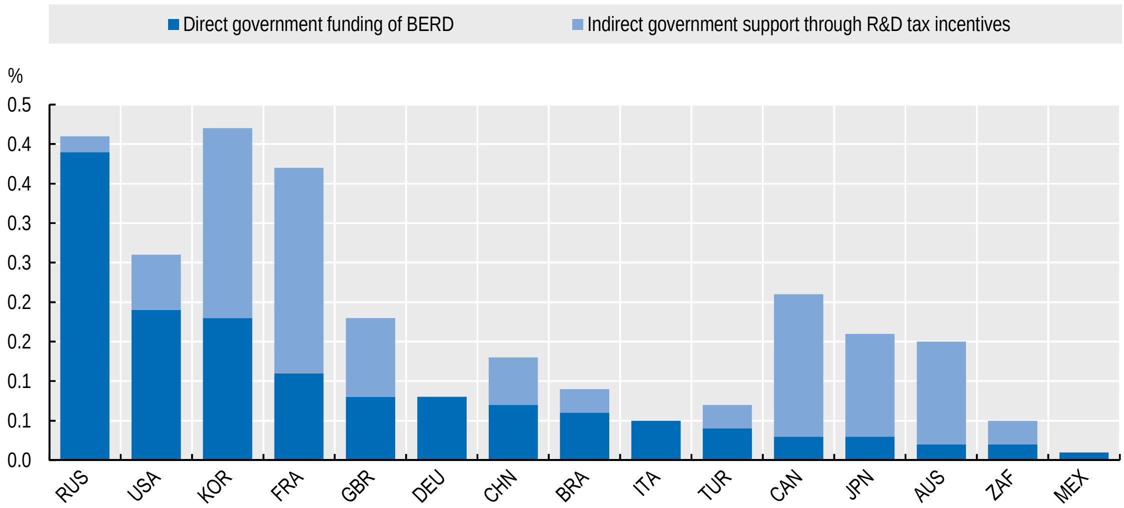
Source: OECD, based on *Eurostat Community Innovation Survey* (CIS-2012) and national data sources, June 2015.

Supporting business innovation

Business innovation depends on supply and demand factors. Government support for business R&D seeks to encourage firms to invest in knowledge that can result in innovations that transform markets and industries and result in benefits to society. Public support for business R&D is typically justified as a means of overcoming a number of market and institutional failures. In addition to providing direct R&D support such as grants or contracts, many governments also incentivise firms' R&D through tax relief measures. In 2015, 28 OECD countries gave preferential tax treatment to business R&D expenditures. Korea, the Russian Federation and France provided the most combined support for business R&D as a percentage of GDP in 2013, while the United States, France and China provided the largest volumes of tax support. The relative importance of tax incentives has increased across a majority of OECD countries and G20 economies, although this is by no means universal. Germany and Mexico do not provide R&D tax incentives. The optimal balance of direct and tax support for R&D varies from country to country and can evolve over time, as each tool addresses different market failures and stimulates different types of R&D under changing conditions.

Figure 17. Direct government funding of business R&D and tax incentives for R&D, G20 economies, 2013

As a percentage of GDP



Note: In this figure, estimates of the cost of R&D tax incentives at the national or federal level have been combined with data on direct R&D funding (R&D grants and purchases), as reported by firms, to provide a more complete picture of government efforts to promote business R&D. The latest edition of the *Frascati Manual* summarises the guidance on reporting data on tax relief for R&D. See http://oe.cd/frascati.

Sources: OECD, *R&D Tax Incentive Indicators*, www.oecd.org/sti/rd-tax-stats.htm; OECD, *Main Science and Technology Indicators* database, www.oecd.org/sti/msti.htm, June 2015.

HOW TO MEASURE R&D TAX INCENTIVES

Tax incentives for business R&D include allowances and credits, as well as other forms of advantageous tax treatment of business R&D expenditure. Estimates exclude income-based incentives (e.g. preferential treatment of incomes from licensing or asset disposal attributable to R&D or patents) and incentives to taxpayers other than firms. While typically non-discretionary and demand-driven, some countries require pre-approval of R&D projects or accreditation. Budget limits may apply at the country level.

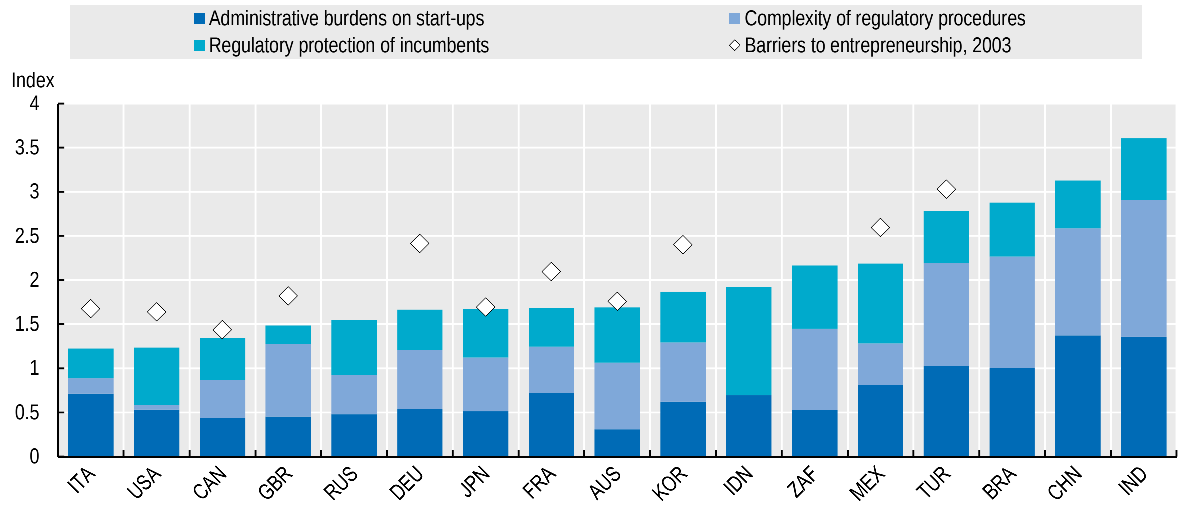
Fostering entrepreneurship

The policy environment plays an important role in encouraging the creation of new firms and promoting healthy competition in the economy. Less red tape facilitates business creation while good insolvency regimes reduce the stigma of bankruptcy for firms and individuals, encouraging entrepreneurs to take risks and innovate. Young innovative firms are particularly crucial for economic growth and job creation. However, they encounter obstacles when seeking financing as they generally lack collateral or a business track record. While not all start-ups require (or deserve) external capital, they often encounter difficulties in obtaining seed and early stage financing because of uncertain profit expectations and riskier growth perspectives.

A high-quality regulatory framework facilitates market entry and growth for businesses. During the last decade, barriers to entrepreneurship have been lowered in most G20 economies. Yet, India, China and Brazil still display relatively high barriers to entry, in particular with respect to high administrative burdens and regulatory complexity. The decision to start a business is also affected by taxes and tax policy, in particular, general taxes (personal income, corporate and capital gain tax rates, and social security contributions) and targeted tax policies (tax incentives for start-ups, young firms, and SMEs).

Figure 18. Barriers to entrepreneurship, selected G20 economies, 2013

Scale from 0 to 6 from least to most restrictive



Notes: The *barrier to entrepreneurship indicator measures* the regulations affecting entrepreneurship on a scale of 0 to 6, with lower values suggesting lower barriers. The index includes the administrative burden of creating new firms, the regulatory protection of incumbents (legal barriers, antitrust exemptions, barriers in network sectors), and the complexity of regulatory procedures (licences, permits, simplicity of procedures).

Higher-level (composite) indicators, such as the barrier to entrepreneurship indicator, are calculated as weighted averages of lower-level indicators, using equal weights for aggregation. The OECD's *Product Market Regulation* (*PMR*) database contains quantitative indicators on regulations that can affect competition. These are derived from qualitative information collected from national administrations. The database is updated every five years with data starting from 1998.

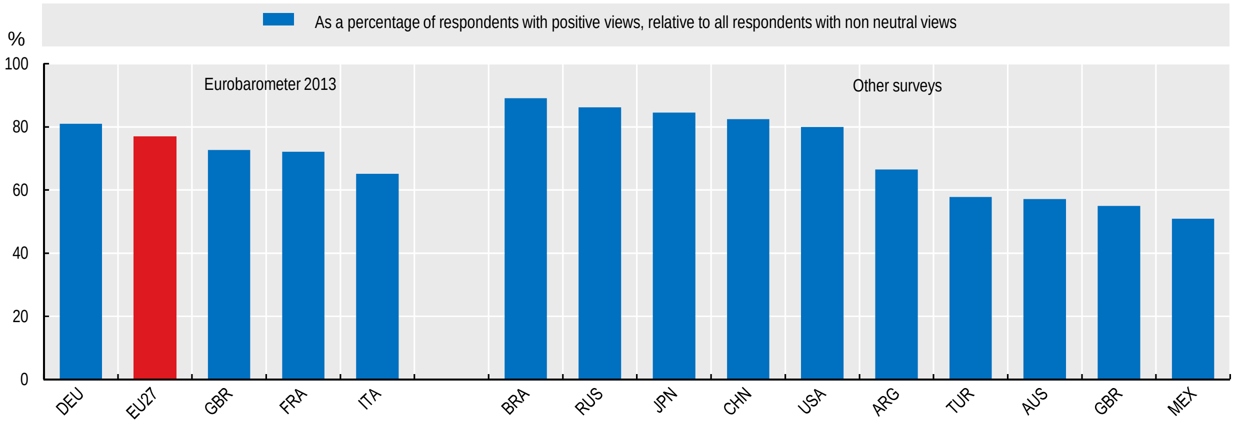
Source: OECD, *Product Market Regulation* database, www.oecd.org/economy/pmr, June 2015.

Empowering society with science and technology

Developments in science and technology have major and visible impacts on people's lives. These depend on the collective action of decisions of not only governments, leading scientists and firms, but entire societies. A country's science and innovation culture can greatly influence the rate and fashion in which new technologies and innovation are developed, adopted and diffused, as well as their broader impacts. A comparison of results from household surveys carried out in different countries indicates that the public has a mainly positive view of the societal impact of science and technology (S&T). However, they also find that a significant proportion of the population has mixed or critical views about S&T, which may in some cases reflect limited knowledge about S&T, but may also reflect a more nuanced and reflexive perspective about its governance and the need for responsible research.

Figure 19. Public perception of impacts of science and technology on society, selected G20 economies, 2013

Net relative balance on: "Is the overall impact of science and technology on society positive or negative?"



Notes: Measuring the S&T culture is often impeded by the fact that available national data sources use slightly different questions and possible answers, while responses can vary according contextual factors. Comparison of responses from surveys with different response options has been undertaken by calculating a summary indicator as the ratio of the difference between positive and negative views, divided by the sum of both groups. This excludes respondents with a neutral position and those who selected “don’t know”, if surveys provided such options. This approach may retain some bias if neutral respondents, when unable to select such an option, are more likely to provide a positive answer than a negative one.

Sources: OECD calculations based on European Commission (2013), *Special Eurobarometer 401*; and other national sources, June 2015.

Part 2

COUNTRY PROFILES

The country profiles presented here display G20 economies' policies in the science, technology and innovation space.[1] They are excerpts of the country profiles prepared for the forthcoming *OECD Science, Technology and Innovation Outlook 2016*. The complete profiles will be made available on the OECD-World Bank Innovation Policy Platform at the release of the *OECD STI Outlook* in early December 2016. The profiles will also be made available on the online G20 Community of Innovation Policy Practice.

1. Due to data limitations, Saudi Arabia is not included.

Argentina

The Argentine government recognises that innovation is a key source of growth. In the context of current social challenges such as exclusion, the Ministry of Science, Technology and Productive Innovation (MINCYT) has made addressing social challenges a priority in its guidelines for the development of the country's innovation system.

Highlights of the Argentine STI system

Investing in innovation: The MINCYT, which had a budget of USD 1 386 million PPP (ARD 4 994 million) in 2013, has a central role in managing innovation investments and R&D institutions. Argentina spent 0.61% of its GDP on R&D in 2014. The government finances the majority of GERD (0.46% of GDP), and its contribution grew by 15.44% a year over 2008-13, faster than the overall annual growth of GERD (9.5%) over the same period. Agencies such as the National Research Council (CONICET) and the National Agency for the Promotion of Science and Technology (ANPCYT) distribute government grants for research, while the Evaluation and Quality Assurance Unit (UEAC) of the ANPCYT and the National Directorate of Programmes and Projects of the Undersecretary of Institutional Evaluation conduct evaluations with a view to quality assurance.

Co-ordination of STI governance: MINCYT's allocation of resources has been progressively aligned over the last five years with policies from other ministries and agencies through the Scientific and Technological Cabinet (GACTEC), an inter-ministerial body in charge of formulating S&T policy. The Federal Council on Science and Technology (COFECYT) acts as an advisory board for maintaining policy coherence among federal, provincial and local governments, and for safeguarding regional interests in the MINCYT's allocation of resources. In March 2013, the MINCYT presented its national STI strategic plan, Argentina Innovadora 2020, which seeks to optimise and articulate the country's public and private STI efforts.

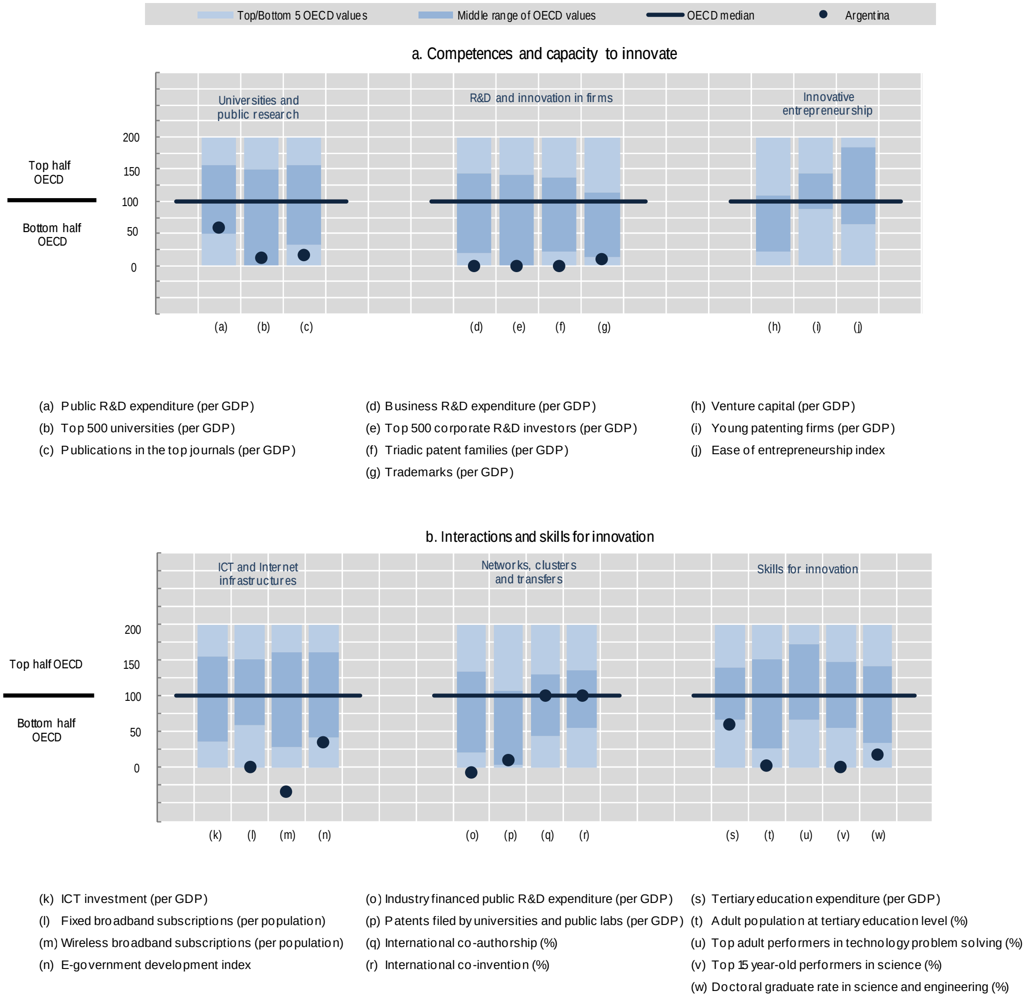
Hot issues

Boosting human resources and skills: Argentina spent 1.12% of its GDP on tertiary education in 2012 (Fig. 20[s]), but the performance of the country's 15-year-olds in science (Fig. 20[v]) points to shortcomings in the quality of education. The share of doctoral graduates in S&E is also low (Fig. 20[w]). To improve the supply of human resources for STI, two programmes, Becas Bicentenario and Becas TICs, provide up to 30 000 scholarships a year for tertiary education for low-income students. CONICET funds domestic doctoral programmes and post-doctoral training and provides grants to support knowledge transfer between universities and the private sector. The government also has programmes targeting Argentina's diaspora. Between 2004 and 2013, more than 1 000 scientists returned to Argentina, contributing to an increased supply of younger researchers, with the share of researchers under age 40 rising from 41% in 2003 to nearly 48% in 2011. Furthermore, to improve the performance of Argentina's researchers, ANPCYT's PITEC and PAE programmes support public-private partnerships in research projects aimed at increasing the contribution of research to Argentina's economy, including by addressing pressing socio-economic challenges.

Innovation in firms: With BERD of 0.12% of GDP in 2014 (Fig. 20[d]), Argentina lags in innovation performance, triadic patents (Fig. 20[f]) and trademark registrations (Fig. 20[g]). To improve innovation performance, government programmes target key knowledge areas and sectors to improve both the quality of human capital for research and innovation and the articulation between public research and industry. Most of ANPCYT's budget focuses on the strategic knowledge areas and business sectors identified in the Argentina Innovadora 2020 plan. FONSOFT is a trust fund to support ICT, in which Argentina hopes to develop a comparative advantage. The FONARSEC fund supports the development of target technologies (e.g. bio- and nano-technology) and sectors (e.g. energy, health and agro-industry). The MINCYT is currently evaluating the means of measuring private R&D; preliminary results indicate that BERD may have been somewhat underestimated.

Figure 20. Science and innovation in Argentina

Comparative performance of national science and innovation systems, 2016



Notes: Normalised index of performance relative to the median values in the OECD area (Index median=100). For Argentina, 2012 values were used for the indicator "Wireless broadband subscriptions (per population)". It is compared to values of December 2015 for OECD countries.

Australia

Australia's economy has been one of the world's most resilient during the global economic crisis. Since 2005, labour productivity has increased faster in Australia than in many other countries while income inequality has declined. However, since the fall in commodity prices in 2014, the country has faced considerable challenges in readjusting policies. Australia's economy relies relatively heavily on primary and resource-based industries; coal and iron exports accounted for 29% of total exports of goods and services in 2014-15. Although the economy is supported by strong macroeconomic frameworks and commodity price levels have tended to stabilise in 2016, maintaining growth in incomes and conserving the country's established position in terms of international competitiveness will require further efforts. In order to address these challenges, the Australian Government developed the National Innovation and Science Agenda (NISA). NISA aims to build a stronger, more productive and diverse economy, with more efficient government and more productive businesses. NISA intends to transform the country into a leading innovator with high wage standards and social welfare safety net. NISA's sub-programmes and initiatives are divided into four key pillars: i) Culture and Capital; ii) Collaboration; iii) Talent and Skills; and iv) Government as an Exemplar.

Highlights of the Australian STI system

Universities and public research: Australia has a strong science base, with a high intensity of public R&D expenditure, several world-class universities and high-quality scientific publications (Fig. 21[a,b,c]). The NISA announced funding of USD 1.6 billion PPP (AUD 2.3 billion) over 10 years for reinforcing the national-scale research infrastructure. This includes operational funding for the National Collaborative Research Infrastructure Strategy (NCRIS). A further USD 17 million PPP (AUD 25 million) over five years is going to be invested in the development of silicon quantum computing technology by the Centre for Quantum Computation and Communication Technology (CQC2T), headquartered at the University of New South Wales. New research funding arrangements will also be provided to universities.

ICT and Internet infrastructures: Internet and ICT infrastructures are relatively well developed, as evidenced by Australia's wireless broadband subscriptions (Fig. 21[m]). In order to maintain or even improve this performance, the government intends to spend USD 3.5 billion PPP (AUD 5 billion) a year on ICT dissemination. The Digital Marketplace, based on a successful UK model, will be an online directory of digital and technological services for government agencies to procure ICT solutions from SMEs. These new digital services will go hand in hand with measures to ensure cyber security. For instance, Australia will invest USD 52 million PPP (AUD 75 million) in Data61, Australia's largest data innovation group. It will use data analytics to connect disparate government datasets and publicly release them on open data platforms, and it will also play a key role in developing new cyber security architectures.

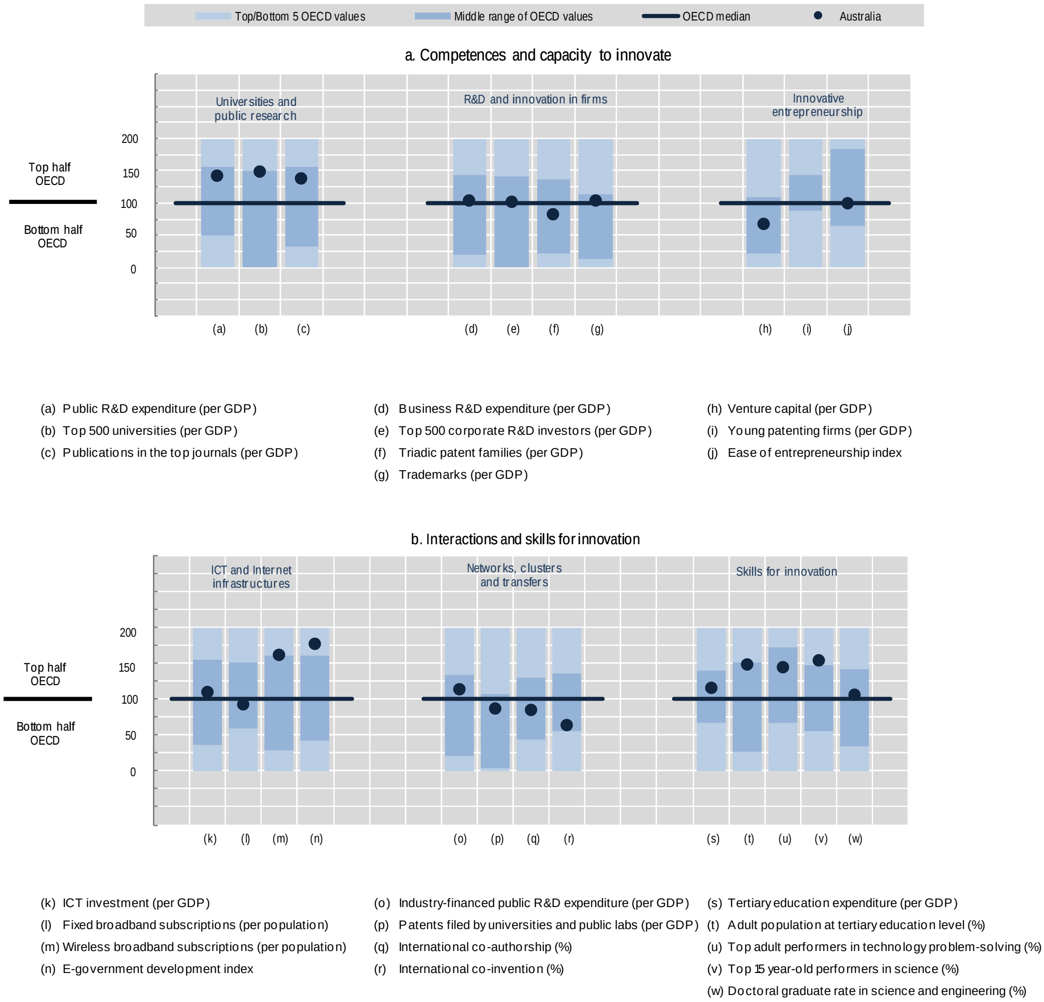
Hot issues

Encouraging business innovation: In line with its industrial structure (a relatively low contribution from high-technology manufacturing), Australia shows a modest BERD intensity (Fig. 21[d]). Innovation output, as measured by triadic patents, is also below the median (Fig. 21[f]), while trademark registrations are slightly above (Fig. 21[g]). The government encourages innovation and entrepreneurship in firms of all size and in all sectors of the economy, reflected in the shift in its policy mix towards non-discretionary R&D tax incentives and the more recent implementation of the NISA. However, Australia has a large share of SMEs and start-ups, and particular focus has been given in recent years to supporting R&D and innovation in small and young firms. Young firms are fairly active in patenting, and administrative and regulatory conditions for entrepreneurship compare well to other developed economies (Fig 21[i,j]). Policies aimed at these firms include the Incubator Support Programme, which provides competitive matched funding in the amount of USD 5.5 million PPP (AUD 8 million) to accelerators in regions or sectors with high innovation potential and assists young firms to find top-quality research and technical talent through secondments of national or international expert advisers.

Targeting priority areas and sectors: The Australian Government aims to achieve a world-class economy by building on the country's areas and sectors of strength. Led by the former Chief Scientist, nine national science and research priorities and related services were developed in 2015 in consultation with researchers, industry leaders and government representatives: i) food; ii) soil and water; iii) transport; iv) cybersecurity; v) energy; vi) resources; vii) advanced manufacturing; viii) environmental change; and ix) health. The implementation of the priorities is expected, over time, to result in increasing the proportion of Australian Government research investment that is allocated on a strategic basis to areas of critical need and national importance.

Figure 21. Science and innovation in Australia

Comparative performance of national science and innovation systems, 2016



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

Brazil

While Brazil remains the world's seventh-largest economy, growth has stagnated over the last two years as commodity prices, industrial activities and services have all declined. To boost the country's economic performance and increase productivity through innovation, the government has introduced new legislation as well as the National Strategy for Science, Technology and Innovation (ENCTI) 2016-19, which sets out the main challenges for STI policy. The strategy aims for gross expenditure on research and development (GERD) to reach 2.0% of GDP in 2019.

Highlights of the Brazilian STI system

Governance of the STI system: Brazil's government has recently introduced significant changes in STI governance. In May 2016, the administration merged the science and telecommunication ministries to form the Ministry of Science, Technology, Innovations and Communications (MCTIC). In the same month, it launched a new National Strategy for Science, Technology and Innovation (ENCTI) 2016-19, setting out the country's key challenges for STI policy: i) closing the technological gap with developed economies; ii) strengthening institutional capabilities to increase productivity through innovation; iii) reducing social and regional inequalities in access to the country's national innovation system; iv) developing innovative solutions for productive and social inclusion; and v) promoting sustainable development. ENCTI also assigned priorities to different economic and knowledge sectors, which the government believes will leverage national development, not only by proposing solutions to domestic issues, but also because they use the country's technological potential, natural resources and industrial capacity. These sectors are: defence, water, food, biomes and bioeconomy, sciences and social technologies, climate change, ICTs, energy (including nuclear), health, and converging and enabling technologies.

Overcoming social challenges: Brazil is working to overcome major societal challenges related to income inequality and poverty, including high rates of youth unemployment and vulnerable employment. The Digital Inclusion Programme aims to guarantee access to ICTs for poor people by providing training and professional qualifications. It plans the creation of Access Centres for Social Technology Development (CATI), where people can improve their professional skills, appropriate knowledge and access scientific information. The CATI also help build collaborative work environments on the Internet. The Digital Inclusion Programme aligns ICT infrastructures so as to optimise their use and funding. Finally, the Connection of Infrastructure for Digital Social Convergence programme works to strengthen social inclusion projects, especially in education, safety and health.

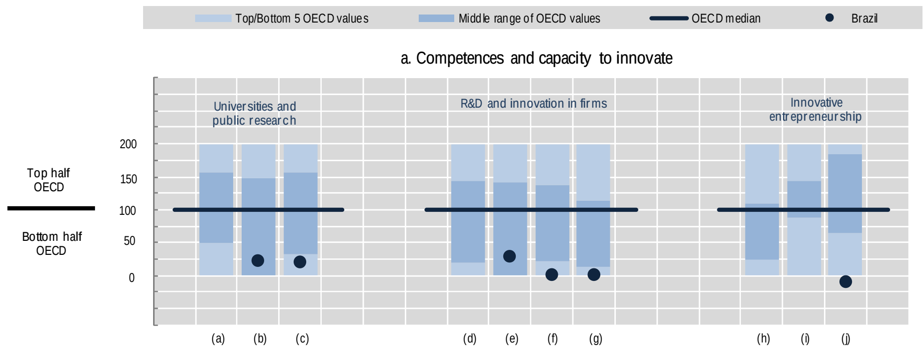
Hot issues

Improving human resources and skills: Human capital is a major bottleneck in the Brazilian innovation system. The share of the adult population with tertiary education is very small (Fig. 22[t]), and the performance of 15-year-olds in science is very poor (Fig. 22[v]), although there were marked improvements in its PISA scores over 2003-12. The education system needs both expansion and improvement. Through the Brazil Scientific Mobility Programme (BSMP), formerly known as "Science without Borders", Brazil has since 2011 sponsored tertiary education studies in STEM disciplines in foreign countries, notably the US, Canada, the UK, France and Germany. This initiative aims to grant 100 000 scholarships to help distinguished Brazilian students enter the world's best universities. It is funded by the federal government organisation Higher Level Personnel Training Coordination (CAPES) and the National Council for Scientific and Technological Development (CNPq), part of MCTIC. In addition, the demography of PhD degree holders in Brazil has recently been evaluated to serve as a basis for evaluating postgraduate policies and to inform the system used by universities to allocate scholarships and grants.

Supporting R&D and innovation in firms: Brazil is home to only a few of the world's largest R&D-investing firms (Fig. 22[e]). While it is at the forefront of high-technology fields such as deep-water oil extraction, this leadership in innovation has not spilled over to the rest of the Brazilian economy. Furthermore, the country's performance on non-technological innovation, as measured by trademark registration, is very weak (Fig. 22[g]). The Funding Authority for Studies and Projects (FINEP) aims to raise the level of R&D in companies through the Company Innovate Plan (*Plano Inova Empresa*). The plan encourages projects that run greater technological risks through combining credit finance with non-refundable grants and equity financing, among other support measures. While the plan allocated USD 10.7 billion PPP (BRL 18.5 billion) in 2014 for companies' investment in product and processes innovation, the budget increased to USD 13.4 billion PPP (BRL 22.7 billion) in 2015.

Figure 22. Science and Innovation in Brazil

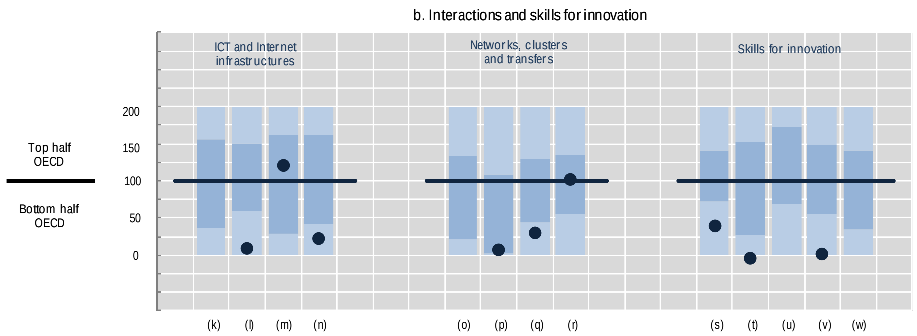
Comparative performance of national science and innovation systems, 2016



(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).

Canada

Canada is the world's tenth-largest economy and a global leader in energy and natural resources. However, with shifts in these markets, in October 2015 the federal government committed to developing an Innovation Agenda that would reshape how Canada supports innovation and growth. Commitments were made to expand support for business innovation networks and clusters, promote the clean technology sector and the adoption of clean technologies, and increase funding to support innovation and growth-oriented firms. In June 2016, the federal government launched a consultation on the development of an Inclusive Innovation Agenda. This engagement focuses on six inter-related action areas: promoting an entrepreneurial and creative society; supporting global science excellence; building world-leading clusters and partnerships; growing companies and accelerating clean growth; competing in a digital world; and improving the ease of doing business.

Highlights of the Canadian STI system

Human resources and skills: Canada enjoys a strong skills foundation and performs well on several skills indicators. The level of adult tertiary educational attainment is high (Fig. 23[t]) and Canadian 15-year-olds and adult population rank relatively high in the PISA and PIAAC tests in science and problem-solving (Fig. 23[u,v]). Canada's Youth Employment Strategy (YES) helps people between the ages of 15 and 30 years to gain the skills, job experience and abilities needed for a successful transition to the workplace. YES includes three sub-initiatives (Career Focus, Skills Link and Summer Work Experience, which includes Canada Summer Jobs), and is delivered through several departments, including the National Research Council (NRC) and its Industrial Research Assistance Programme. Budget 2016 invested an additional USD 136 million PPP (CAD 165.4 million) in YES in 2016-2017.

Public R&D capacity and infrastructure: Canada has a strong university-centred research system, which performs well compared to peers (Fig. 23[a,b,c]) and is well linked to industry funding (Fig. 23[o]). Within the next decade, the Canada First Research Excellence Fund will provide USD 1.2 billion PPP (CAD 1.5 billion) to advance the global research leadership of Canadian institutions. Funding is awarded following a competitive peer-reviewed adjudication process involving experts from around the world. Since 2014, the federal government has also continued to make additional new investments in research through its granting councils, including both funding for targeted research and, more recently in Budget 2016, for investigator-led discovery-based research, with USD 78 million PPP (CAD 95 million) support granted annually on an ongoing basis. In addition, the federal government provided up to USD 1.6 billion PPP (CAD 2 billion) over three years for strategic projects to improve the research and innovation infrastructure.

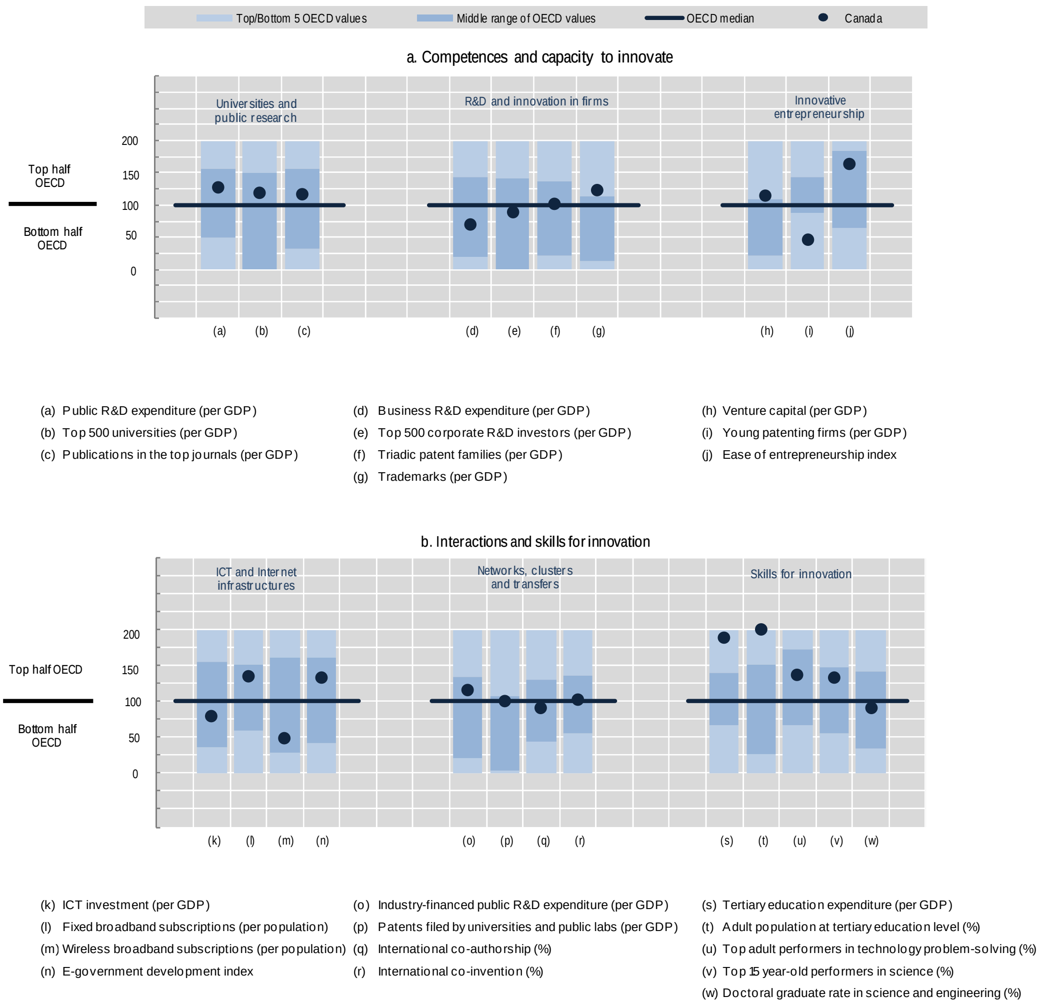
Hot issues

Targeting priority areas/sectors: Climate, health and space are just some of the areas in which Canada is making targeted efforts in recent years. Canada has joined Mission Innovation, a global partnership announced at the United Nations 2015 Climate Change Conference, which is aimed at doubling government investment in clean energy innovation over five years while encouraging private sector leadership in clean energy. The Mission Innovation initiative also seeks to better co-ordinate and report on clean energy efforts. To fully reap the benefits of public investment in health research conducted in Canadian universities, and to advance the development of high-value therapies, the government will provide significant funding to fuel the growth of the Centre for Drug Research, support the Brain Canada Foundation for its Canada Brain Research Fund; and support the Stem Cell Network's research, training and outreach activities to further Canada's long-standing leadership in this research field. Opportunities for the space industry sector have also been created, with USD 311 million PPP (CAD 379 million) over eight years provided to the Canadian Space Agency so as to extend the country's participation in the International Space Station to 2024.

Encouraging business innovation and entrepreneurship: Canadian BERD as a share of GDP decreased steadily over recent years, from 1.02% in 2009 to 0.80% in 2014, and remains well below peers (Fig. 23[d]), despite the generous Scientific Research and Experimental Development (SR&ED) tax incentive. The SR&ED tax relief amounted to USD 2.4 billion PPP (CAD 3.0 billion) in 2014 and accounted for 82% of total public support for business R&D (the figure excludes sub-national R&D tax incentives). This is one of the most generous R&D tax regimes in the world and the most relevant instrument for financing business R&D in the Canadian policy mix. As part of the Innovation Agenda's goals to better co-ordinate and align support for Canadian innovators, the government announced support for a new initiative to help high-impact firms to scale up and raise their global competitiveness. The government also earmarked USD 3.3 million PPP (CAD 4 million) over two years to renew the Canadian Technology Accelerator Initiative, which provides expertise and assistance to innovative technology firms to access global markets.

Figure 23. Science and Innovation in Canada

Comparative performance of national science and innovation systems, 2016



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

China

Following three decades of an unprecedented high rate of economic growth, succeeding in the transition to a new growth trajectory will require an unwavering commitment not only to structural reforms but also to making science, technology and innovation (STI) a key engine for growth. China has steadily increased STI investment, with GERD reaching 2.05% of GDP in 2014. China has set up numerous science and technology (S&T) programmes and foundations, which have played a significant role in enhancing the country's scientific and technological strength, improving its competitiveness, and supporting economic and social development. The 13th Five-Year Plan, launched in March 2016, and the 13th Five-Year Plan on Scientific and Technological Innovation, released in August 2016, established a set of targets and policies for S&T development for 2016-20. Public budgets are forecast to increase in the coming years, but at a slower pace than in previous years.

Highlights of the Chinese STI system

Supporting R&D and innovation in firms: BERD as a share of GERD has risen significantly, with firm self-funded R&D reaching 94% of BERD in 2012. The review of the implementation of the Medium- and Long-Term National Plan for S&T Development (2006-20), carried out in 2010, noted that there was a need for greater vitality and drive with respect to business participation in technological innovation. The Chinese government regards the enterprise sector as the main body for innovation, and has steadily increased direct and indirect support for business innovation, although equity funding still remains the most relevant instrument in the policy mix. Several funding schemes have been restructured in order to set up a national SME development fund with USD 17 billion PPP (CNY 60 billion). The fund focuses on support for the development of seed, start-up and growth-oriented SMEs. In April 2015, China launched a national strategy for mass entrepreneurship and innovation, which aims to enable more people to start their own business.

STI policy and governance: China is establishing an open and unified national S&T management platform, which consists of a new evaluation and inspection mechanism. A programme to evaluate National Engineering Technology Centres has been designed using a new set of indicators. China has also started making use of the results of STI evaluation exercises to improve S&T management and enhance the national innovation policy design. In 2014, the China Publishing and Distribution Trading Cloud Platform was established, serving the publishing industry chain, based on cloud computing technology. The Ministry of Science and Technology (MOST) also established the National S&T Information System, a public information service platform to access reports and information, including on resources and data about publicly financed R&D projects. Those undertaking S&T projects receiving public funding are requested to submit relevant S&T reports, a summary of their S&T achievements and relevant IP information to the National S&T Information System.

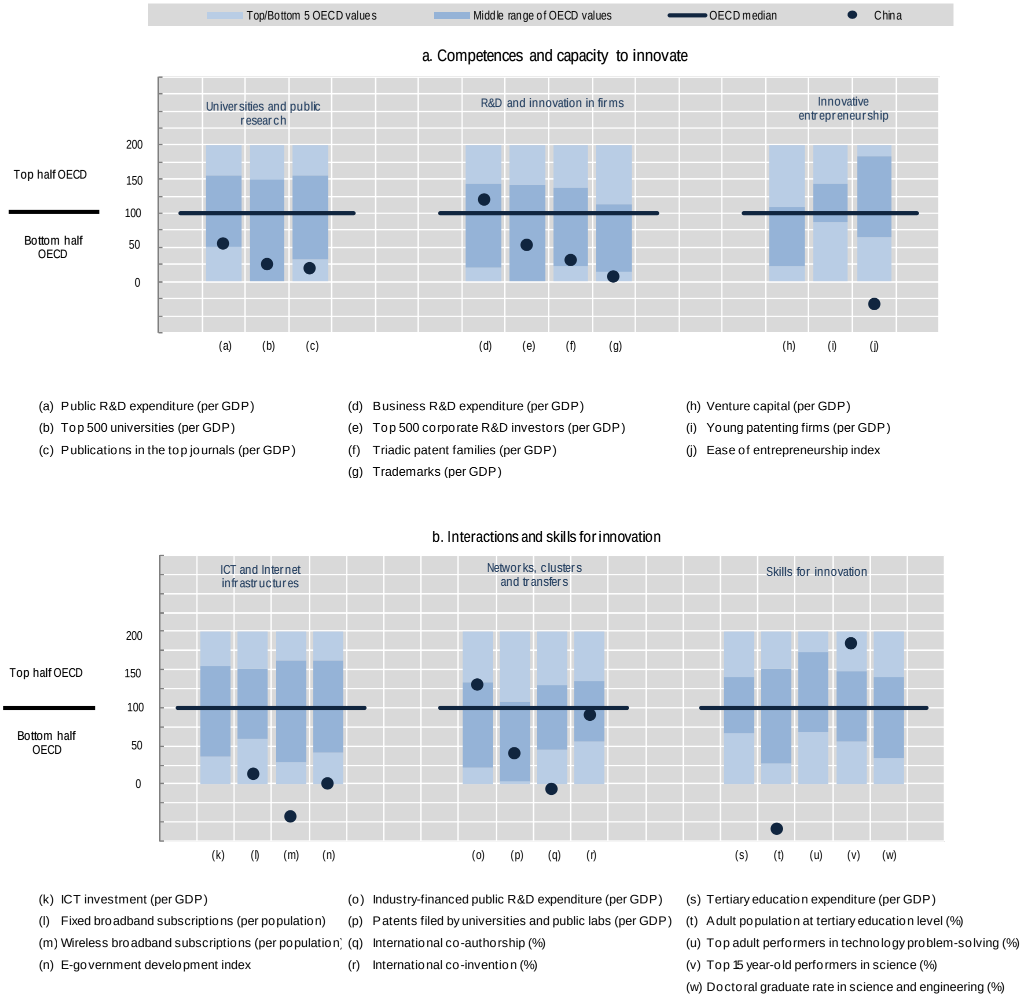
Hot issues

New sources of growth: China's competitive advantage as a global manufacturer is faced with a challenge, as Chinese labour costs have increased, and multinationals, including Chinese ones, are increasingly relocating their manufacturing activities to countries with lower labour costs. To address these challenges and to seize the opportunity of the "next production revolution", China launched "Made in China 2025" in 2015, as part of a 30-year strategy to strengthen China as a manufacturing country. This is the first in a series of national ten-year plans, and it focuses on enhancing innovation, product quality and environmental sustainability, optimising industrial structure and developing human resources in Chinese manufacturing. Ten key sectors were targeted for support, including ICT, robotics, agriculture, aerospace, marine, railway equipment, clean energy, new materials, biological medicine and medical devices. In parallel, the "Internet Plus" initiative was launched in 2015, with a view to digitalising major sectors of the economy and building a service-oriented interconnected intelligent industrial ecosystem by 2025.

Technology transfer and commercialisation: While a significant share of China's public research is funded by industry, signalling the existence of sound industry-science co-operation, China's universities and PRIs are not very engaged in patenting activities (Fig. 24[o,p]). The government encourages enterprises to entrust universities and PRIs with research; up to 50% of the expenditure can be deducted before income tax. Under the Law on the Promotion and Transformation of Scientific and Technological Achievements (revised in 2015), the government encourages R&D institutions and higher education institutions to transfer S&T achievements to enterprises or other organisations by assignment, license, investment as a trade-in, and other means. In December 2015, China's State Council published an opinion on the acceleration of the development of an IPR system by 2020.

Figure 24. Science and Innovation in China

Comparative performance of national science and innovation systems, 2016



Notes: Normalised index of performance relative to the median values in the OECD area (Index median=100). For China, 2012 values were used for the indicator (m) Wireless broadband subscriptions (per population). It is compared to values of December 2015 for OECD countries.

France

Business investment picked up in France in 2015, and the country's economy started experiencing a modest recovery. However, sluggish growth in productivity and exports is still a challenge. In this context, the government is continuing to promote innovation-led growth through its STI policy, and has reinforced its STI strategies and policies promoting business R&D and the development of young firms.

Highlights of the French STI system

Contributing to structural adjustment: The second phase of the New Industrial France Programme (*Nouvelle France industrielle*, NFI), announced in April 2015, focuses on nine industrial solutions (eco-mobility, data economy, smart objects, medicine of the future, sustainable cities, digital trust, new resources, transport of tomorrow, and smart food production). It also includes a cross-cutting initiative (Industry of the Future) for the modernisation and transformation of industrial enterprises. The nine solutions will receive government funds to commercialise new technologies from the Invest in the Future Programme (*Programme d'investissements d'avenir*, PIA). The second phase of the NFI aims to concentrate public and private efforts to modernise industrial assets and transform firms' business models in these sectors to 2020. A complementary plan, the New Deal for Innovation (2013), is promoting the evaluation of public policies (through the C2IT and CNEPI public bodies created in 2014) and an entrepreneurial culture (through Bourse French Tech created in 2014), and improving the framework conditions for technology transfer and the growth of innovative firms.

Boosting the returns to science: France's public R&D expenditure as a share of GDP compares well to its peers (Fig. 25[a]), and French PRIs file a relatively high amount of patents (Fig. 25[p]). To leverage this favourable position, French policy is continuing to strengthen the commercialisation of public research in the interest of increasing business competitiveness and addressing societal challenges. The National Research Agency (ANR) is providing ongoing support to PRIs' efforts on commercialising research, following the major challenges set out by the France Europe 2020 Agenda. In particular, in 2016 the ANR-funded Carnot Institutes programme (founded in 2006) granted 29 multidisciplinary institutes additional funding that rewarded industrial partnerships. The same year, the ANR introduced a new label "Carnot Springboards", granting nine research centres with funds to strengthen their capacity to develop partnerships with the private sector.

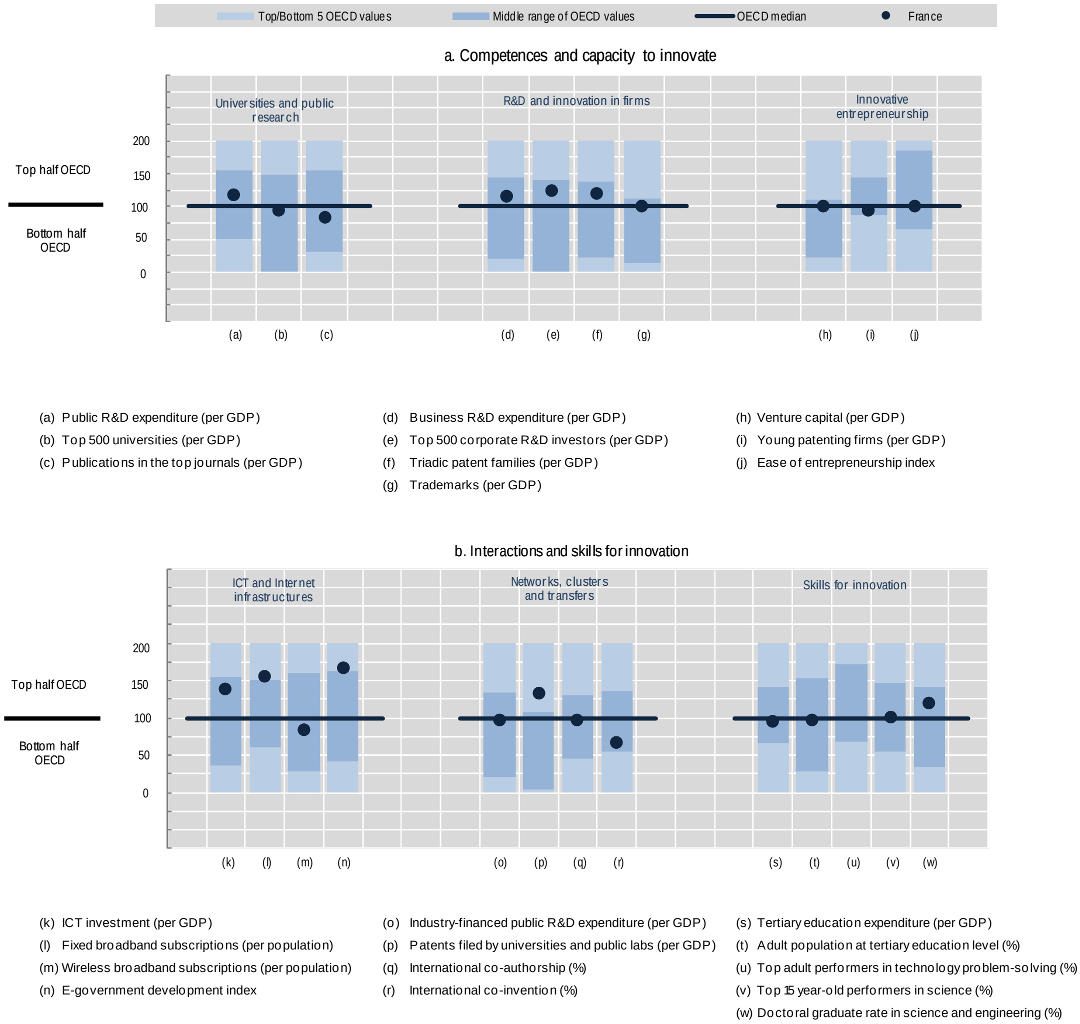
Hot issues

Innovative entrepreneurship: France performs averagely in innovative entrepreneurship according to several indicators (Fig. 25[h,i,j]). A number of instruments aim at improving the conditions for the creation and growth of start-ups. Bpifrance, the country's public investment bank, provides financial support for start-ups (including seed capital loans) and renewed support for the venture capital sector with funds of funds (national seed capital fund, *multicap croissance*). Bpifrance also provides direct investment funds for ICT firms (*Ambition numérique*) and biotechnology-intensive firms (Innobio). In particular, the French Tech initiative aims to accelerate start-up growth through accelerator programmes (*French Tech Accélération* and *Pass French Tech*) and innovation grants (*Bourse French Tech*, operated by Bpifrance). In 2011, a fund of funds (FNA), with USD 711 million PPP (EUR 600 million) was established for seed capital. It has invested notably in digital technologies, life sciences and clean technology.

Globalisation: Increasing the exposure of French researchers and firms abroad remains a key policy goal. Following the 2013 higher education law, the International Transversal Group for Dialogue (GCTI) was redefined in 2015 with the mission of steering the international research and innovation strategy. Over 2013-14, about 13 800 students were part of the International Mobility Support programme, which supports study in foreign countries. The "chairs of excellence" continue to allocate up to USD 2.4 million PPP (EUR 2 million) to selected foreign researchers for a period of 18-48 months in France. Bpifrance has intensified efforts for the internationalisation of French firms by broadening access to export credit since 2013; by end 2016, this institution will also start managing government export guarantees, seeking to simplify and expand companies' access to export financing. Moreover, in January 2015 several export-promotion funds were merged to create Business France, an agency aiming to assist SMEs to better project themselves internationally and attract more investors to France. The French Tech initiative also aims to promote the internationalisation of SMEs through funds from the NFI's second phase, by fostering entrepreneurial hubs across cities worldwide and through a seed accelerator programme that encourages foreign entrepreneurs to establish themselves in France.

Figure 25. Science and Innovation in France

Comparative performance of national science and innovation systems, 2016



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

Germany

Germany's economic growth rebounded quickly following the global financial and economic crisis in 2009, but 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. The government has gradually shifted the focus of its High-Tech Strategy (*Hightech-Strategie* – HTS): while initially attending to the market potential of specific technology areas, as of 2010 the HTS concentrated especially on society's need to develop and implement forward-looking approaches to policies, while the third edition, adopted in August 2014, 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). 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.

Highlights of the German STI system

Improving knowledge transfer: German industry and science already have strong links, and a very high proportion of public research is funded by industry (Fig. 26[o]). The HTS aims to improve regional, national and international networking between science and industry; initiatives 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 validation of 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.

Targeting priority areas/sectors: 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, it 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. 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: i) energy should be used more efficiently; and ii) energy supplies should be increasingly based on renewable energies.

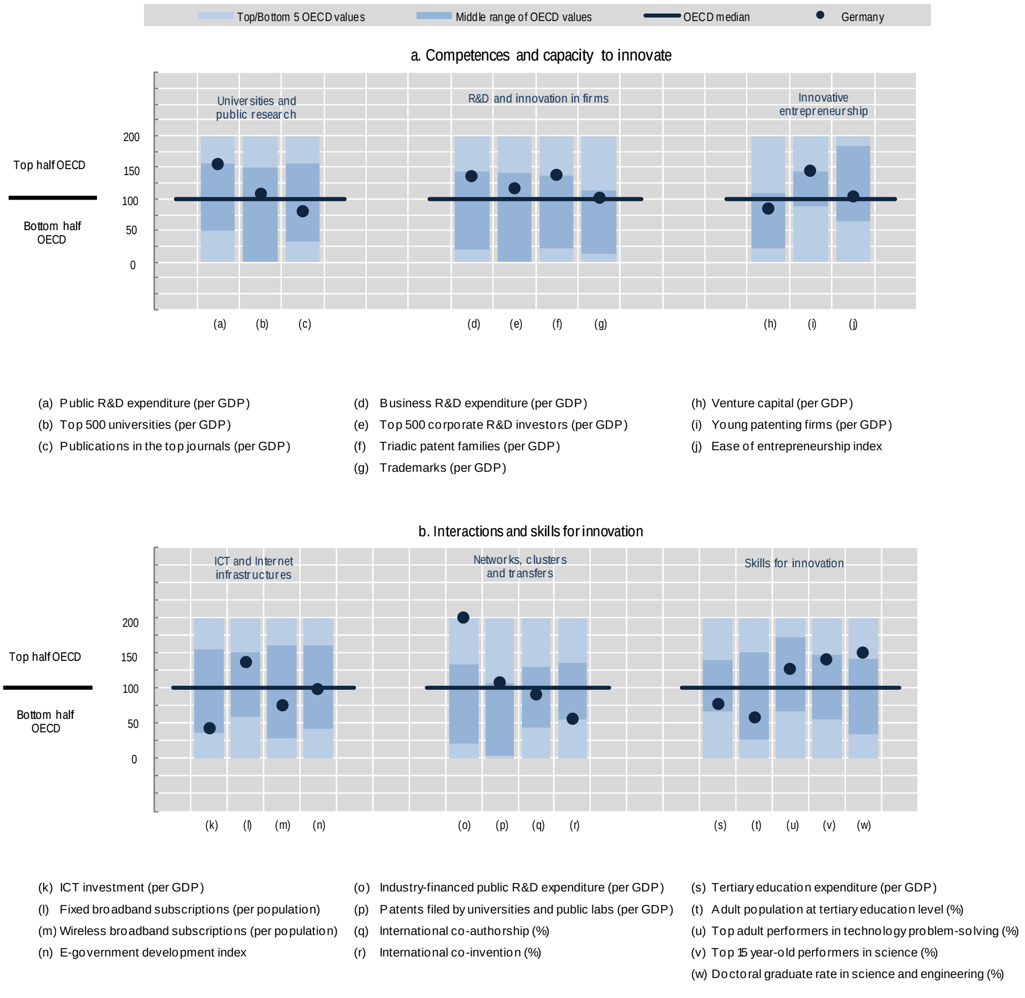
Hot issues

ICT and Internet infrastructure: The coverage of fixed and mobile broadband infrastructure is uneven in Germany, the latter being particularly weak compared to peers (Fig. 26[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.

Skills for innovation: At over 41 million, the number of employees on the German labour market has never been higher. At the same time, some sectors and regions lack qualified professionals. According to 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 STEM Careers, launched in 2008 and now in phase three; ii) several new state-level initiatives to promote STEM in secondary schools; and iii) nationwide school student and youth competitions, devised to select participants in the respective International Olympiads, including in physics, mathematics and chemistry.

Figure 26. Science and Innovation in Germany

Comparative performance of national science and innovation systems, 2016



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

India

India is one of the world's largest, fast-growing emerging economies, with a rapidly increasing population. Thanks to strong economic growth for nearly a decade, poverty has been cut in half. Growth faltered between 2012 and 2014; nevertheless, future growth prospects look good, although poverty continues to be a major challenge. Innovation is seen as critical to India's socio-economic development. India's 12th Five-Year Plan seeks to address social challenges, especially poverty and exclusion, by catalysing a growth process that will promote more inclusive and sustainable development. The Department of Science & Technology (DST) together with the Ministry of Human Resource Development (MHRD) have implemented a series of Impacting Research Innovation and Technology projects (IMPRINT) that will address major societal and developmental needs such as healthcare, ICT, energy, sustainable habitat, water resources and river systems, security and defence, and the environment and climate.

Highlights of the Indian STI system

Innovation to address social challenges: "Inclusive innovation" initiatives that focus on innovation outcomes which benefit poor and excluded groups receive particular attention in India, as do the innovation activities of the poor themselves. India's Inclusive Innovation Fund of USD 3.2 billion PPP (INR 50 billion) supports the development of innovative solutions targeting the "bottom 500 million", while the National Innovation Foundation (NIF) supports grassroots innovators, i.e. people from poor and excluded groups, at various stages of the innovation process. With respect to health, India encourages the utilisation of indigenous systems of medicine. The NIF, with the help of the Massachusetts Institute of Technology in Boston, has set up an augmented fabrication laboratory to support herbal technology R&D. The NIF helps farmers patent their innovations and maintains an online database on technological ideas, innovations and traditional knowledge practices, including traditional medications prepared from locally available biological resources.

Design and implementation of STI policy: The Ministry of Science and Technology operates three departments that have a wide range of activities, including human and institutional capacity-building, community engagement and STI policy support: the DST, which plays a pivotal role in promoting S&T; the Department of Scientific and Industrial Research (DSIR), which supports industrial R&D and technology transfer activities; and the Department of Biotechnology, which promotes S&T in the biotechnology area. The DST has given emphasis to aligning its activities with the national agenda in various policy domains (e.g. Make in India, Start-up India, Digital India, Clean India, etc.). In 2015, the government released its technology roadmap to 2035, which identifies 12 high-impact technology areas and provides a common vision of STI's contribution to India's future.

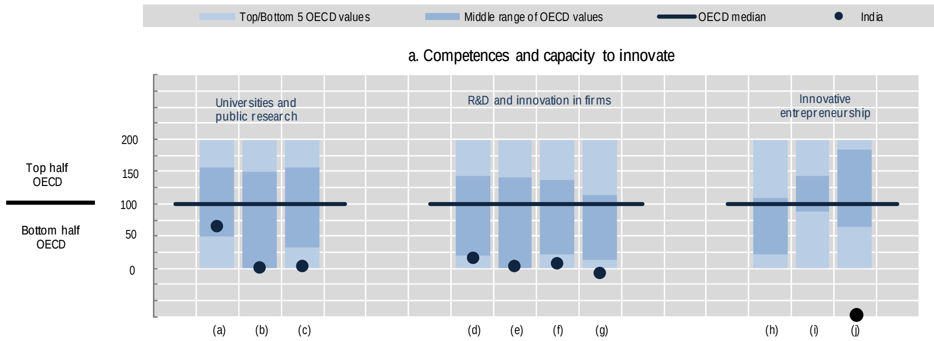
Hot issues

Universities and public research: India has one of the largest public research systems in the world: in terms of absolute R&D expenditure by the higher education and government sectors, it is larger than in France and almost as large as in Japan. However, in relative terms, India has fewer world-class universities and a weaker S&T publication record in leading international academic journals in comparison to emerging economies such as Brazil, China and South Africa (Fig. 27[b,c]). As public research institutions are governed by the ministries in charge of sectoral research areas, there is no consolidated public research budget and no central research funding body. The budget for PRIs has recently declined in real terms, but evaluations are being used in an increasingly systematic way to assess research performance in universities.

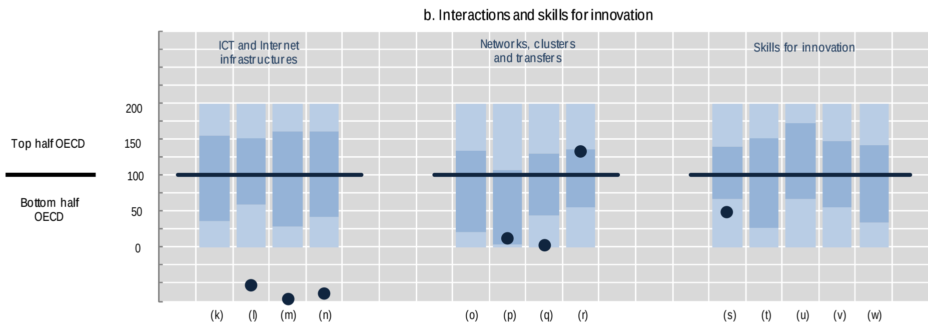
Innovative entrepreneurship: India has a preponderant informal sector and many small low-productivity firms that are unable to exploit economies of scale. The regulatory and administrative framework for entrepreneurship in India is complex (Fig. 27[j]), and stringent labour laws plus frequent changes in tax laws undermine business activity. In early 2016, the government announced the launch of the Start-up India initiative with a view to spreading start-up dynamics from the digital sector to other sectors, including agriculture, manufacturing, the social sector, healthcare and education, and from large cities to semi-urban and rural areas. Start-up India intends to cut red tape, create a one-stop shop for knowledge exchange and access to funding, develop a fast-track patent application procedure for start-ups and facilitate start-ups' access to public procurement. It also aims to improve access to funding for start-ups, and offers promotion services and improved conditions for setting up incubators, research parks and academic spin-offs.

Figure 27. Science and Innovation in India

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 (%)

Notes: Normalised index of performance relative to the median values in the OECD area (Index median=100). For India, 2012 values were used for the indicator (m) Wireless broadband subscriptions (per population). It is compared to values of December 2015 for OECD countries.

Indonesia

The Indonesian economy relies mainly on the exploitation of the country's rich endowments of natural resources, and its expansion is therefore tied to developments on global commodities markets, as primary commodities account for more than half of its exports. Indonesia has enjoyed strong and stable growth over the past decade, with GDP growth rates above 5% annually until 2014, and the country has taken important steps toward further opening up its economy. The Vision and Mission of Indonesia S&T Statement (2005-25) sets out a common vision for improving Indonesia's global competitiveness and fostering its transition toward a knowledge-based economy. The Third National Medium-Term Development Plan (RPJMN, 2015-19) is at the heart of the government's agenda to stimulate inclusive, sustainable growth and its plans to boost the further development of STI in 100 regions. Recent policy emphasis on the role of S&T for achieving national economic development aims to encourage greater R&D investment in the future.

Highlights of the Indonesian STI system

New sources of growth: Indonesia has become a global player in many key farm and food markets (e.g. palm oil, rubber, fishery products). The government is promoting research in synthetic biology for the generation of new crop and grass varieties. The Indonesian Institute of Sciences (LIPI) has stepped up its research activities on drought- and flood-tolerant rice varieties to mitigate the impacts of climate change. Recent achievements include the development of a transgenic drought-tolerant variety of sugarcane. A new programme, Agrifarm Training, provides seed capital and training for the development of a technology-based business in this sector, and the government is also promoting several fields of research, including electrical cars, biorefineries and the use of microbes to produce bioethanol.

ICT and Internet infrastructure: The Indonesian archipelago that encompasses thousands of islands has faced persistent problems in terms of basic infrastructure. Fixed broadband infrastructures are, for instance, highly undeveloped and fragmented (Fig. 28[l]). In October 2014, the government launched the Indonesia Broadband Plan, which aims to provide fixed broadband access to all government offices, hotels, hospitals, schools and public spaces by 2019, with a speed of at least 2 Mbit/s. In addition, investment in data centres and cloud computing technologies by local industries has gained momentum. The government is considering giving a boost to this trend by developing incentives for attracting FDI to the ICT sector.

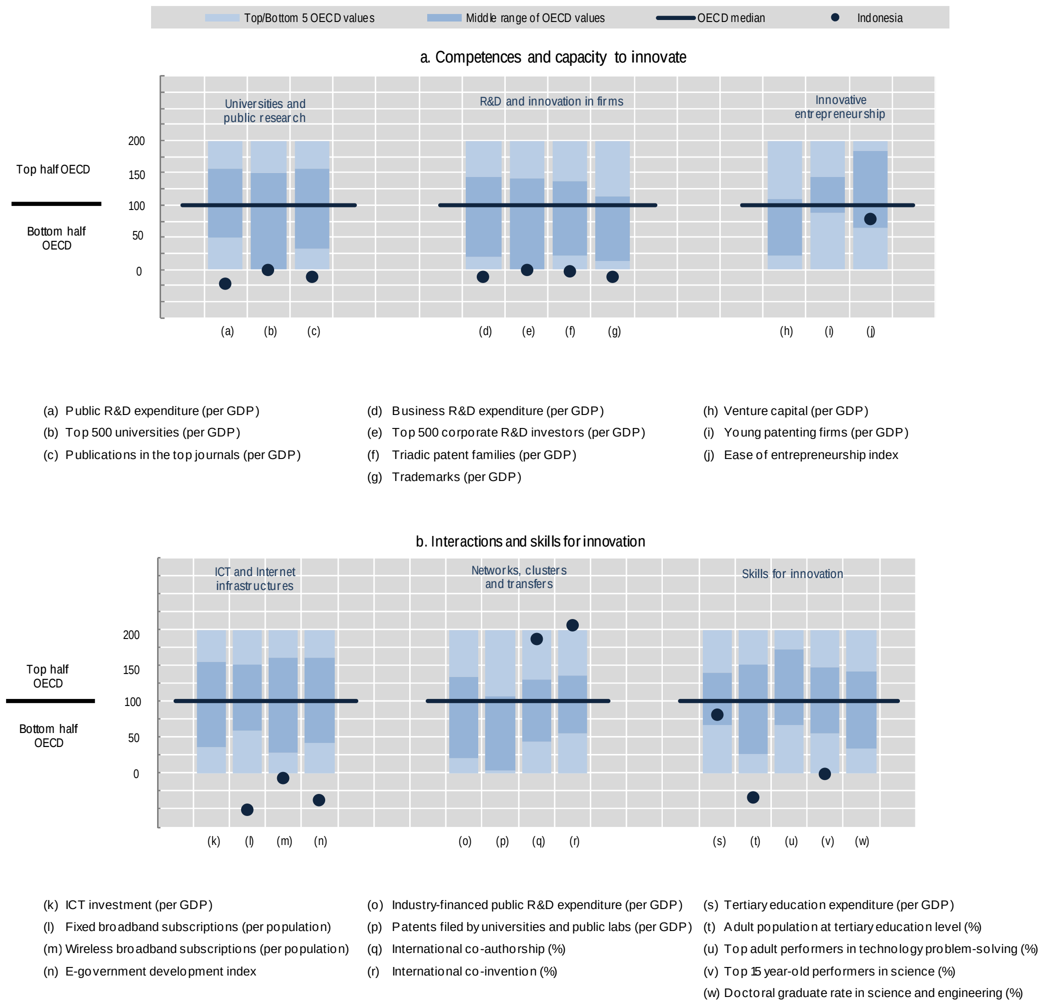
Hot issues

Supporting R&D and innovation in firms: Many Indonesian firms do not engage in innovation, as indicated by the low intensity of BERD and the very low numbers of patents filed and trademarks held (Fig. 28[d,f,g]). R&D-performing companies are concentrated mostly in the manufacturing sector, which is dominated by SMEs characterised by medium-low and low technology. Indonesia's industrial structure combined with the lack of multinationals' investment in R&D (Fig 28[e]) seriously limits the prospects for the development of business R&D. In 2013, a Presidential Decree renewed a 2007 Government regulation that had introduced incentives to encourage private firms to conduct R&D and innovative activities and to diffuse technology. These incentives consist of both fiscal elements and technical support for R&D, including access to public laboratory equipment and instruments or personnel. The government plans to further increase public funding for R&D and innovation within the next five years, as the policy focus moves towards S&T-driven competitiveness. New funding instruments are increasingly in use, including competitive grants, debt financing and risk-sharing mechanisms, as well as a number of tax incentives. Recently, Indonesia has also consolidated its funding schemes for business innovation and revised its public procurement arrangements so as to make them more flexible and accessible. An Electronic Procurement Agency (LPSE) provides an electronic procurement system aimed at easing and supporting procurement procedures.

Building a broad innovation culture: Human resources are a major weakness of Indonesia's STI system. Although expenditures on education have increased steadily over the past two decades, the country still lacks skills to support knowledge-based growth (Fig. 28[s,t,u]). Indonesia is aiming to build a stronger culture for innovation through education, awareness-raising and the design of more participatory policies. Education curricula have been revised in high schools and universities so as to raise scientific literacy and inspire students with an entrepreneurial spirit. The Science for All programme, for instance, aims to make teaching in high school science more attractive. The government has also implemented a new training programme on procurement and entrepreneurship, and entrepreneurship is being encouraged through awards and competitions organised jointly with private actors and international bodies.

Figure 28. Science and Innovation in Indonesia

Comparative performance of national science and innovation systems, 2016



Note: Normalised index of performance relative to the median values in the OECD area (index median=100). 2012 data was used for indicator (m) "Wireless broadband subscriptions (per population)". It is compared to the values for December 2015 for OECD countries. For indicator (j) "Ease of entrepreneurship index", the 2008 value was used, compared to 2013 values for OECD countries.

Italy

Italy has continued the structural reforms and fiscal consolidation undertaken since 2011 to put the economy on a sustainable growth path. Labour productivity has stagnated in Italy since 2005 and the economic recovery will depend notably on the effectiveness of public initiatives to stimulate productivity and private demand and to facilitate the availability of bank credit. The government's decree law *Sblocca Italia* (September 2014) introduced a series of provisions aimed at supporting the national productive sector and boosting competitiveness. The major actions funded through the decree law include: i) strategic infrastructures, railway and highway networks; ii) new social security benefits/provisions; iii) the internationalisation of enterprises; iv) interventions against hydrogeological instability and for enhancing water infrastructures; v) a more efficient exploitation of national oil and gas resources; vi) the renovation of buildings; and vii) energy recovery from waste. Top STI policy priorities include an increase in public investment, the re-launch of the industrial system, reducing unemployment, and reform of education and research.

Highlights of the Italian STI system

Improving framework conditions for innovation: In the framework of the European Digital Agenda, Italy has developed a national strategy for fostering its digital culture and economy. The Agency for Digital Italy (*Agenzia per l'Italia Digitale*) was established in March 2012, and the Council of Ministers launched the Digital Growth Strategy (*Strategia per la crescita digitale 2014-20*) to make ultra-broadband subscriptions more attractive. Particular emphasis has been placed on the next Italia Log In platform. This tool will group all public administration services for citizens and enterprises in a "one-stop shop", and will be open for contributions from all the public administration agencies.

Universities and public research: Italy has a relatively high share of top universities (Fig. 29[a,b,c]), although its public R&D expenditure is lower than many of its peers, as is its research output in terms of international publications in top scientific journals. In 2015, Italy's new multiannual National Research Programme (NRP) 2015-20 set out objectives and modes of implementation for all public research activities. Currently, the Ministry for Education, University and Research (MIUR) plans to invest about USD 3.3 billion PPP (EUR 2.5 billion) by 2020, along six axes: i) internationalisation; ii) human capital; iii) research infrastructure; iv) public-private partnerships; v) southern Italy; and vi) the efficiency and quality of expenditure. A National Plan for Research Infrastructure (2015-20) has also been developed that aims at defining a national roadmap and prioritising public investment on research infrastructure. To improve bottom-up interdisciplinary research in the public sector, USD 135 million PPP (EUR 100 million) has been allocated for 2016 under the PRIN2015 scheme, which is intended to be re-iterated annually.

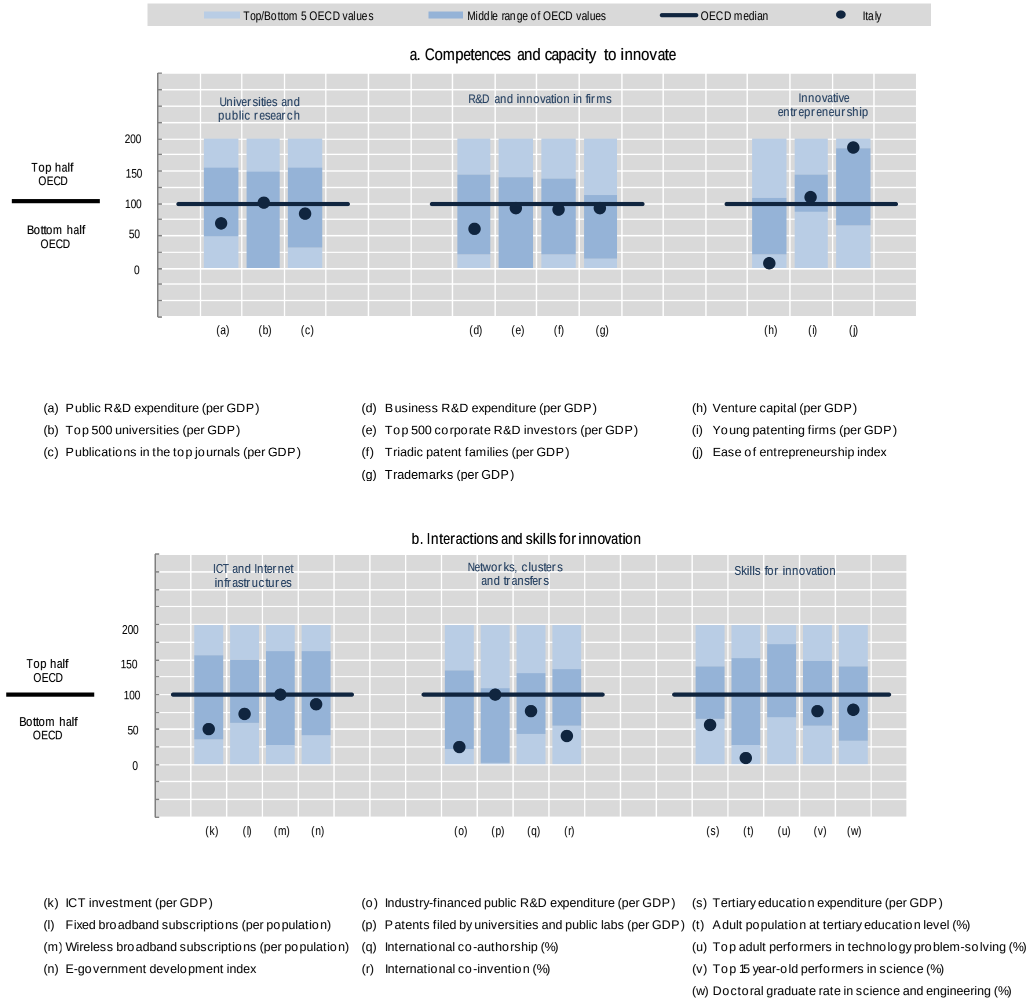
Hot issues

Supporting R&D and innovation in firms: The Italian business sector accounts for barely over half of GERD, a low share for an industrialised economy. A set of innovative firms coexists with a large majority of small and micro enterprises with low productivity. The Italian government has deployed a broad range of financial tools to support business R&D and innovation, with priority recently been given to reforming the tax portfolio. The 2015 Stability Law (L190/2014) introduced a 25% tax credit, granted on incremental investments in R&I incurred by enterprises during the period 2015-19. The tax credit is increased to 50% if new investments are related to hiring highly qualified personnel. As part of the same Stability Law, the government has granted a total of USD 4.7 billion PPP (EUR 3.5 billion) in fiscal incentives to private employers who permanently hire new personnel. The Stability Law also reduces the regional tax on productive activities. Similarly, the Patent Box (Ministerial Decree of 30 July 2015) provides incentives through an optional system of taxation for income derived from the use of intellectual property, industrial patents, trademarks, designs and processes in legally protectable fields in industry, commerce and science.

Globalisation: Italy is weakly integrated into international knowledge networks, as is reflected in its poor performance in international co-authorship and co-patenting (Fig. 29[q,r]). Over 2014-16, Italy has reinforced its network of bilateral and multilateral agreements for scientific and technological co-operation with partner countries, covering almost all European and a growing number of non-European countries. Strengthening the internationalisation of Italian universities, PRIs and businesses is also an aim of Destination Italy. Since 2013, the ITA-Italian Trade Agency has been supporting the internationalisation of Italian firms and in 2015 the Ministry for Economic Development (MISE) committed funding (Decree of 1 July) to consortia for internationalisation to support SMEs in foreign markets and promote the international spread of their products and services.

Figure 29. Science and Innovation in Italy

Comparative performance of national science and innovation systems, 2016



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

Japan

After two decades of sluggish growth, despite recent signs of renewed dynamism, Japan's growth prospects (projected to be 0.6% in 2016 and 0.7% in 2017) are still clouded by an ageing population, a high national debt and other socio-economic challenges. The 5th S&T Basic Plan (2016-20), prepared by the Cabinet Office with the input of experts, identifies sustainable development, the safety and security of the country and its people, climate change and biodiversity as overarching fields for determining a medium- to long-term STI strategy. As the world's third-largest economy after the United States and China, Japan is also the world's third most R&D-intensive country, with 3.59% of GDP dedicated to R&D in 2014. The government has set a target for GERD of 4% of GDP, about USD 246 billion PPP (JPY 26 trillion), by 2020.

Highlights of the Japanese STI system

Addressing societal challenges: Japan's Comprehensive Strategy on STI, established in May 2016, focuses on shaping a world-leading "super smart society" (Society 5.0) that addresses both economic development and societal challenges. The Comprehensive Strategy will be revised annually to facilitate flexible policy management. In the field of health care and medicine, the government is seeking to become a "health country" with world-class health and medical technology and improved medical supply. The Research Centre Network for Realisation of Regenerative Medicine was launched in 2013 to advance induced pluripotent stem cell research, which has been administered by the Japan Agency for Medical Research and Development since 2015. Japan also promotes preventive medicine and supportive nursing, in addition to medical treatment. The 3rd Basic Programme for Shokuiku Promotion was established in March 2016 and encourages education on food and nutrition. In terms of building modern R&D frameworks, new infrastructures that use cutting-edge technologies (e.g. information technologies) and integrated approaches (e.g. Smart Life Project) are being developed to meet the needs of an ageing population.

Improving framework conditions for innovation: Japan has recently reinforced the IP legislative framework in light of the global momentum to harmonise IP systems across countries. The Patent Law was amended in 2015 to enhance relief measures and to establish a new system that enables any person to file an opposition to a granted patent within six months from the date of publication of the gazette of the patent. Under the revised Design Act, applicants will be able to file single applications to register their designs in multiple countries. Under the revised Trademark Act, legal protection will be expanded so that non-traditional trademarks will be given protection, and more entities will become eligible to register regional collective trademarks. In 2013, the Japan Patent Office (JPO) introduced a system of "collective examination for IP portfolios" to examine cross-sectional applications. The JPO revised the examination guideline in terms of simplification, clarification, greater information about sample cases and international acceptability in 2015.

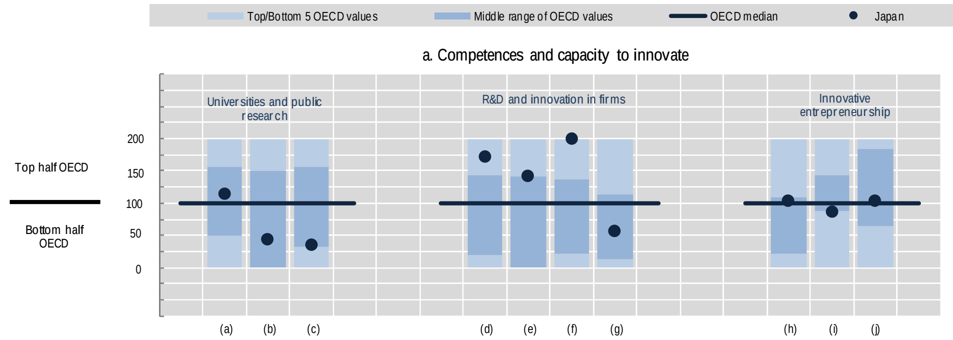
Hot issues

Strengthening public research: Japan's public R&D expenditure per GDP amounted to 0.75% in 2014 (Fig. 30[a]), a relatively stable level since 2000 but modest in light of Japan's high GERD intensity. Applied R&D and experimental development absorbed about 70% of public R&D expenditure in 2014 and basic research about 30%. However, the number of universities of global stature, the level of publications in top academic journals and the international mobility of researchers rank low (Fig. 30[b,c]). To address the problem of young researchers having few opportunities to secure stable academic positions, the Programme to Distinguished Researchers was launched in 2016 to ensure stable employment and an independent research environment. It aims both at creating new career paths across industry, universities and the national research system and at developing a new agency for excellent researchers. Similarly, the 5th S&T Basic Plan follows the 4th edition in fostering world-class basic research, with emphasis on the development and shared use of advanced research facilities as well as open data and open science infrastructures.

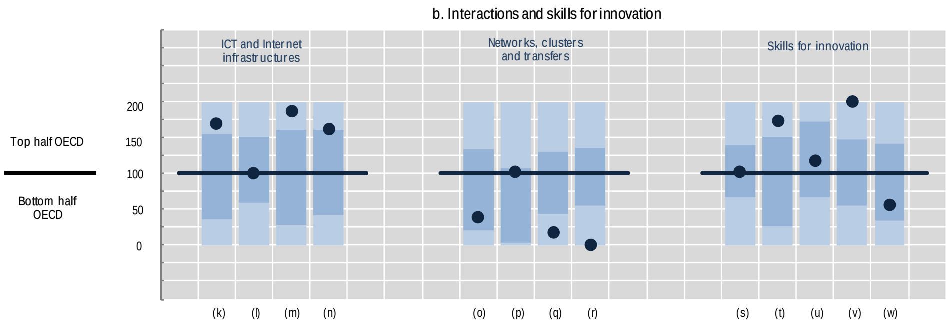
Skills for innovation: Japan has a sound skills foundation with a large pool of university graduates (Fig. 30[t]) and high scores on international assessments of adults in technology problem-solving and of young students in science (Fig. 30[u,v]). However, there are relatively few doctoral graduates in science and engineering (Fig. 30[w]) owing both to the low participation of youth (especially women) in doctoral programmes and to the lack of interest among youth in S&T studies. Japan has sought to improve the attractiveness of research careers, including for women. The Initiative for Realising Diversity in the Research Environment supports the integration of female researchers in science – women accounted for only 14.7% of all researchers in Japan in 2015 according to national statistics – by improving the working environment so that female researchers can balance childbirth, childrearing and nursing care with research.

Figure 30. Science and Innovation in Japan

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).

Korea

Korea weathered the global crisis better than most economies, and it is the world's most R&D-intensive country, with GERD at 4.29% of GDP in 2014. Korea does nevertheless face some challenges: slowing growth, rising inequality and unemployment, a rapidly ageing society and emerging environmental problems. The 3rd S&T Basic Plan (2013-17) sets out the government's road to economic prosperity and public well-being with the High Five Strategy to address long-term challenges. Its action plan was established in 2015. Furthermore, the Creative Economy Initiative introduced a major STI policy governance reform and new policy initiatives. Creative Economy is a strategy to shift Korea's growth paradigm from an industrial economy to a knowledge economy by unlocking the productive potential of national STI and cultural ecosystems. In particular, the highest priority is given to advancing the S&T and ICT sectors and to refocusing Korea's research and innovation system on entrepreneurship and the innovative application of technology.

Highlights of the Korean STI system

Fostering sustainable/green growth: Korea has been at the forefront of green growth initiatives and aims to be a hub for global green growth. The government approved the 2nd National Energy Plan in 2014, which provides a long-term strategy that will determine the direction of the country's energy policy. The plan shifts the focus for the energy management system from a centralised, supply-side orientation to a distributed, demand-side approach. The 10-Year Energy Technology Development Plan (2014-23) has a budget of USD 20 billion PPP to assist in the creation of a new energy industry and innovation ecosystem. Part of this is establishing a new R&D system in terms of supply-demand convergence, encouraging the commercialisation of technology through a more strategic alignment of research with the market, and building capacity and an ecosystem for collaboration between central government, regional government, state-owned enterprises and government-funded research institutes. The related Transition Strategy (2015-17) has been allocated USD 500 million PPP from public budgets, with matching USD 1 billion PPP from private and state-owned enterprises, to promote a new, sustainable energy industry ecosystem that could create 14 000 new jobs by 2017.

ICT and Internet infrastructures: Korea has a strong revealed technology advantage in ICT, with almost half of business R&D performed by the computer, electronics and optical industries. The government is planning to further increase R&D investment in the software industry and to create a software ecology by establishing a software bank, nurturing talent and cultivating an environment for technology proliferation. The government has also pledged to foster convergence in ICT through the ICT Convergence Flagship Project (e.g. next-generation game, ScreenX, and Theme Park) and the Software Convergence Project (e.g. shipbuilding/marine engineering and healthcare).

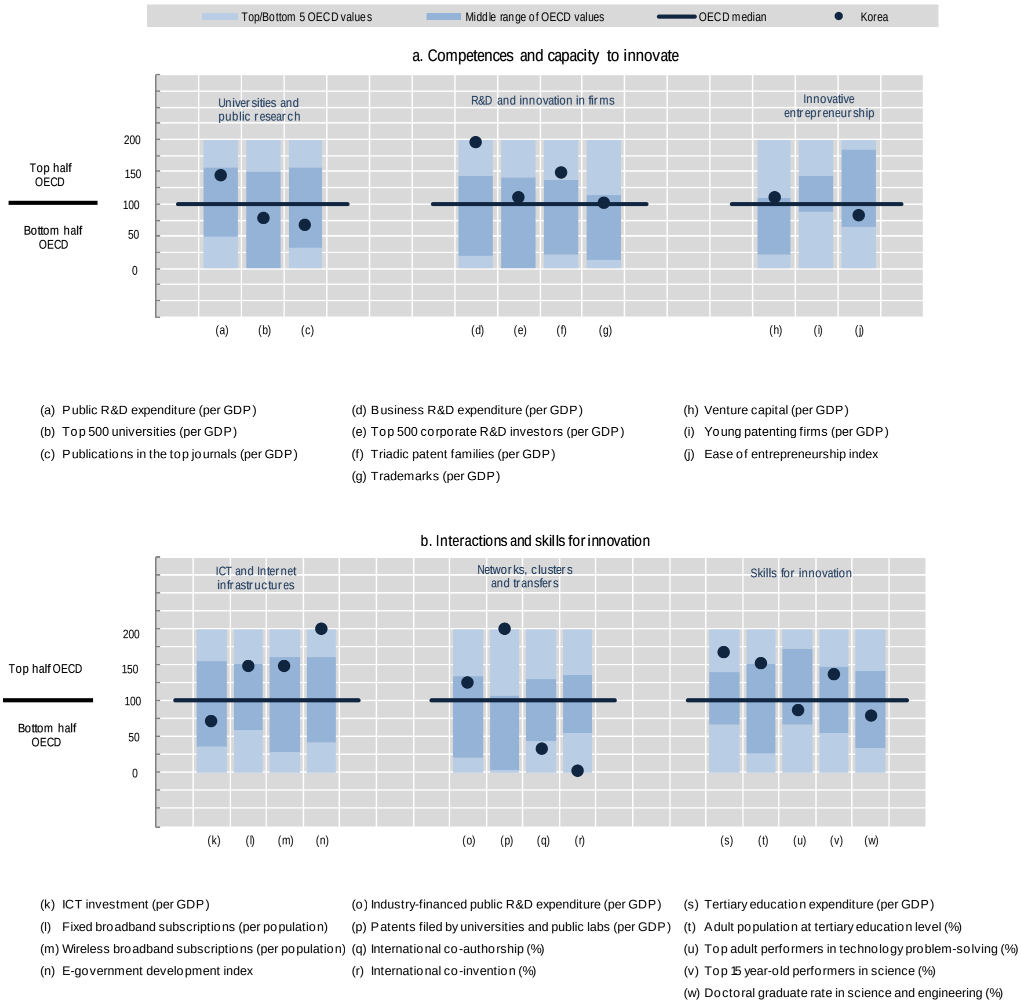
Hot issues

Skills for innovation: Korea has invested heavily in higher education and ranks third in the world in terms of the share of GDP spent on higher education (Fig. 31[s]). However, the Korean education system has mixed results. For example, despite a large share of tertiary-qualified adults, adults' technical problem-solving ability is average (Fig. 31[t,u]), and while 15-year-olds perform well in science, the rate of engineering (S&E) doctorates is modest (Fig. 31[v,w]). The government has developed a Comprehensive Plan for the Scientifically Gifted and Talented (2013-17) to identify pupils with high potential and to nurture their creativity. The Five-Year Plan for University Start-ups (2013-17) aims to improve entrepreneurial education in secondary schools and universities. The National Scholarship programme and the 3rd Women S&E Promotion Basic Plan (2014-18) have been launched to increase youth participation in the field of science and engineering in higher education. The government is also implementing various initiatives to attract young scientists and engineers to SMEs, e.g. by establishing a one-stop information network for job markets and encouraging the pre-employment of students.

Strengthening the public research system: While Korea's public R&D expenditure is high, it still has few world-class universities and produces few high-impact publications in comparison to peers (Fig. 31[a,b,c]). One reason is that the public research system has historically been skewed towards applied and development-oriented research, much of which is performed in the public research institutes that supply technology for industrial R&D. The government has increased investment in basic research, from 30% of total government R&D investment in 2008 to 36% in 2015, with a target of 40% by 2017. At the same time, the government is encouraging the PRIs to leverage funds from collaboration with the private sector and to develop industrial technology research contracts.

Figure 31. Science and Innovation in Korea

Comparative performance of national science and innovation systems, 2016



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

Mexico

The Mexican government is continuing to reinforce the instruments and strategies set forth by the National Development Plan (PND) (2013-18) for ensuring sustainable socio-economic growth. The Special Programme for Science, Technology and Innovation (PECITI) (2014-18) was designed to transform Mexico into a knowledge-based economy by: i) increasing national investment in STI; ii) forming highly qualified human resources in science and technology (HRST); iii) strengthening regional development; iv) promoting science-industry linkages; and v) developing the S&T infrastructure. The federal government budget for STI is expected to increase by 25.6% during 2014-18, with GERD set to rise to 1% of GDP by 2018.

Highlights of the Mexican STI system

Strengthening public research: Mexico is taking significant steps to boost its public research system. Recognising the importance of strengthening the scientific and technological infrastructure, the government increased its funding from USD 37 million PPP (MXP 285 million) in 2011 to USD 140 million PPP (MXP 1 097 million) in 2013. To improve the performance of its public research system, the Council for Science and Technology (CONACYT), the principal body in charge of Mexico's STI policy, created 799 new research positions in public universities and PRIs during 2014-2015. The goal of this programme is to increase the share of young researchers in public research. In 2014, the National System of Researchers (SNI), which recognises excellence in research and provides monetary rewards to top-level researchers, was extended to researchers in private universities.

Globalisation: Mexico is very open to world markets and well engaged in international co-patenting activities (Fig. 32[r]), although its connections with the global academic community through international co-authorship are loose (Fig. 32[q]). The CONACYT maintains diverse multilateral and bilateral co-operation agreements and has provided various scholarships aimed at encouraging international mobility at the higher education level. Areas of research co-operation include geothermal energy, ICT and health, in particular chronic diseases (e.g. diabetes), and infectious disease preparedness. The International Scholarships programme supported 4 196 beneficiaries conducting graduate programmes abroad in 2013. While Mexico is still in the process of defining a concrete institutional policy for the internationalisation of its STI system, its participation in the European Horizon 2020 programme provides a major opportunity for internationalising its research system. To support capitalising on this opportunity, the CONACYT provides additional funding to institutions and researchers that have been awarded H2020 grants.

Hot issues

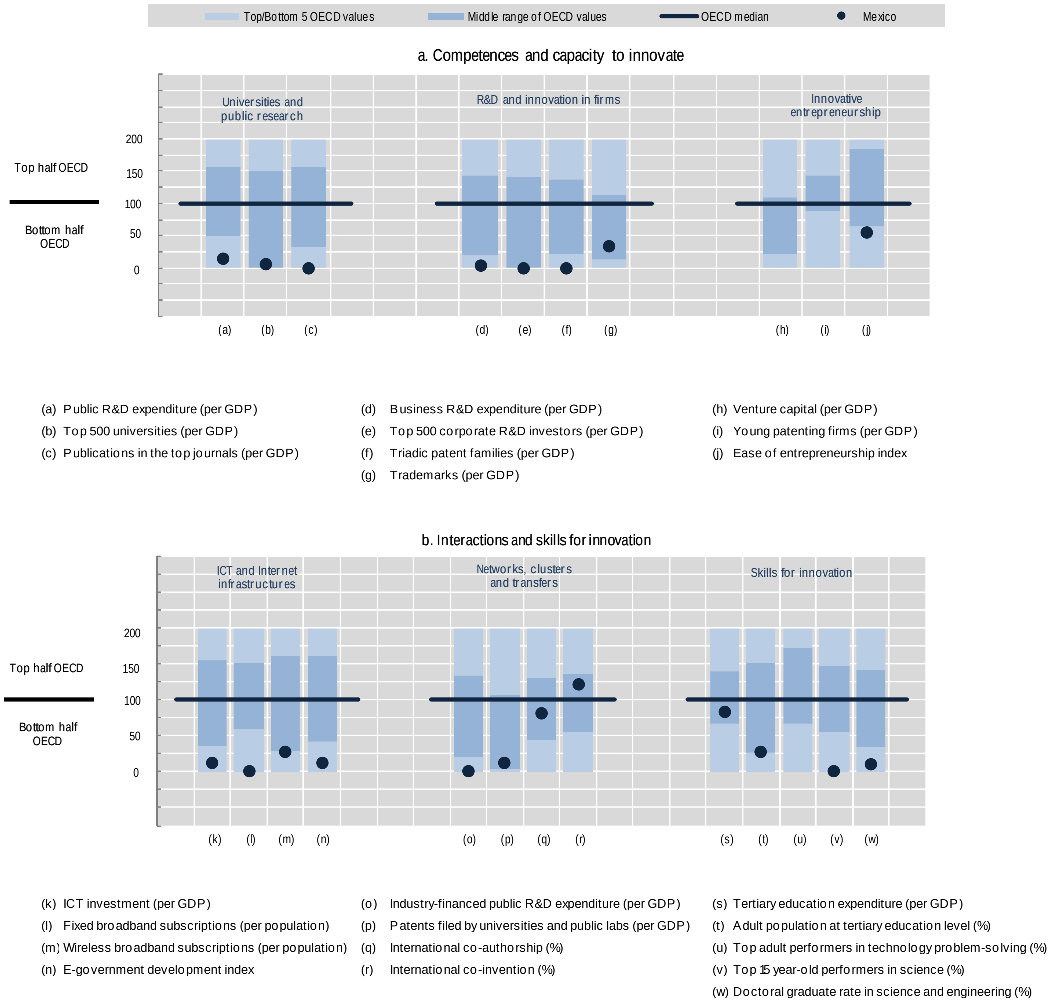
Improving human resources and skills: Public expenditure on higher education as a share of GDP is comparable to peers (Fig. 32[s]). However, a number of indicators suggest the need to improve the scale and quality of the education system (Fig. 32[t,v,w]). The CONACYT is continuing to address the challenge of improving the quality of HRST through several initiatives. The Young Talents programme, introduced in 2014, provides scholarships for graduate studies in Mexico or abroad, fosters the creation of S&T-oriented programmes and promotes Mexican HEIs internationally. The National Programme of Quality Graduate Programmes (PNPC) is continuing to improve the quality of the graduate programmes offered by HEIs and PRIs through a rigorous accreditation process based on international standards. In 2015, the PNPC launched a call to recognise postgraduate programmes with strong industry linkages that meet quality standards. Some 22 courses have already been approved, while others continue to be evaluated.

Encouraging business innovation and entrepreneurship: As in other Latin American countries, Mexico's ratio of BERD to GDP is relatively low (Fig. 32[d]). The CONACYT, which manages around 40% of the public STI budget, seeks to encourage business R&D and innovation, essentially through competitive grants. Its Innovation Incentives Programme (PEI) has proved to be effective in stimulating business innovation, particularly in SMEs.

The Programme's overall budget increased from USD 223 million PPP (MXP 1 663 million) in 2009 to an estimated USD 500 million PPP (MXP 4 000 million) in 2014. In 2013 the government created the National Institute of the Entrepreneur (INADEM) to support SMEs and manage funds to promote national, regional and sectoral growth through entrepreneurship and business development. In 2014, the Fund for Supporting SMEs (Fondo Pyme) and the Entrepreneur Fund (Fondo Emprendedor) were merged to form the National Entrepreneur's Fund, to be managed by the INADEM. In addition, on September 2016, the government presented a proposal to implement a corporate income tax deduction for 30% of R&D investments. It is expected that this new R&D tax credit will be implemented by mid-2017.

Figure 32. Science and Innovation in Mexico

Comparative performance of national science and innovation systems, 2016



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

Russian Federation

The Russian government aims to revitalise the country's long-standing strengths in S&T in an effort to diversify the economy and reduce its reliance on natural resources. In 2015, amidst the economic downturn, the Innovation Development Strategy of the Russian Federation to 2020, adopted in 2011, was revised to address the economy's weaknesses by strengthening STI. A new strategic document, "Long-term Strategy for Scientific and Technological Development of the Russian Federation", is expected in late 2016 and will orient the national research and innovation agenda for the coming years.

Highlights of the Russian STI system

Universities and public research: Russia has a large public science base, dominated by industrial research institutes and the institutes of the State Academies of Sciences (RAS). In 2013, the latter were extensively reorganised through the establishment of the Federal Agency for Scientific Organisations, which has the responsibility to administer the property of the RAS, to evaluate and oversee the activities of the RAS institutes and to distribute public funding to them. New arrangements for assessing the performance of public scientific organisations in the civil sector were also introduced in 2013 to improve accountability, while a new Russian Research Foundation was set up to distribute research grants on a competitive basis. Since 2013, the government has adopted several roadmaps aimed at stimulating the productivity of the Russian science sector, delivering a greater economic impact from research, and redressing the ageing of the Russian research community. A series of initiatives should improve the country's public research infrastructure, including a Mega-Science Infrastructure Projects programme within the DST (2013-20) for creating and developing very large research facilities. It provides competitive funding for infrastructures to both public and private research institutes and universities.

Clusters and regional policies: The government launched a new nationwide programme in 2012 to support pilot innovative territorial clusters to promote value-added production chains and drive growth in Russia's regions. A total of 25 clusters were established, in seven strategic sectors: nuclear and radiation technology; aircraft and space vehicles manufacturing; shipbuilding; pharmaceutical, biotechnology and medical industries; new materials; chemicals and petrochemicals; and information technology and electronics. In 2013, a federal subsidy of USD 63 million PPP (RUB 1.3 billion) was allocated to support 14 pilot clusters, with an equal matching fund provided by the regional governments. Funding support was further extended to another 11 clusters in 2014, with up to USD 154 million PPP (RUB 3.1 billion) expected to be available from the federal budget annually over 2014-16. The next focus of the Russian cluster policy is to implement broader regional cluster programmes and to create cluster development centres to facilitate co-ordination and networking.

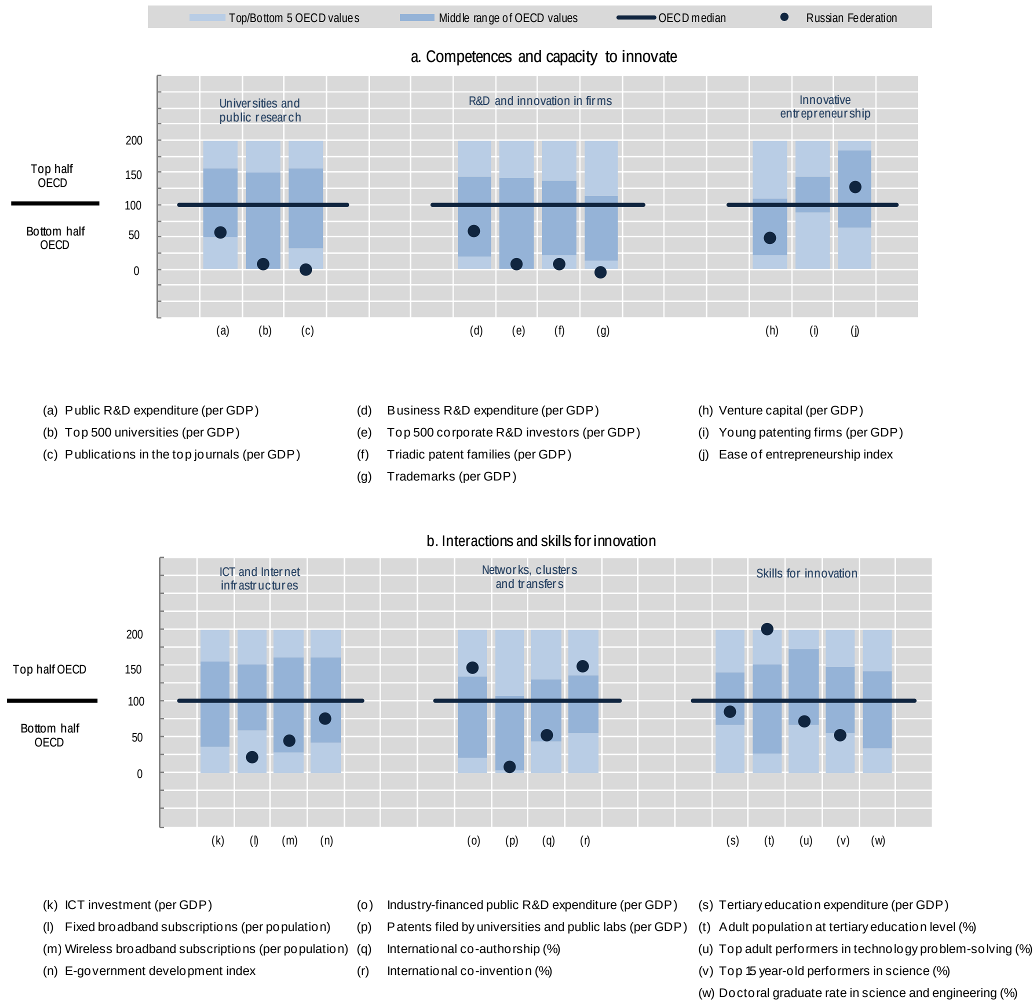
Hot issues

Improving the attractiveness of scientific and research careers: One of the main challenges for Russia is the decline and ageing of its research community. Several measures seek to address this challenge by making research careers more attractive. The Innovation Development Strategy of the Russian Federation to 2020 focuses on the creation of an effective economic and moral impetus to attract the most qualified specialists, active entrepreneurs and creative youth to the education and science sectors, which are crucial for innovation. The Presidential Decree on Measures for the Implementation of State Social Policy targets raising the average salary of researchers to 200% of the regional average by 2018. To support the development of human resources for science and education and their effective reproduction, grants of the President of the Russian Federation provide financial support and incentives to young Russian scientists in two age groups, i.e. below the age of 35 and below the age of 40, respectively.

Encouraging business innovation and entrepreneurship: BERD accounted for 0.71% of Russia's GDP in 2014. A distinguishing feature of the Russian system is that the federal budget for state-owned enterprises and industrial R&D organisations accounts for the major share of business R&D expenditures. On many measures, the innovation performance of Russian firms lags (Fig. 33[e,f,g]). Several government initiatives seek to stimulate innovative activities in the business sector. Russia updated its tax code in 2015 to provide exemptions from VAT for R&D and wider S&T activities, as well as for operations involving the protection and commercialisation of IPRs. Several existing programmes remain prominent. The long-established Russian Research Foundation for Technological Development was transformed into the Industry Development Foundation in 2014 to provide interest-free loans to support business innovation activities. Its budget was increased significantly and is expected to be around USD 1.9 billion PPP (RUB 40 billion) in 2016.

Figure 33. Science and Innovation in Russia

Comparative performance of national science and innovation systems, 2016



Notes: Normalised index of performance relative to the median values in the OECD area (Index median=100). For Russia, the 2012 value was used for the indicator (m) Wireless broadband subscriptions (per population). It is compared to values of December 2015 for OECD countries.

South Africa

South Africa has progressively shifted away from dependence on primary resource production and commodity-based industries to open up to international trade and build capacity in some knowledge-intensive industries. The National Development Plan (NDP), *A vision for 2030* (2011-30), provides a general roadmap for South Africa's transition towards a diversified economy, with innovation underpinning almost every aspect and a strong focus given to strengthening human capital. The National R&D Strategy (2002 onwards) has planned for increasing public and private investment in the science base and improving the system of S&T governance. In parallel, the Ten-Year Innovation Plan (2008-18) identified five areas of competitiveness to be developed: bioeconomy (formerly pharmaceuticals), space, energy security, global change including climate change, and social and human dynamics.

Highlights of the South African STI system

Globalisation: South Africa's integration into international knowledge networks is relatively good (Fig. 34[q,r]). South Africa participates actively in various international R&D programmes and has signed bilateral and multilateral agreements to support the international mobility of researchers. Particular efforts have been made recently to reinforce regional co-operation in the Southern African Development Community (SADC), where South Africa plays a prominent role in developing the SADC STI Strategy. South Africa is also a major partner of the African Union's STI Strategy for Africa 2024 (STISA 2024), which places STI at the centre of the region's socio-economic development and growth. The Square Kilometre Array (SKA) project, constructing the world's largest radio telescope, is one of South Africa's major cross-border initiatives (one square kilometre of collecting area will be located in South Africa and Australia). Key science projects will start in 2020.

Clusters and regional policies: The government has placed strong emphasis on strengthening South Africa's international attractiveness as a location for biotechnology companies, a sector where it has a large and increasing revealed technology advantage. The Cape Health Technology Park is a new facility for pharmaceutical companies, research institutes, clinical trial facilities and health-related academic and government programmes. It aims to reinforce South Africa's specialisation in biotechnology and provide support to local manufacturers to integrate into global biotech value chains. The Biosciences Park is continuing to assist biotechnology start-ups in developing marketable products and incubating innovative approaches. Following the National Science Park Development Plan (NSPDP 2009), some initiatives are also underway at provincial levels, such as the Innovation Hub in Pretoria, supported by the Gauteng Provincial Government and providing funding to establish core infrastructure and incubation facilities in the region.

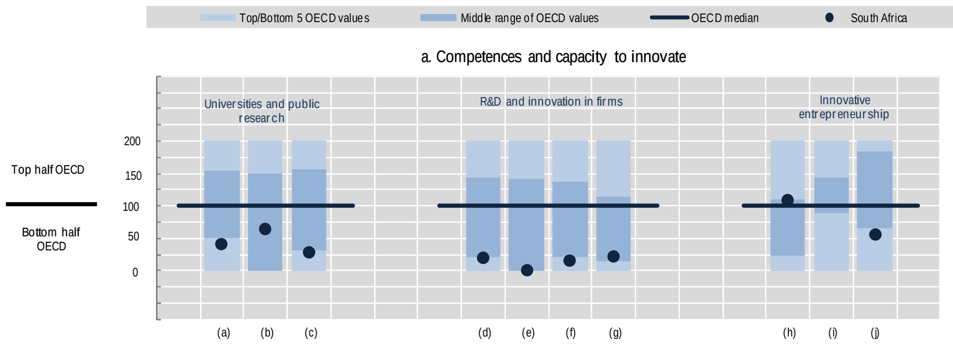
Hot issues

Improving human resources and skills: A major bottleneck for South Africa's socio-economic development in general, and for the advancement of STI in particular, is the lack of a broad skills foundation. The share of the adult population with tertiary-level education is extremely low (Fig. 34[t]), and the ageing of the white male-dominated STI workforce is further weakening the skills base. The government has taken a series of initiatives that focus on improving access to science and mathematics education for youth and on supporting postgraduate students and researchers. University enrolment has increased by 7.7% between 2011 and 2013 to nearly 1 million in 2013, which is in line with the NDP aim to increase enrolment to 1.62 million by 2030. Postgraduate students supported by the National Research Foundation (NRF) doubled from 5 061 in 2008/09 to 11 400 in 2013/14. In addition, in order to improve participation and inclusiveness in higher education, South Africa has long adopted equity targets in its human resources development programmes and offers targeted financial support to women and the black community. Examples include the Thuthuka programme and the 2013 Guidelines for Achieving Equity in the Distribution of Bursaries, Scholarships and Fellowships.

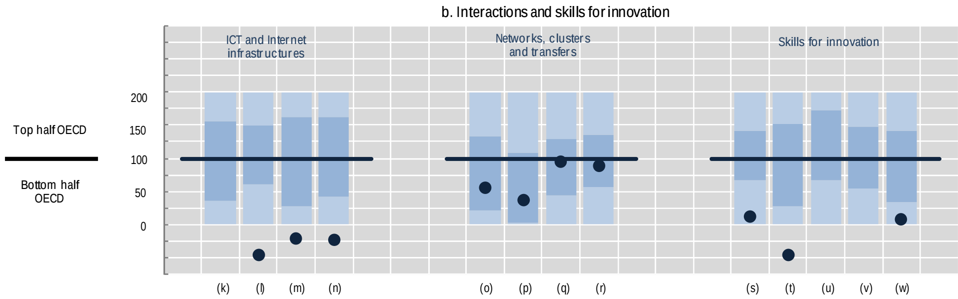
Encouraging business innovation and entrepreneurship: South Africa's business R&D input and innovation output are low (Fig. 34[d,e,f,g]), and BERD decreased in both absolute terms and as a share of GDP over 2009-12. The latest national business survey (2014) shows, however, some improvement in business R&D investment. The policy mix for promoting business-sector R&D and innovation has remained stable, and receives continuous attention. R&D tax incentives provide 150% in tax deductions on the R&D expenditure incurred by firms of all sizes that undertake R&D in the country. Other policies include the Support Programme for Industrial Innovation (SPII), which supports technology development through matching grants for the late developmental or early commercialisation phases, and the Competitive Supplier Development Programme (CSDP), which gives local enterprises technology support to strengthen their ability to supply competitively to large public procurement projects and foreign multinationals.

Figure 34. Science and Innovation in South Africa

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 (%)

Notes: Normalised index of performance relative to the median values in the OECD area (Index median=100). For South Africa, 2012 values were used for the indicator "Wireless broadband subscriptions (per population)". It is compared to values of December 2015 for OECD countries.

Turkey

Turkey has made significant strides in building up its STI capacities, with international STI co-operation playing a pivotal role. GERD grew by 9.7% annually over 2009-14, and Turkey is committed to sustaining its investment in STI. Currently, the National Science, Technology and Innovation Strategy (UBTYS) 2011-16 and the Tenth Development Plan 2014-18 provide the guidelines for Turkey's national STI policy. Ongoing impact assessment exercises will serve as a basis for the new National STI strategy 2017-23. Targets for GERD and BERD were set by the Supreme Council for Science and Technology (SCST) to reach 3% and 2% of GDP, respectively, by 2023.

Highlights of the Turkish STI system

Skills for innovation: Turkey has almost quadrupled the number of full-time equivalent researchers since 2002 from a very low human resource base (Fig. 35[s,t,u,v,w]). The authorities adopted the Turkish Qualifications Framework in 2015, which seeks to improve the quality of education and training and to develop the qualifications required by the labour market. Under the Making Use of Information Technologies initiative, the Ministry of National Education funds a number of training programmes for every level of education so as to develop and extend ICT competences and skills. The Vocational and Technical Education (VET) Strategy Document and Action Plan (2014-18) was implemented to strengthen investment in technological infrastructure. A co-operation agreement on Promoting Entrepreneurship was signed between the relevant ministries and TÜBİTAK to improve the quality and innovative aspect of VET. More than 15 000 teachers and administrators received training on leadership and entrepreneurship between 2012 and 2015.

STI policy design and evaluation: Turkey has recently placed greater emphasis on encouraging broader participation in STI policy design. High-level prioritisation groups, Delphi surveys of experts in the sector concerned and focus groups combine strategic and bottom-up initiatives as well as both qualitative and quantitative measures in order to set future sectoral priorities. This approach facilitates the broad, active participation of non-state actors. The Inter-Governmental Coordination Council for R&D, Innovation and Entrepreneurship, chaired by the president of TÜBİTAK, was established to harmonise all R&D support schemes nationwide and to better co-ordinate the R&D financing institutions so as to ensure the integrity and coherence of public actors and a target-oriented approach to public support. The Coordination Council for R&D is also responsible for evaluating all national R&D support schemes. In total, the Council has assessed 62 R&D support mechanisms since its foundation in 2011. An additional decree is to be presented to the upcoming SCST meeting to diversify the support mechanisms that are related to research commercialisation.

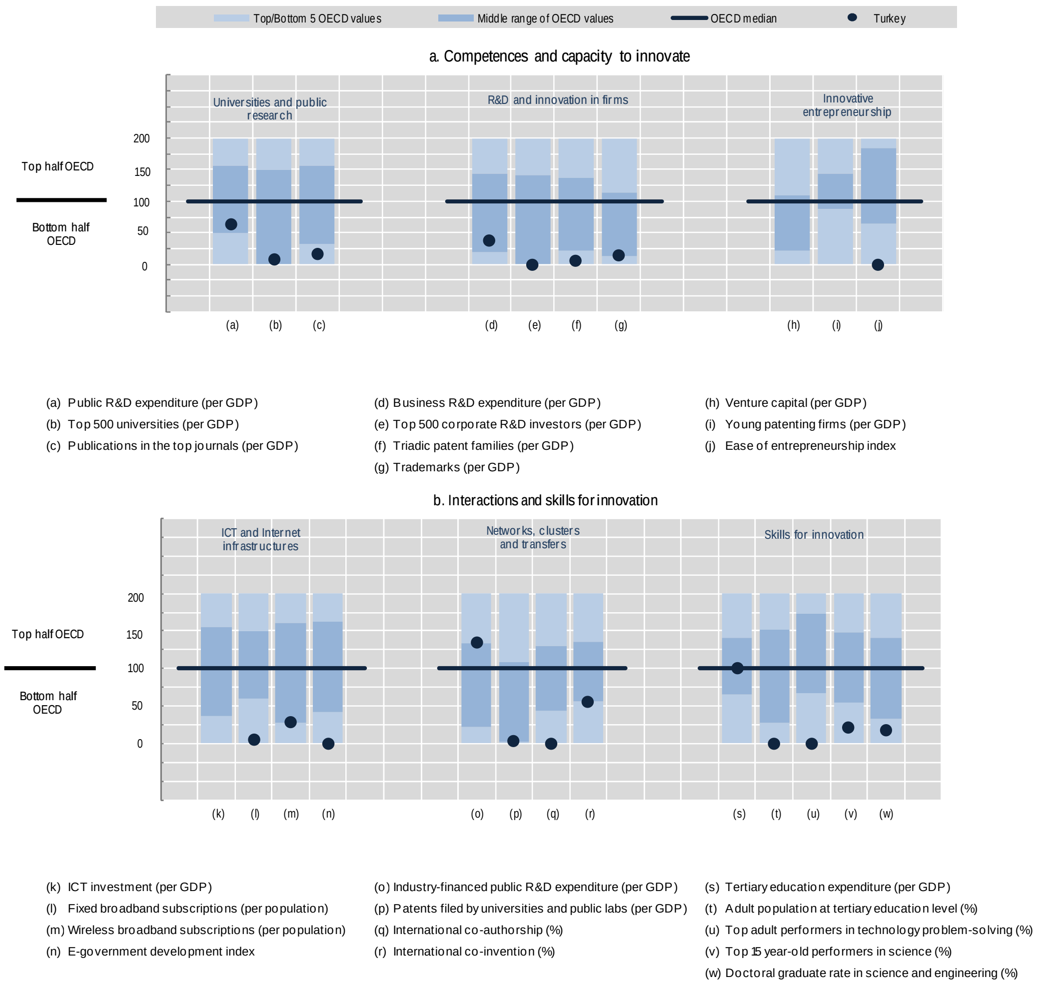
Hot issues

Encouraging business innovation and entrepreneurship: According to the World Bank's Ease of Doing Business Index, entrepreneurship conditions in Turkey could be significantly improved (Fig. 35[j]). The government considers an ecosystem approach centred on the business sector and entrepreneurs crucial for a well-functioning innovation system. Support for entrepreneurship and SMEs is therefore one of the priorities of the SCST. Several decrees and policy initiatives have recently been put in place, such as the International Incubation Centre in 2015 as well as the Acquisition of Foreign High-Tech Companies and the R&D Centres of International Enterprises, both in 2014. The scope of the business-sector R&D Centres Programme was expanded to R&D design issues and accordingly renamed the R&D and Design Centres Programme in 2016. Furthermore, the Ministry of Science, Industry and Technology (MoSIT) started the Technological Products Promotion and Marketing Programme in 2013 and the Technological Products Investment Support Programme in 2014. Both target firms have previously received public/international R&D and innovation support.

Universities and public research: Turkey's public research system, as measured by public R&D expenditure per GDP, is rather small (0.5 % in 2014) (Fig. 35[a]). Turkey produces few international publications in top scholarly journals (Fig. 35[c]) and has only one world-class university (Fig. 35[b]). Public research is currently undergoing major reforms to improve its quality and relevance, to increase collaboration with the private sector, and to leverage private funding. The 2014 Law on the Funding of Research Infrastructure constitutes a legal basis for a performance-based funding system in HEIs and regulates the utilisation and sustainability of research infrastructures. In 2014, the SCST passed a new decree for a support programme to develop excellent research centres. This was followed in 2015 by two new initiatives to improve the efficiency and quality of public research in universities, including two decrees: one to Support the Development of Universities' R&D Strategy in line with regional competences, research capacities, and needs, and a second one to Increase the Quality and Quantity of doctoral graduates in science and engineering, which is still at a low level (Fig. 35w).

Figure 35. Science and Innovation in Turkey

Comparative performance of national science and innovation systems, 2016



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

United Kingdom

The United Kingdom is a very open and globalised economy, and its STI system enjoys a good level of funding and participation by foreign firms. Although unemployment rates have fallen to 5% in 2016, labour productivity growth is sluggish and the results of the Brexit referendum have raised uncertainty regarding economic growth. The Productivity Plan, *Fixing the Foundations: Creating a More Prosperous Nation* (2015), sets out a policy agenda to boost the UK's productivity growth, and the Competition Plan, *A Better Deal: Boosting Competition to Bring Down Bills for Families and Firms* (2015), aims to incentivise firms to invest in technology and to innovate. These cross-governmental strategies have been complemented by a number of important reviews focused on specific aspects of the UK STI system, providing the stimulus for significant structural changes in the governance and management, as well as the focus, of public investment in STI.

Highlights of the UK STI system

Improving governance of the STI system: A new evaluation strategy for science and innovation was published in 2014 that focuses on improving the use and coverage of evaluations, strengthening governance, increasing analytical capability and ensuring independent and transparent quality assurance. In addition, a new single non-departmental public body operating at arm's length from government – UK Research and Innovation (UKRI) – will bring together the seven Research Councils and Innovate UK. The UKRI is designed to enable a greater focus on cross-cutting issues and improved collaboration between the research base and the commercialisation of discoveries in the business community. To complement these major structural changes in the way public investment in STI is to be managed, the Government Office for Science, working with the Research Councils, has launched a series of foresight exercises and science and innovation audits. These are designed to help build joint visions and directions.

Addressing societal challenges: There is an emphasis in the Productivity Plan and the associated reviews on STI to address complex global challenges, such as developing a low-carbon economy. One initiative in this direction is a new Global Challenges Research Fund, with USD 2.17 billion PPP (GBP 1.5 billion), to be spent over the 2016/17 to 2020/21 period. This fund will target areas where multidisciplinary research is required to address new and emerging social, environmental and health challenges throughout the world. This will be managed through the Research Councils, national academies and other partners. The Global Challenges Research Fund will provide additional funding to support research initiatives with a global dimension. It will complement targeted investment in areas such as energy, where a new grants programme, targeted at industry and focusing on clean energy, is being launched by the Department of Energy and Climate change. USD 724 million PPP (GBP 500 million) has been set aside for this programme over the period 2016-2021.

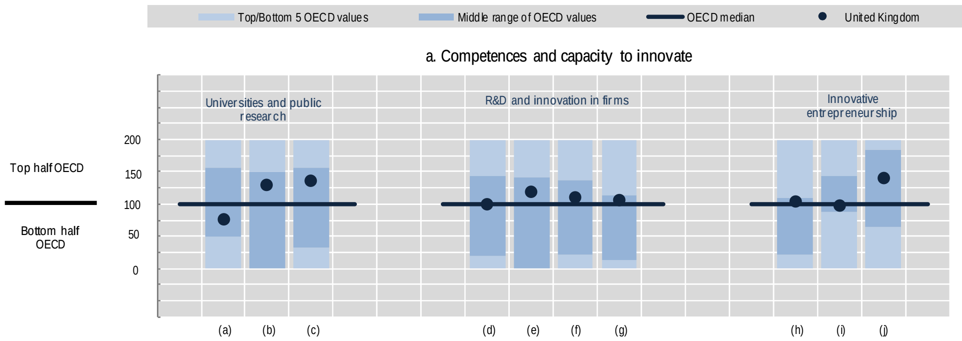
Hot issues

Innovation in firms: Promoting R&D in domestic firms and manufacturing industries is a particular challenge for the UK. The UK government has implemented a variety of novel direct and indirect support measures to increase innovation in companies and support SMEs. Among these, R&D tax credits are the single largest government support for business investment in R&D and are available to any company in any sector liable to pay corporation tax. Businesses are also entitled to an R&D Allowance, formerly known as the scientific research allowance, which gives 100% relief for capital expenditures on R&D. The Patent Box scheme was introduced to provide an additional incentive for companies to retain and commercialise existing patents. The Patent Box applies a lower rate of corporation tax to profits attributable to patents and equivalent forms of IP on products derived from UK and EU patents. The benefit is being phased in, and companies will benefit from the full 10% rate from 2017/18.

Technology transfer and commercialisation: Industry-science linkages in the United Kingdom, as measured by the private funding of public R&D, are lower than might be expected (Fig. 36°). The objective of the Knowledge Transfer Network (KTN) is to stimulate innovation through knowledge transfer. The government, through Innovate UK, provided support of around USD 21 million PPP (GBP 15 million) in 2015-16 for the KTN, which has over 43 000 business members and 14 000 non-business members. The Dowling review on university-business research collaboration (2015) considered the role of government in fostering the conditions under which the excellence in UK universities can connect with innovative businesses at home and overseas. This review concluded that that the complexity of public support mechanisms for research and innovation poses a barrier to business engagement in collaborative activities, particularly for SMEs. It emphasised the need to promote and incentivise mobility and exchange between academia and industry, and for university technology transfer offices to focus more on knowledge exchange than on short-term income generation.

Figure 36. Science and Innovation in the United Kingdom

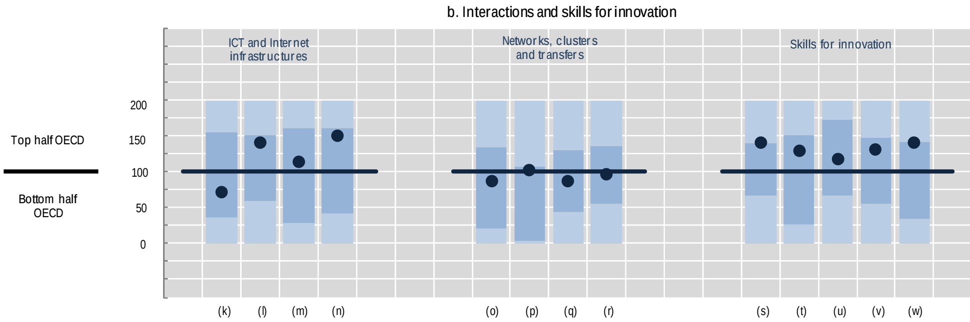
Comparative performance of national science and innovation systems, 2016



(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).

United States

The United States has long been, and still is, at the forefront of cutting-edge STI. However, indicators such as business innovation surveys and data on the growth of multi-factor productivity suggest that the US lead is narrowing in spite of its world-class universities and global technology companies. R&D and patenting by businesses have also grown less rapidly than in the past. The 2009 *Strategy for American Innovation: Driving towards Sustainable Growth and Quality Jobs*, which was updated in February 2011 and again in October 2015, provides the strategic directions for government policies to further an innovation-based economy.

Highlights of the US STI system

Supporting knowledge transfer: A government-wide policy mandating increased public access to scientific publications and digital data resulting from federally-funded research was issued in 2013 and will be implemented by the end of 2016. Although there are agency differences, the standard is for all research publications resulting from federally-funded research to be publicly accessible within one year of publication, and for data resulting from federally-funded research to be publicly accessible as soon as and as openly as possible. Some agencies are supporting dedicated infrastructures for open access, including data repositories, publication repositories and public-private collaborations to create repositories. A US Executive Order in 2013 established open and machine-readable data as the default for government information. This Executive Order is being implemented by US government agencies through Open Data Initiatives in various fields (including health, energy, climate, education, finance, public safety and global development). The White House has also launched Project Open Data to share best practices and code so as to assist US federal agencies in making their data more open. The aim is to make these data available in open, machine-readable formats, and many of these data sets are accessible through the central portal of data.gov.

Fostering sustainable/green growth: The commitment of the United States to sustainable growth and clean technology has been on the rise over the last few years, and there is a plan to double US investment in clean energy innovation over five years. The 2016 Budget allocates funding for clean energy R&D with the aim to develop the technologies that will reduce US dependence on oil, build the domestic energy industries and jobs, as well as help reduce the emissions implicated in climate change. The 2016 Budget proposes USD 325 million for the Department of Energy to conduct transformational energy R&D; USD 2.7 billion for the Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE), with a focus on improving clean vehicle technologies and on developing advanced materials and processes to cut manufacturing costs by using less energy; and USD 2.7 billion for the US Global Change Research Program (USGCRP) to understand, predict, mitigate and adapt to global change.

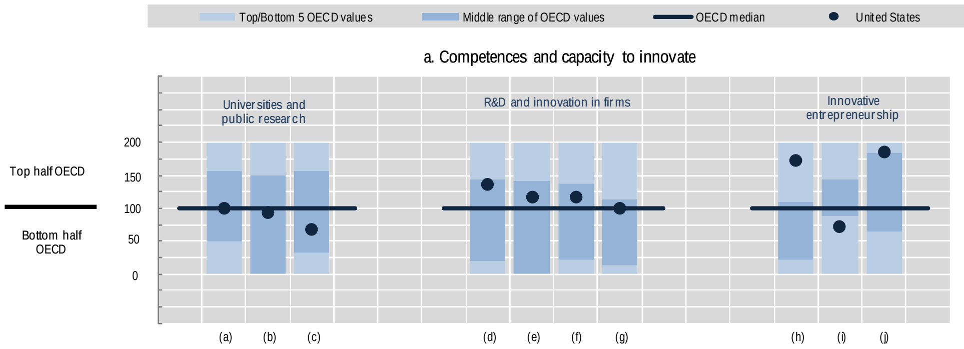
Hot issues

Improving human resources and skills: With a notable share of GDP spent on higher education, the United States has a good skills foundation and a high share of a tertiary-qualified workforce (Fig. 37[s,t]). However, there has been a relative decline in doctoral graduates in science and engineering, and American 15-year-olds perform below peers in science (Fig. 37[w,v]). The federal government is committed to improving STEM education at all levels to nurture a highly skilled, competitive US workforce for the future. In June 2013, President Obama released a Five-Year Strategic Plan for Federal STEM Education (2013-17) to increase efficiency and co-ordination in STEM programmes across the federal government. The 2016 Budget includes a major new investment of USD 3.1 billion in federal programmes on STEM education, seeking to advance a government-wide goal of increasing by one-third (by one million) the number of well-prepared college graduates with STEM degrees over the next decade. The 2016 Budget also proposes USD 50 million to create the Advanced Research Projects Agency for Education (ARPA-ED) to produce breakthroughs in learning technology.

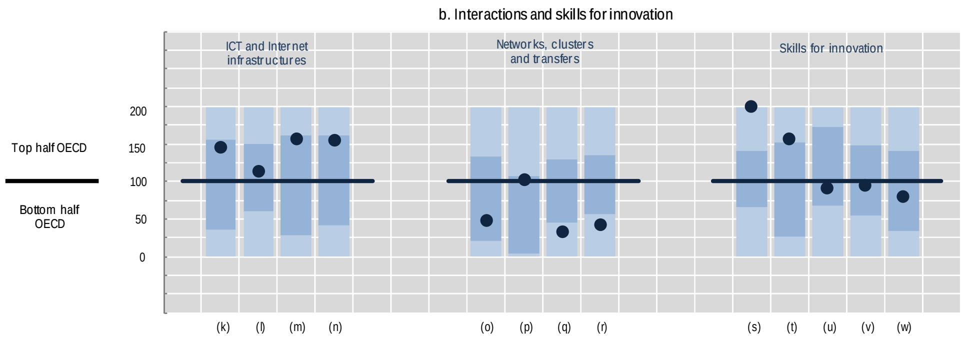
Innovation in firms: While public funding of business R&D has declined since 2008, primarily because of declines in defence budgets, more emphasis has recently been placed on direct support for business R&D and innovation. In December 2015, the Research and Experimentation Tax Credit was retroactively extended and made permanent. Over the next several years, a greater share of US R&D investments made through competitive grants will go to small businesses and small business-led consortia. Technology consulting services/extension programmes were introduced in 2013 with a focus on manufacturing and on new firms arising from advances in basic research. The US government continues to propose expansions of loan guarantees and risk-sharing mechanisms, particularly in the clean-energy sector.

Figure 37. Science and Innovation in the United States

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).

European Union

The European Union's 28 member states account for nearly a quarter of world GDP and contribute to the world's R&D on a similar order of magnitude (24%). EU member states are at different stages of development in their STI capabilities, and these cross-country differences have been increasing since 2009. The European Union's Horizon 2020 (H2020) Framework Programme for Research and Innovation (2014-20) has set the strategic direction for its research and innovation policy and investment for the next few years. With a budget of nearly USD 98.6 billion PPP (EUR 78.6 billion), H2020 increased the EU R&D budget by nearly 30% in real terms as compared to the previous programming period (2007-13). A special focus has been put on improving the capacity of the European Union's STI system to address societal challenges.

Highlights of the EU STI system

STI policy governance: The European Union is placing an emphasis on policy evaluation. The European Commission introduced the European Semester mechanism so as to analyse members' policy and reform efforts, including in the research and innovation (R&I) policy domain, and assess progress towards the Europe 2020 R&I goals. Since March 2015, the Policy Support Facility (PSF) has provided EU members with practical support to identify, implement and evaluate reforms of R&I policies, such as opening up public funding to competition. The PSF also supports peer reviews by government officials from other countries and provides access to independent expertise and analysis. The European Commission's Directorate-General for Research and Innovation is instrumental in assessing national research and innovation policy and reform programmes. Recently, greater use has been also made of foresight as a priority-setting support tool, and a dedicated internal unit responsible for policy development and co-ordination has been created. In addition, a Scientific Advice Mechanism was introduced in 2015, drawing on the expertise of a High-Level Group of independent scientific experts who can provide timely and independent scientific advice for policy making.

Skills for innovation: The European Union considers that human resources are key to future competitiveness (Fig. 38[t,v,w]). The 2016 Skills Agenda for Europe introduces a number of actions to ensure that the right training, skills and support is available and visible to people throughout the Union. Under H2020, the Marie Skłodowska-Curie actions support researchers at all stages of their careers in all disciplines to combine academic research with work in companies, as well as with other innovative training that helps enhance employability and career development. Furthermore, ensuring a gender balance in science and research careers is at the top of the EU research agenda. A number of H2020 funding programmes allow for the promotion of gender equality and gender mainstreaming, in particular, through: i) gender balance in advisory groups and evaluation panels; ii) the selection of grant beneficiaries and research teams; and iii) a gender dimension in research content.

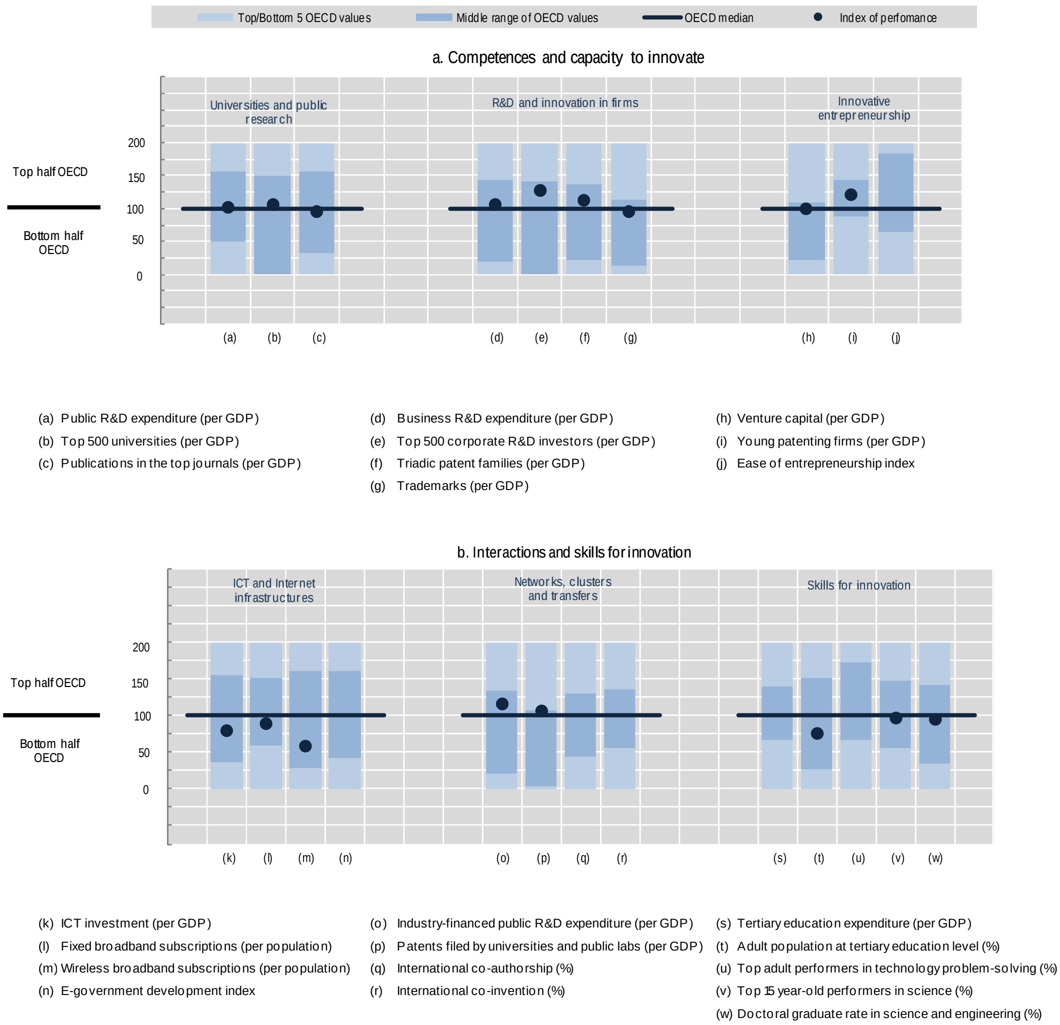
Hot issues

Encouraging business innovation: The EU business and entrepreneurial environment was weakened during the financial crisis and STI policy efforts are currently being undertaken to simplify access to (and fill gaps in) existing innovation support measures. One feature of H2020 is strengthened support for the close-to-market stage of innovation. H2020 funding has been made available for all STI activities, from research to market commercialisation, but with a renewed focus on innovation-related activities, such as piloting, demonstration and test-beds, together with support for public procurement and market uptake. Particular emphasis is being given to direct funding, through competitive grants, equity funding and public procurement. The European Commission has also deployed new financial instruments that intend to leverage private investments. A debt facility provides loans, guarantees and other forms of debt finance to all firms, while an equity facility provides finance for early- and growth-stage investments, with a particular focus on early-stage SMEs with high growth potential.

ICT and Internet infrastructures: ICT investment in Europe is still relatively low and fixed and mobile broadband networks are unevenly deployed (Fig. 38[k.l.m]). In early 2016, the European Commission released its Digital Agenda, which aims to achieve a Digital Single Market based on interoperability, security, fast access for all, digital literacy, ICT R&D and ICT-enabled benefits. ICT are included in all H2020 activities, either through specific calls or as part of a broader set of contributing technologies. The EU Cloud Initiative aims to make it easier for researchers, businesses and public services to move, share and re-use research data across borders, institutions and research disciplines. The European Data Infrastructure will support the European Open Science Cloud, by deploying the high-bandwidth networks, large-scale storage facilities and super-computer capacity necessary to effectively access and process large datasets stored in the cloud. By making research data openly available, the initiative also aims to boost Europe's competitiveness, especially for start-ups, SMEs and companies that can use data as a basis for R&D and innovation.

Figure 38. Science and Innovation in the European Union

Comparative performance of national science and innovation systems, 2016



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

Readers' guide

Country profiles are designed to provide a concise overview of science, technology and innovation (STI) policy and performance in a given economy. Each profile is based on information gathered from the latest country's responses to the *EC* (*European Commission*)/*OECD International Survey on STI Policies* (*STIP*), as well as various additional OECD and non-OECD sources. The STIP Survey reviews on a biennial basis major changes in national STI policy portfolios and governance arrangements. Responses are provided by government representatives. The OECD Committee for Scientific and Technological Policy (CSTP) and the European Research and Innovation Committee (ERAC) jointly guarantee the relevance of national input.

The profiles include a double figure that sheds light on the strengths and weaknesses of economies' STI performance. It uses indicators on national innovation systems and performance with respect to: universities and public research; business R&D and innovation; innovative entrepreneurship; information and communication technology (ICT) and Internet infrastructure; networks, clusters and transfers; and skills for innovation. The dot for each indicator positions the country relative to the OECD median and to the top and bottom five OECD countries. Non-OECD countries are also compared to the OECD countries, and may fall out of the range indicated in the figure. All indicators are normalised (by GDP and population size) to take account of the size of the economy and the relevant population, and are presented as indices (OECD median = 100) for comparative purposes.

In the text, all amounts are given both in USD in purchasing power parities (PPP) of the relevant year (if available) and in national currencies. Further details on the methodology, data sources and descriptions of indicators used in the country profile will be provided on the OECD-World Bank Innovation Policy Platform.

Abbreviations used in the country profiles

BERD	Business expenditure on research and development
EU	European Union
FDI	Foreign direct investment
GBAORD	Government budget appropriations and outlays for R&D
GDP	Gross domestic product
GERD	Gross expenditure on research and development
GOVERD	Government expenditure on R&D
HERD	Higher education expenditure on R&D
HEIs	Higher education institutions
ICT	Information and communication technology
IPRs	Intellectual property rights
ISO	International Organization for Standardization
IT	Information technology
MNEs	Multinational enterprises
PISA	Programme for International Student Assessment
PRIs	Public research institutes
R&D	Research and development
SME	Small and medium-sized enterprise
STI	Science, technology and innovation
S&T	Science and technology
STEM	Science, technology, engineering and mathematics
TTO	Technology transfer office
USD	United States dollar (converted using the purchasing power parities of the relevant year)
VC	Venture capital

FURTHER READING

OECD (2016), *OECD Science, Technology and Innovation Outlook 2016*, OECD Publishing, Paris, http://dx.doi.org/10.1787/sti_in_outlook-2016-en.

OECD (2015), *OECD Science, Technology and Industry Scoreboard. Innovation for Growth and Society,* OECD Publishing, Paris, http://dx.doi.org/10.1787/sti_scoreboard-2015-en.

OECD (2010), *Measuring Innovation. A New Perspective*, OECD Publishing, Paris, http://dx.doi.org/10.1787/9789264059474-en.

www.oecd.org/innovation

www.innovationpolicyplatform.org

@OECDInnovation

STI.contact@oecd.org

OECD

BETTER POLICIES FOR BETTER LIVES