OECD Science, Technology and Innovation Outlook 2016

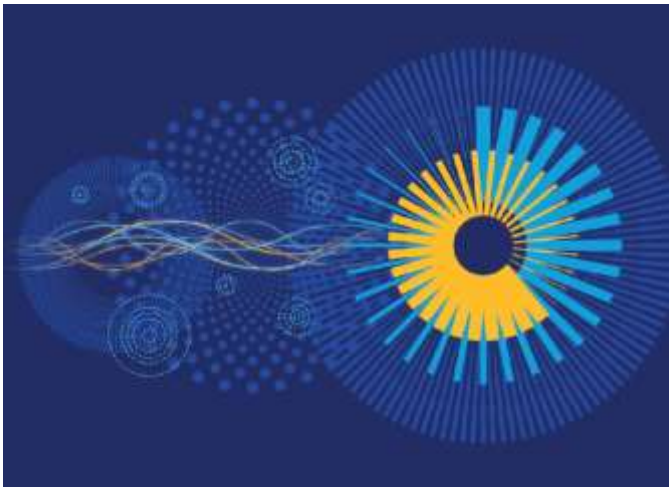
Highlights

OECD

These highlights draw upon the OECD report

(OECD, 2016) *OECD Science, Technology and Innovation Outlook 2016*

More information, thematic Policy and Country Profiles available at
http://oe.cd/STIOutlook



Megatrends are shaping future STI capacity and activities

Ageing societies, climate change, health challenges and growing digitisation are, among other factors, expected to shape future R&D agendas and the scope and scale of future innovation demand. Novel demands and markets are likely to emerge, creating new skills needs and new growth and job opportunities. New approaches to sustainable growth, e.g. through the circular economy, are also emerging.

STI is widely seen as key to addressing these grand challenges. STI activities could however be confronted with strong resource constraints. Possibly insufficient growth in developed and emerging economies, as well as competing policy priorities and agendas, may limit the financial resources available. Similarly, an ageing population, together with changing patterns in migration, might affect the availability of STI skills. This could compromise the role of STI to address future challenges.

The megatrends raise urgent issues that demand urgent policy responses, including in the STI field. But the capacities of governments to intervene will likely face major constraints, including high public debt, increasing international security threats, rising protectionist reactions, a possible erosion of social cohesion, and the rise of influential non-state actors that challenge their authority and ability to act.

Technology is set to disrupt societies, with tremendous potential but uncertain outcomes

Future developments in STI could accelerate, intensify or reverse megatrend dynamics. But these developments also have the potential to offer solutions to the challenges we face. For example,

- Globalisation will be further enabled by advances in communications and transport technologies. Global digital platforms are helping drive down costs of cross-border communications and transactions, thereby reducing the minimum scale at which businesses can operate globally and enabling small businesses to become "micro-multinationals".
- Income growth will be increasingly driven by STI developments, especially in the digital economy. Between 2014 and 2020, an additional 1.1 billion individuals will acquire a mobile phone for the first time. Both China and India will soon have more Internet users than the entire population of the U.S. and Western Europe combined. In two or three years, Africa will connect more people than the U.S. has population. The sharing economy, enabled by smart apps, is expected to reach a global value of USD 335 billion by 2025.

- Reductions in CO_2 emissions will depend on the development of new, cleaner energy technology. Biotechnology offers unique solutions to dependence on oil and petrochemicals. Bio-based batteries, artificial photosynthesis and micro-organisms that produce biofuels are some recent breakthroughs that could support a bio-based revolution in energy production.
- And improved health outcomes and increasing life expectancy will heavily depend on health technology innovation. While still small-scale and marginal, do-it-yourself science groups and maker communities are likely to be increasingly visible in the healthcare field, enabled by low-cost advanced technologies like synthetic biology and additive manufacturing that allow them to research and develop their own therapeutics and medical devices.

On the other hand, emerging technologies carry several risks and uncertainties, and many raise important ethical issues, too. STI developments could exacerbate inequalities without wider innovation diffusion and skills acquisition. Developments in artificial intelligence and robotics raise concerns around future jobs; the Internet of Things and big data analytics around privacy; 3D printing around piracy of intellectual property; synthetic biology around biosecurity; and neurosciences around human dignity.

Still, emerging technologies are expected to have wide impacts across several fields of application and will often depend on other "enabling" technologies for their development and exploitation. Technology convergence and combination could be further helped by cross-disciplinary working arrangements and skills training.

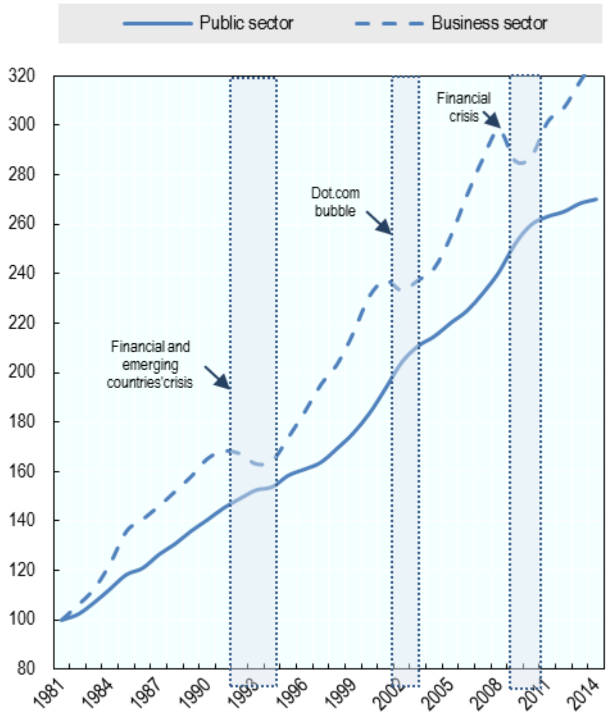
Public science has a central role to play, provided it can manage its own transition

Public sector science will continue to play leading roles in developing new knowledge and skills for nurturing these technological advances and supporting their exploitation in the wider economy. But it will also undergo its own transformation.

Expenditures on R&D by universities and public research institutes (PRIs) in OECD countries, most of which is funded by governments, began flattening out in 2010 following three decades of growth (Figure 1). Growth in public R&D budgets has slowed down in many countries as other policy priorities, such as state pensions, health and social care, have absorbed a growing share of public resources. Data on government budget appropriations and outlays for R&D (GBAORD) as a percentage of total government spending for 2000 and 2015 show that while countries like Germany, Korea, Portugal and Switzerland are spending more on R&D, others including Australia, France, Italy, Spain, the United Kingdom and the United States have reduced their R&D efforts. Furthermore, continued pressure on public finances in many countries and sluggish economic growth suggest that public spending on R&D (GBAORD), be it towards public research or business R&D, is likely to plateau at current levels or decline even further.

Figure 1. Expenditures on public R&D in OECD flatten out following three decades of growth

OECD R&D expenditure, index 1981=100

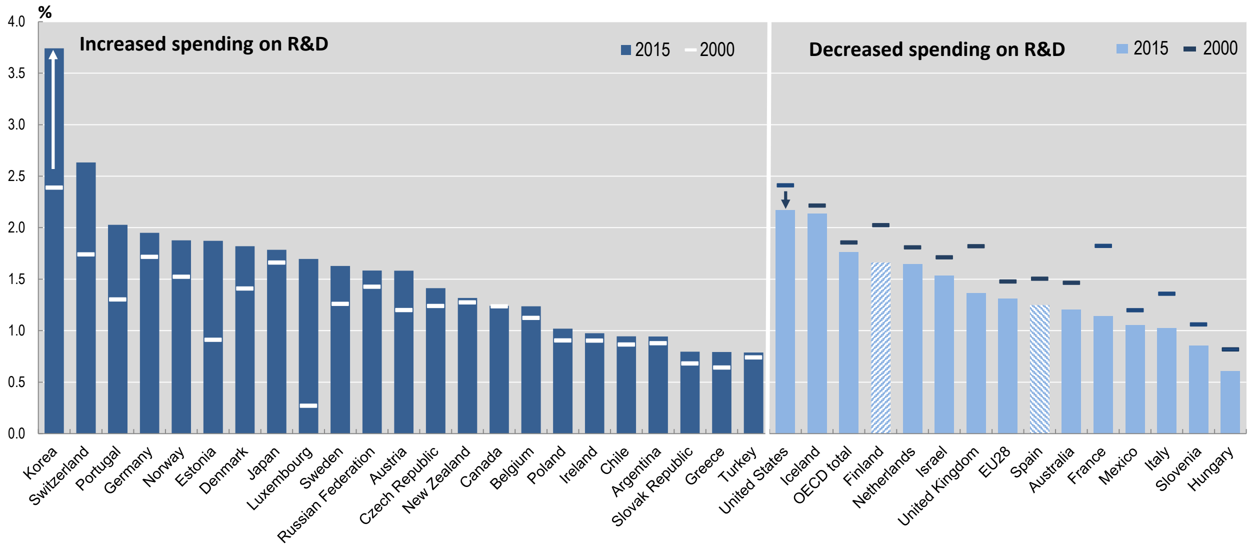


Source: Based on OECD (2016), Main Science and Technology Indicators (MSTI) Database, June; Eurostat R&D Indicators and UNESCO Institute for Statistics, S&T Indicators, June 2016. Data extracted from IPP.Stat on 22 July 2016, https://www.innovationpolicyplatform.org/content/statistics-ipp.

StatLink http://dx.doi.org/10.1787/888933433354

Figure 2. R&D has fallen behind other policy priorities in many countries

Government budget appropriations and outlays for R&D (GBAORD) as a % of total government expenditures, 2000 and 2015



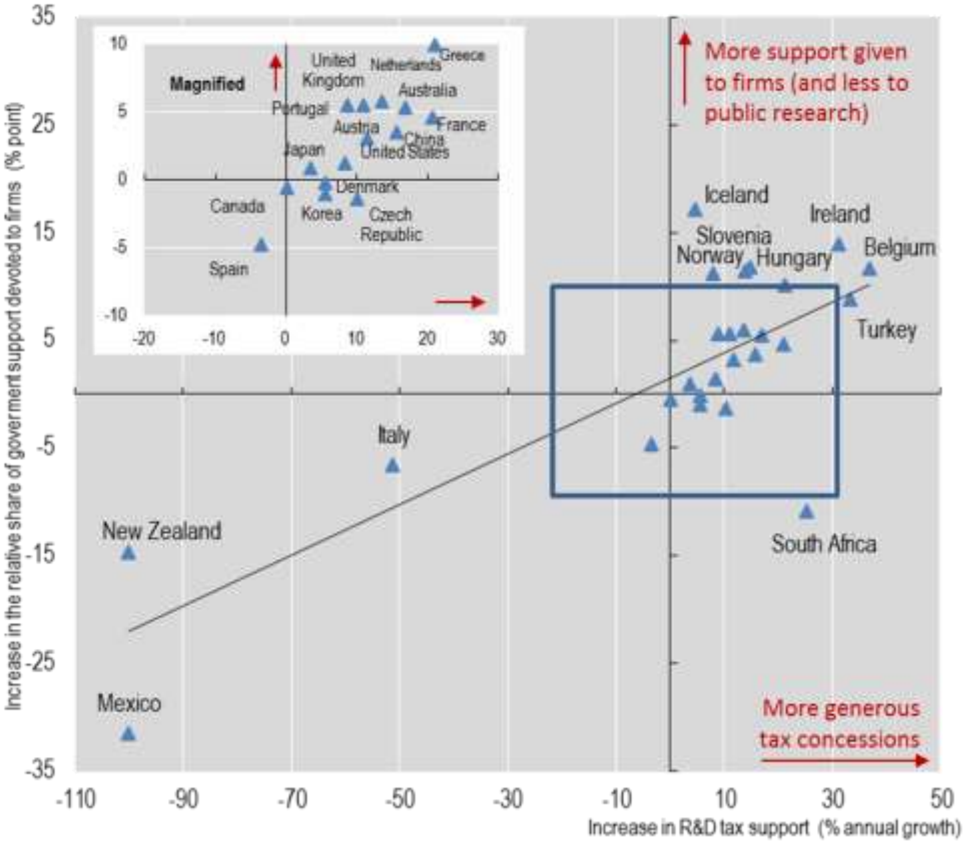
StatLink http://dx.doi.org/10.1787/922016061P1G091

Source: OECD, Research and Development Statistics (RDS) Database, April 2016, www.oecd.org/sti/rds; OECD National Accounts Database, September 2016 ; Eurostat RD Databases August 2016, UNESCO Institute for Statistics, June 2016 and World Economic Outlook Database, October 2016. Data retrieved from IPP.Stat on 26 November 2016.

Part of the decline in GBAORD is also related to a more widespread use of tax incentives for R&D in recent years. This substitution between a spending approach (R&D budgets) and a non-spending approach (tax reliefs) signals a shift in the policy mix for innovation towards firms and more economic objectives. Country responses to the latest EC/OECD International Survey on STI Policies (STIP) also confirm the recent policy focus given to restoring competitiveness and accelerating growth in many OECD countries and non-OECD key economies.

Figure 3. Less public support has gone to public research while more R&D tax incentives were given to firms

Percentage change in the relative share of government support granted to firms (y-axis) and annual growth of R&D tax support estimates (x-axis), 2006-14 or nearest years available



Source: Based on OECD R&D Tax Incentive Indicators, www.oecd.org/sti/rd-tax-stats.htm, July 2016; OECD Main Science and Technology Indicators, www.oecd.org/sti/msti.htm, June 2016; OECD R&D Statistics (RDS) Database, April 2016, www.oecd.org/sti/rds.

StatLink http://dx.doi.org/10.1787/888933433595

At the same time, there is emerging evidence that less public support has gone to public research while more generous R&D tax incentives were given to firms (Figure 3). A tendency among governments to focus more on offering R&D tax incentives to firms than funding R&D in universities and public laboratories is also tilting the balance towards the private sector. That can mean funds are allocated to where new products or profits are most likely rather than to less directly-focused research and blue sky research, which are frequently the source for unexpected breakthroughs.

Indeed, although they carry out less than 30% of total R&D in the OECD area, universities and PRIs perform more than three-quarters of basic research. They often undertake longer-term and higher-risk research, as well as the kind of projects that have more potential to translate into tangible societal benefits. Artificial intelligence and personalised medicine are two examples of innovations that came about thanks to scientific and technological developments enabled by public research.

Public research systems are also experiencing intrinsic transformations that raise both challenges and opportunities (Figure 4). Universities are increasingly at the core of national and local research systems and they are increasingly relying on new sources of funding, including from charities, philanthropists and private foundations, particularly in the area of health and at the scientific frontier. This will have an impact on future public research agendas, especially as central governments budgets remain under severe pressure. Private foundations, charities and philanthropies are, for instance, strong advocates for open access.

Open science is the next frontier. Open data access practices are increasingly widespread. Encouraging the sharing and re-use of research data could generate more value for public money. Science is also becoming a less institutionalised endeavour, with citizens contributing to research alongside the scientific community. However, deep changes in academic culture will be necessary to realise the full potential of a more open science.

Emerging technologies are also opening up a new age for research. Big data and algorithms are generating huge amounts of data, changing scientific methods, instruments and skills requirements and creating new fields of research. Yet, research careers are likely to remain precarious, especially for women, with consequences for attracting future generations of researchers.

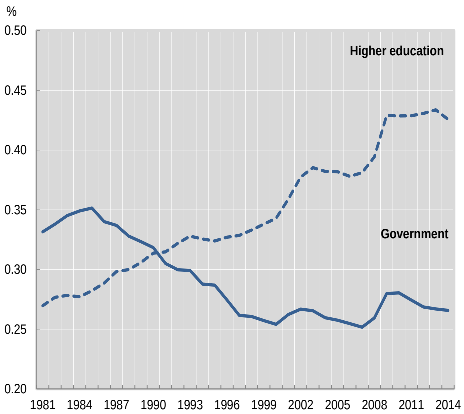
Governments will increasingly work with wider society to shape and exploit STI

Governments are increasingly managing the risks and uncertainties around emerging STI developments by adopting more "responsible research and innovation" (RRI) policies. RRI principles have diffused into policy agendas, funding programmes and governance arrangements, integrating ethical and social considerations "upstream" in the innovation process.

Figure 4. Public research is in transition

Public research has shifted towards universities…

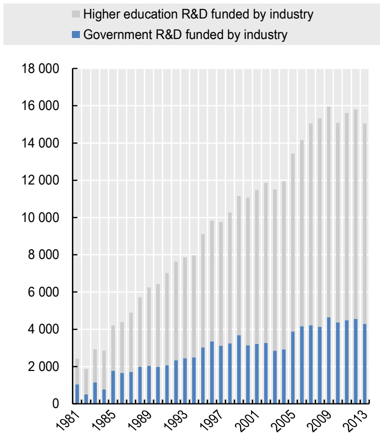
Public R&D expenditure, total OECD, as a % of GDP, 1981-2014



StatLink http://dx.doi.org/10.1787/888933433428

…that are increasingly reliant on private funding

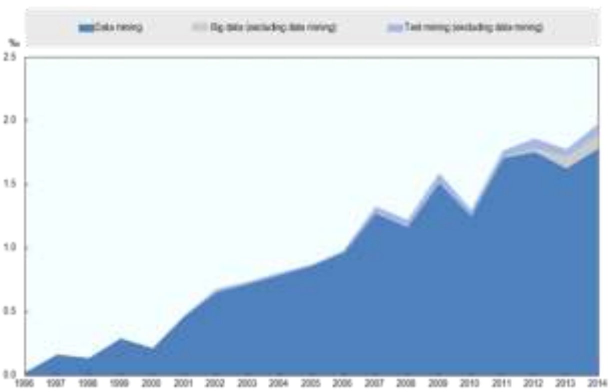
Public research funding by industry, OECD, USD million PPP at constant prices, 1981-2013



StatLink http://dx.doi.org/10.1787/888933433392

Digitalisation is changing research subjects…

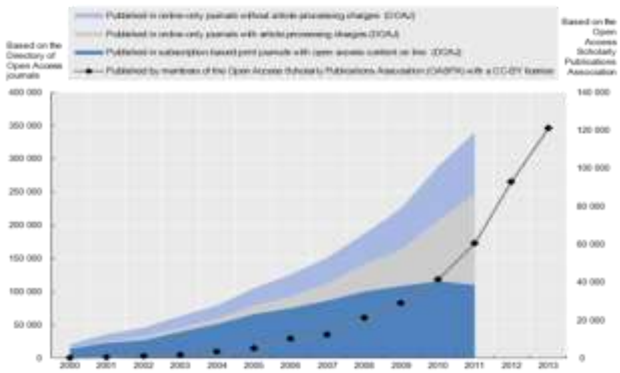
Data mining-related scientific articles, per thousand articles, 1996-2014



StatLink http://dx.doi.org/10.1787/888933433466

… and opening science to new practices and actors

Number of papers, 2000-13



StatLink http://dx.doi.org/10.1787/888933433448

Notes: Public R&D expenditure includes higher education R&D expenditure (HERD) and government R&D expenditure (GOVERD).

Source: Based on a) OECD (2016), *OECD R&D Statistics* (*RDS*) *Database*, April, www.oecd.org/sti/rds; b) OECD (2016), *Main Science and Technology Indicators* (*MSTI*) *Database*, June, www.oecd.org/sti/msti.htm; c) OECD (2014d), Measuring the Digital Economy: A New Perspective, http://dx.doi.org/10.1787/9789264221796-en, based on ScienceDirect repository, www.sciencedirect.com, July; d) Laakso, M. and B.-C. Björk (2012), “Anatomy of open access publishing: A study of longitudinal development and internal structure”, BMC Medicine, Vol. 10, p. 124, http://www.biomedcentral.com/1741-7015/10/124, and website of the Open Access Scholarly Publications Association (OASPA), http://oaspa.org/growth-of-fully-oa-journals-using-a-cc-by-license/. Data extracted from IPP.Stat on 25 July 2016, https://www.innovationpolicyplatform.org/content/statistics-ipp.

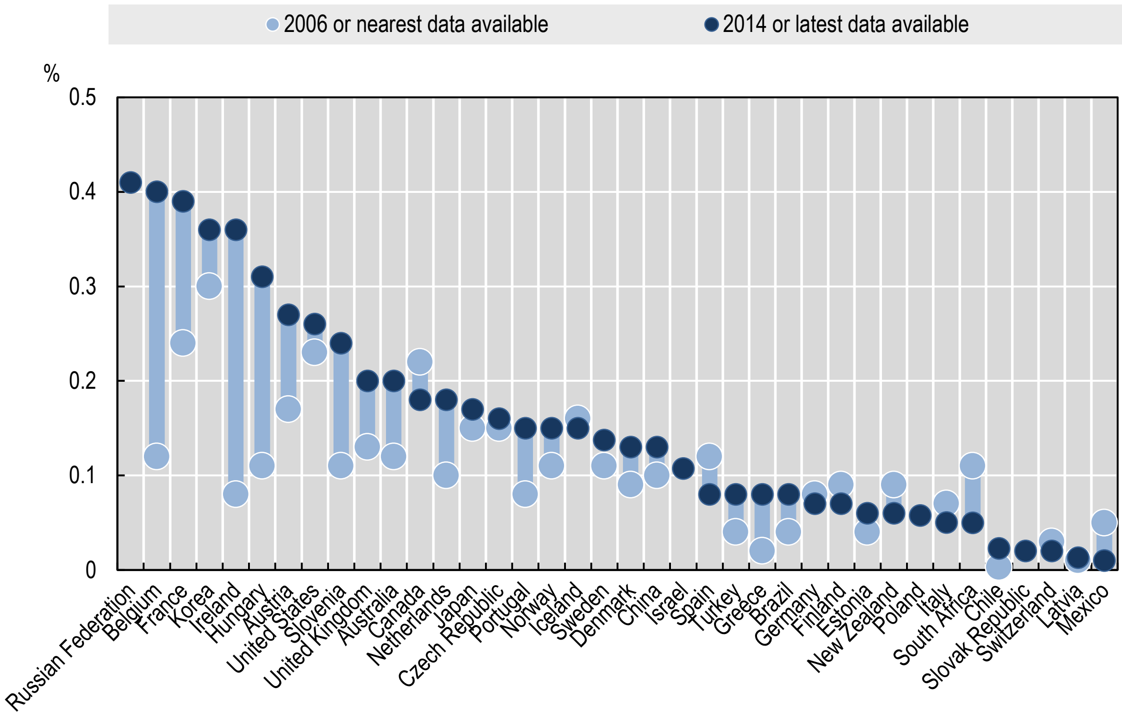
Today, policy attention remains focused on immediate economic imperatives

The recent financial crisis hit STI activities hard, and the subsequent rebound has remained weak. Financial conditions for innovation and entrepreneurship remain difficult, especially for SMEs.

OECD countries and non-OECD economies have placed considerable emphasis on supporting firms' capacity to innovate. Many countries have sought to consolidate their business support programmes to make them more accessible and more cost-efficient (Figure 5). Many countries have also adjusted their policy portfolios to assist SMEs and start-ups, especially for accessing global markets.

Figure 5. Most governments have increased their support to business R&D and innovation…

Combined direct and indirect financial support, as a percentage of GDP, 2006 and 2014

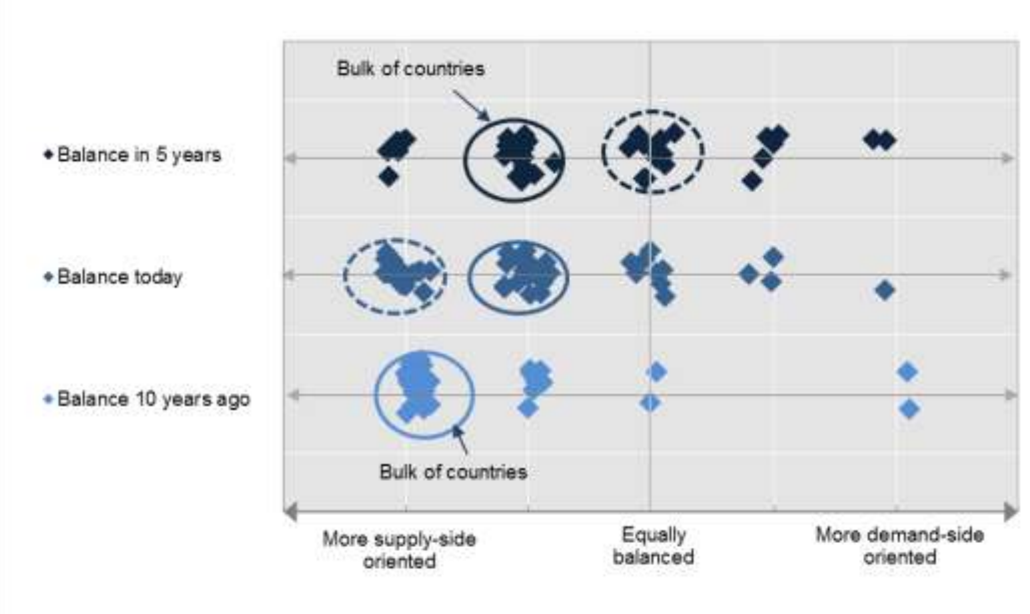


Source: Based on OECD (2016), *OECD Research and Development Statistics (RDS) Database*, April, www.oecd.org/sti/rds; and OECD (2016), *OECD-NESTI data collection on R&D tax incentives*, July, www.oecd.org/sti/rd-tax-stats.htm. Data retrieved from IPP.Stat on 08 August 2016.

StatLink http://dx.doi.org/10.1787/888933433581

Figure 6. … and greater focus is being given to public procurement and demand-side approaches in the policy mix

Changing balance in the policy mix for business innovation, country self-reported assessment



Note: The balance in the policy mix for business innovation is defined by country self-assessment answers to the question: "What is the balance between different types of policy instruments in the policy mix for business R&D and innovation? How has this balance shifted over time and is forecasted to change in the coming years? Please rate the balance between the following types of policy instruments according to their relative importance/significance in the innovation policy mix" Responses are provided by Delegates to the OECD Committee for Scientific and Technological Policy (CSTP) and the .European Research and Innovation Committee (ERAC).

Source: Based on EC/OECD (forthcoming), *International Database on STI Policies (STIP)*, https://www.innovationpolicyplatform.org/sti-policy-database.

StatLink http://dx.doi.org/10.1787/888933433631

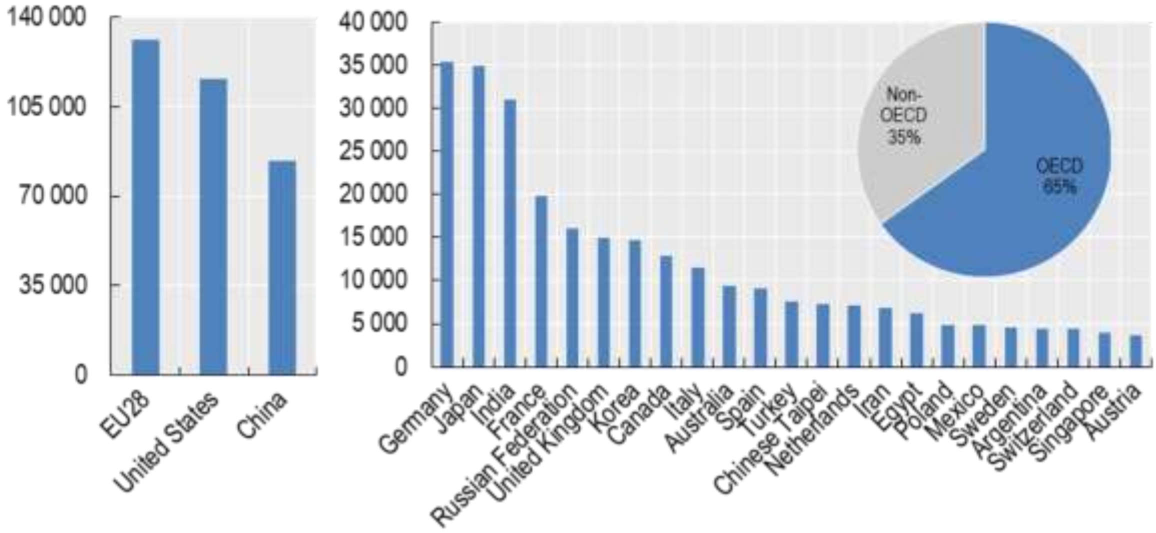
In their "no-spending" approach in supporting innovation, OECD and non-OECD governments have also shifted towards a new policy toolset by placing a greater emphasis on public procurement and demand-side instruments (Figure 6). Smart public procurement initiatives, such as improved dialogue between procurers and suppliers, lead market initiatives, prizes and standards have sprung up in a range of countries.

International cooperation for R&D and innovation are essential

Socio-economic activities are increasingly global, and research and innovation are no exception. International knowledge networks are more diverse and connections are more multiple than a decade ago. Although global R&D remains concentrated into several economies, the number of global actors engaged in R&D has increased steadily in recent years (Figure 7) as well as the number of scientific cooperation channels.

Figure 7. There are large public research systems outside the OECD area

Expenditure on public R&D, million USD PPP, and share in world total, 2014 or latest year available



Source: OECD R&D Statistics (RDS) Database, April 2016, www.oecd.org/sti/rds.

StatLink http://dx.doi.org/10.1787/888933433376

Over a third of the public research carried out globally, i.e. in government and higher education institutions, takes place in non-OECD economies. China spent around twice as much on public R&D as Japan in 2014. India, the Russian Federation, Chinese Taipei, Iran and Egypt have some of the world's biggest public science systems. Five countries – the US, China, Japan, Germany and India – accounted for 59% of global public R&D in 2014, while 25 countries were behind 90% of the total. This dominance by a few partly reflects their large size. In the future, economies with fast-growing populations and GDP, as in Africa, may become more important players.

International mobility remains a major channel for knowledge circulation, if not the primary one. Recent evidence based on bibliometrics data show that more mobile scientists are also those who enjoy higher citation impacts. And there is a risk that rising protectionist reactions in some countries threatens international cooperation for R&D and innovation.

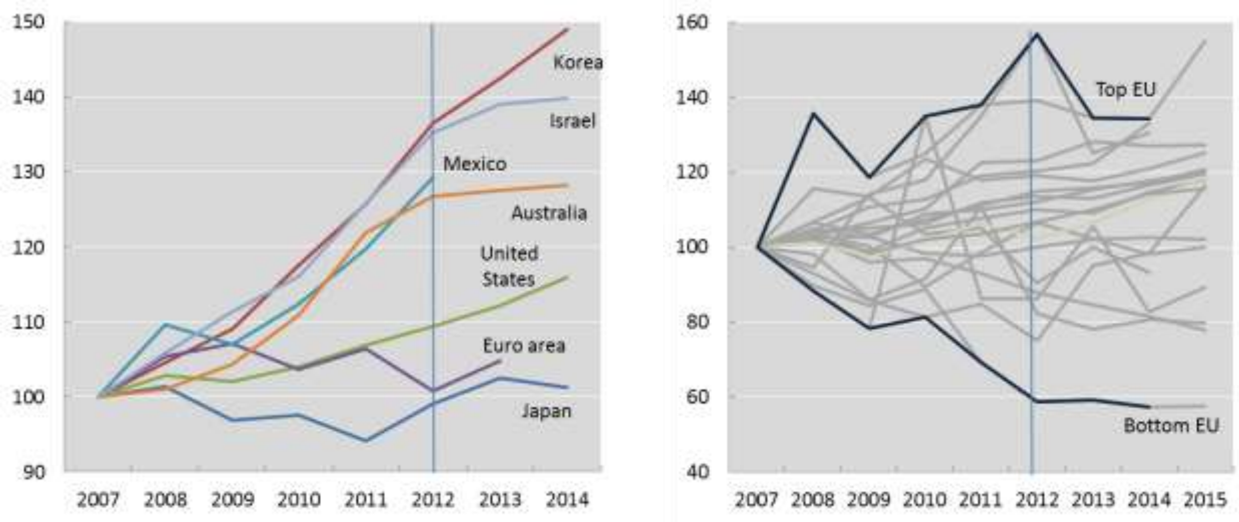
International cooperation is likely to feature more importantly in STI policies as resources available for R&D and innovation at national level shrink. The uneven economic recovery has widened the gap between countries experiencing low growth, and which have difficulty maintaining R&D expenditure and investments in intangible assets, and countries experiencing higher growth, and expanding their national intellectual asset portfolio. Even within Europe, noticeable cross-country differences in investment profiles signal a growing threat to the cohesion of the European Union (Figure 8).

Figure 8. Cross-country divergence in investments in intellectual assets is widening

Gross fixed capital formation, intellectual property products, index 2007=100, 2007-14

Panel 1. Divergences across the OECD — index 2007=100, 2007-14

Panel 2. Intra-European divergences — index 2007=100, 2007-14



Source: Based on the OECD (2016), *OECD National Accounts Database*, July. Data extracted from OECD.Stat on 20 July 2016.

StatLink http://dx.doi.org/10.1787/888933433578