OECD Science, Technology and Industry Outlook 2014

Highlights

The OECD Science, Technology and Industry Outlook 2014 reviews key global trends in science, technology and innovation (STI) policies and performance. It draws on a unique policy survey conducted every two years by the OECD with more than 45 countries, including OECD and major emerging economies, and brings in the latest OECD work on STI policy analysis and measurement.

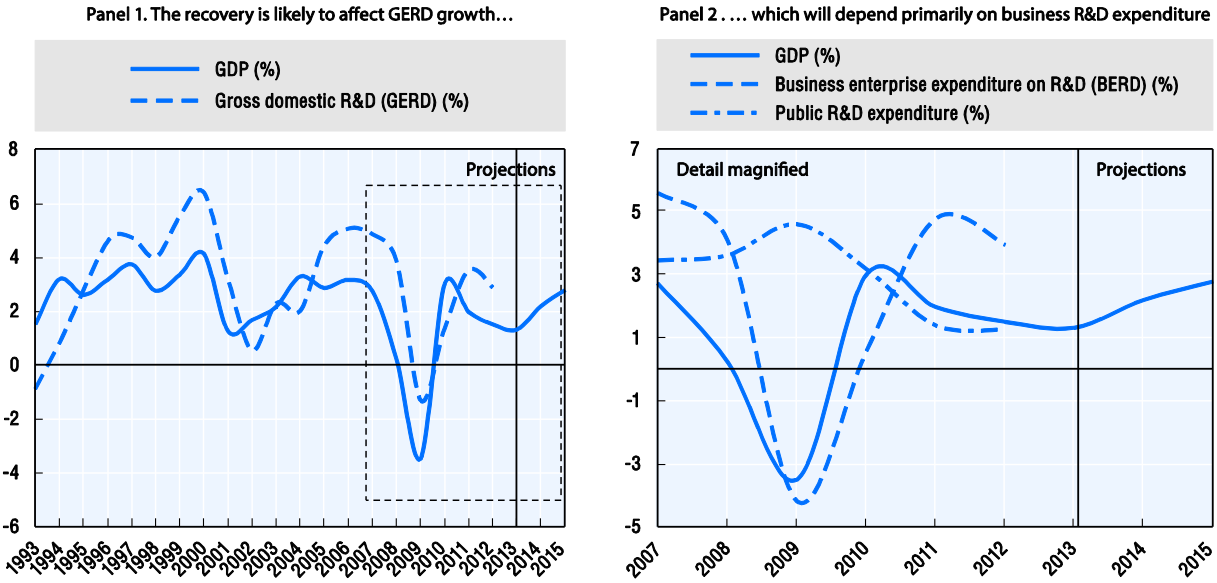
The shock of the crisis has yet to be fully absorbed

The impact of the recession on innovation was considerable, and the global recovery is too modest for innovation activities to be back on track. At 1.6%, yearly growth in gross expenditure on research and development (R&D) in OECD countries over 2008-12 was half the rate for the years 2001-08.

In a context of fiscal consolidation, fewer public resources can be mobilised, and public R&D budgets have levelled off in many countries and have started to decline in others. In 2008-09, governments partially offset drops in business R&D spending, but the buffering effect of public research during the downturn has faded in the aftermath of the crisis (see Figure 1).

Figure 1. The buffer effect of public R&D has faded in the aftermath of the crisis

Annual growth rate of GDP, GERD, BERD and public sector R&D at constant prices, 1993-2013 and projections for 2014-15



Source: OECD, *Economic Outlook No. 95 Database*, May 2014; OECD, *Main Science and Technology Indicators (MSTI) Database*, June 2014.

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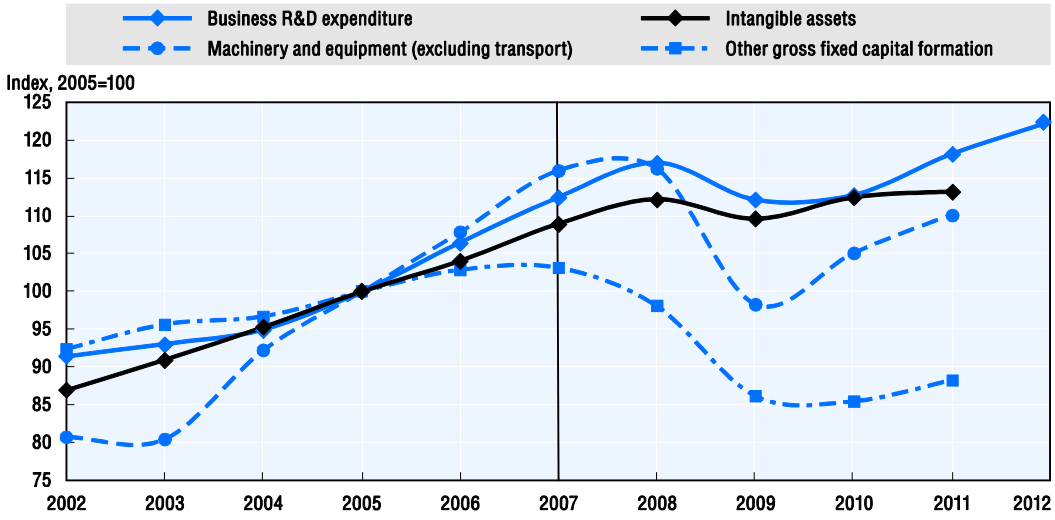
Weak demand dampened business investments globally, including on knowledge-intensive activities and R&D (see Figure 2). Firms hesitate to reinvest profits or spend on capacity upgrades. OECD business expenditure on R&D (BERD) grew by 1.1% a year in 2008-12, against 4.2% in 2002-08 –although it did accelerate in 2012. Investments in physical assets have been slower to recover than knowledge-intensive investments, including R&D or software, reflecting both the central role of knowledge-based assets in market competition and firms' reluctance to build new production capacity. Patenting activities are equally lukewarm. Applications to the three major patent offices in Europe, the US and Japan increased after 2011, but they remain low compared to earlier levels.

Figure 2. Business investment in knowledge assets recovered sooner

OECD, index 2005 = 100



Source: OECD, *MSTI Database*, June 2014 ; OECD, *National Accounts Database*, April 2014.

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Smaller firms in particular suffered from the crisis. Recent OECD evidence shows that most net job creation over the crisis is thanks to young and fast-growing firms. Yet small and medium-sized enterprises (SMEs) were more severely hit than larger firms, as they faced particularly tightened credit conditions during the turmoil. Increased payment delays and bankruptcies over the period reflect their struggle to maintain cash flows. As corporate profit margins shrank, the incentive to take risks declined. In 2011, equity investments were still well below pre-2007 levels in many countries, thus widening all the more the investment gap for young firms. In contrast to small firms, the 2 000 top spenders – mainly multinationals, which use their own cash flows to fund investment, rather than relying on access to finance – increased their R&D by 6.2% in 2012 (at a time when OECD BERD was growing by 3.9%).

Under current conditions, a strong resurgence of R&D and innovation in the next two years remains unlikely: in the coming years R&D is likely to be primarily driven by business investment.

The evolving global R&D landscape

Global R&D is increasingly performed outside the OECD area. The OECD share of global R&D has slipped steadily from 90% to 70% within ten years.

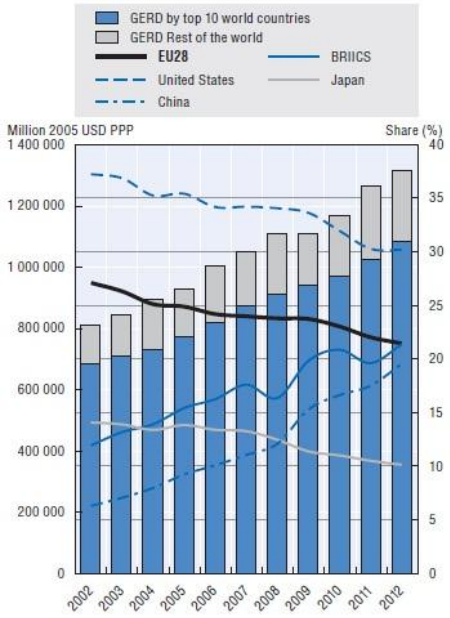
Asia is on the rise. China is poised to become the top world R&D performer by the end of the decade if recent trends continue. Despite a slowdown in growth compared to 2001-08, R&D expenditure doubled over 2008-12. China's R&D intensity is now on par with that of the EU28. The rise of China is driven by its economic dynamism and its long-term commitment to STI. China's Medium and Long-term National Plan for S&T Development (2006-20) fixes a target of R&D spending of 2.5% of GDP by 2020. Korea too enjoyed a sizeable upward shift in R&D intensity, becoming the world's most R&D intensive country (4.36%) in 2012. Chinese Taipei showed the sharpest increases in R&D intensity (+0.91%). This shift in scientific leadership is also apparent in patents and publications.

Over the past decade, Asia has been the source of an unprecedented migration of talent towards the OECD area, with Asian immigrants being on average more skilled than other migrants and, for newcomers, even more skilled than OECD nationals. But, according to new bibliometric indicators, China, Korea and Chinese Taipei are now also the main destinations of scientific authors from the United States and experience a net brain gain over the period 1996-2011.

Figure 3. The recent crisis has reinforced on-going shifts in the global R&D landscape

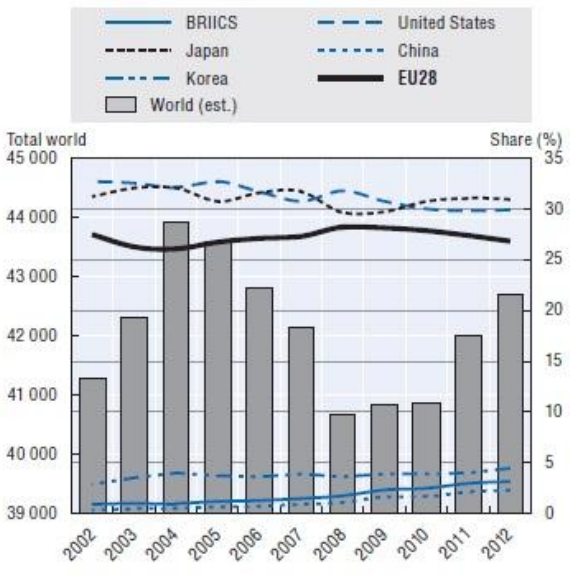
World R&D efforts remain concentrated

Total world R&D expenditure and share of major R&D performers



World patenting activities are slow to recover

Total world triadic patent families and share of major players



Source: OECD, *MSTI Database*, June 2014, www.oecd.org/sti/msti.htm; UNESCO Institute of Statistics (UIS), *Science, Technology and Innovation Database*, June 2014.

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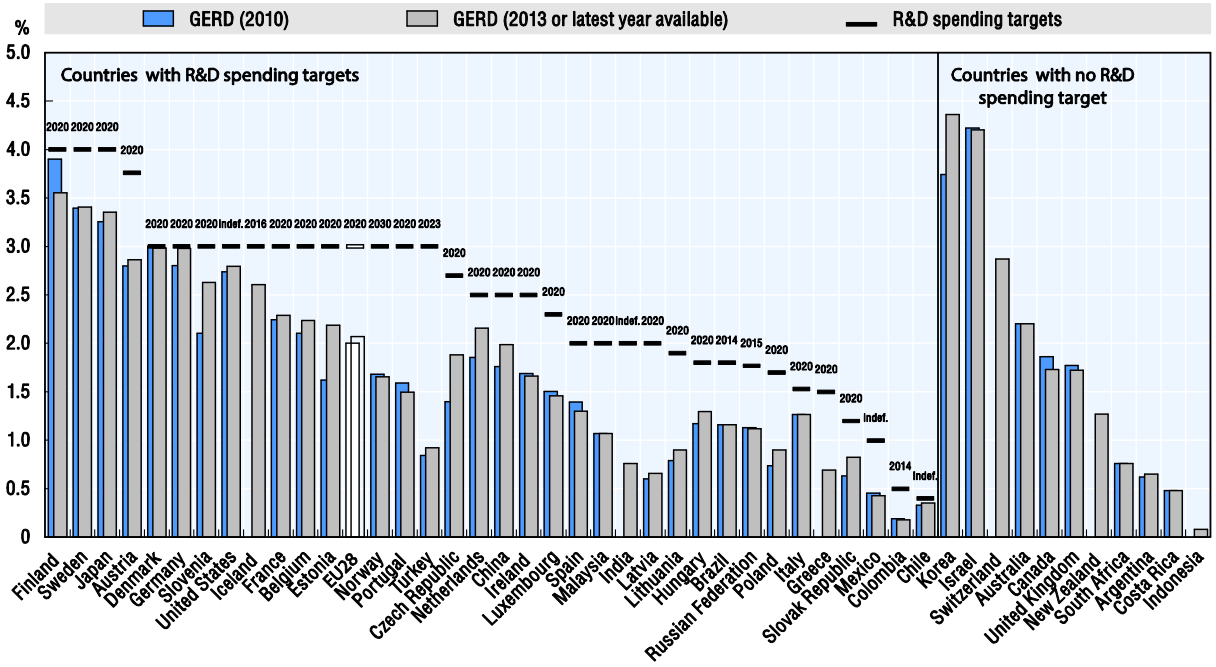
Escaping the "middle-income trap". The BRIICs (Brazil, Russian Federation, India, Indonesia and China) have experienced a serious slowdown in economic growth in recent years, raising fears that some may be stuck in a "middle-income trap". The BRIICS are thus attempting to switch to higher value-added activities, and shift their positions – both upstream and downstream – in global value chains (GVCs). Innovation is the key to capacity upgrade. Industrial R&D capacities have developed fast in these regions and steady increases in R&D intensities point to growing global competition in R&D assets.

Traditional STI leaders are losing ground. The share of the US, EU and Japan in world R&D, patents and scientific publications is on the wane, slowly giving way to the BRIICS, led by China. But the US still has a lead in the most advanced industries (information and communication technologies [ICTs], biotech) and benefits from world-class universities. Although Japan shows signs of renewed dynamism, firms have difficulty rebuilding R&D capacity and BERD remains stuck at 2007 levels (USD 116 billion PPP). Other leading R&D performers have experienced a decline in R&D intensity since 2002 – in most cases, this occurred before the crisis. Sweden (-0.40% of GDP), Iceland (-0.35%), Israel (-0.34%) and Canada (-0.30%) have recorded the sharpest falls.

Diverging Europe. Taken as a whole, EU28 business R&D intensity (1.24%) weighs on overall OECD performance. But European countries have increasingly diverged, with some moving towards meeting their R&D-to-GDP targets, while others, notably southern countries have fallen further behind (see Figure 4). European venture capital is significantly lower than before the crisis, whereas it has fully recovered in the US.

Figure 4. National R&D spending targets and gap with current levels of GERD, as a % of GDP, 2014



Note: The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD is without prejudice to the status of the Golan Heights, East Jerusalem and Israeli settlements in the West Bank under the terms of international law.

Source: Country responses to the OECD STI Outlook policy questionnaires 2012 and 2014; OECD, *MSTI Database*, June 2014; Eurostat and UNESCO UIS, June 2014; International Monetary Fund, *World Economic Outlook*, April 2014.

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Acute social and environmental challenges…

Governments need to restore competitiveness and find new sources of growth and job creation. But they must also address acute societal and environmental challenges.

Maintaining jobs and economic growth in open economies requires greater competitiveness. In 2013, more than 48 million people were unemployed in the OECD. Innovation remains the driving force behind improved economic performance. However, the recent decline in productivity growth in nearly all OECD countries, including traditional innovation leaders, has raised concerns about long-term growth prospects.

The transition to a low-carbon economy and the preservation of natural resources is a major challenge. The current growth model is altering the environment. Meeting green challenges will require technological breakthroughs, rapid deployment of existing or new technological solutions, heavy investments in infrastructures and system-level changes (in policies, regulation, behaviours etc.).

Ageing will dramatically increase pressure on economic performance, social and health care, and public finances. Dementia and Alzheimer's disease already constitute a significant public health challenge that is not limited to the OECD area. New technologies can assist the elderly to remain independent and autonomous for longer. Innovation for an ageing society can lead to new growth industries, but suffers from insufficient finance and policy coherence.

Income inequality has increased during the crisis. ICTs and innovation can contribute alleviating poverty, not only by raising average GDP per capita but also by targeting specifically the poorest categories of the population. ICTs offer opportunities to support inclusive innovation by extending the circle of individuals and businesses that engage in innovation activities. **Education and training policies** will be essential to avoid exclusion. The deployment of digital technologies and a broader Internet access are critical too.

…could be met thanks to the promises of technology

Recent technology developments have focused on global issues and productivity growth. R&D investment by the world's largest companies is concentrated in a few sectors, with pharmaceuticals and biotechnology, technology hardware and equipment, and automobiles accounting for half of the total. The ICT-related and healthcare-related sectors remain among the most dynamic. Over the past decade, accelerated technological progress (as reflected in "patent bursts") have been observed in:

- **climate change mitigation,** e.g. through lighting, electric power, electric and hybrid vehicles, energy generation, batteries, motors and engines;
- **ageing, health and food security**, e.g. through chemistry and biotechnology;
- **information and communication management**, including infrastructures for "big data" and virtual payments;
- **new manufacturing processes,** e.g. through. chemistry, nanotechnology, composite materials, new materials, 3D printing and laser technology.

The convergence of ICT, bio-, nano- and cognitive sciences has the potential to lead to "the next industrial revolution". A range of disciplines will need to be mobilised, in a way that can harness multidisciplinary research.

Access to inventions and innovations is faster, cheaper and better, with technology now a part of mass culture. Widespread adoption of broadband has opened up a world of digital content to users. **Cloud computing** has shown great potential as a platform for new services. It has significantly reduced IT barriers for SMEs, allowing them to expand faster and innovate. **Massive open online courses** are starting to change higher education and creates a new field of learning informatics that could provide a new feedback for universities. As the Internet expands, the importance of **cybersecurity** increases.

Big data could enable vast technological and non-technological innovation. The declining cost of data collection, storage and analytics, combined with the increasing deployment of smart ICT applications generates large amounts of data, which can become a major resource for innovation and efficiency gains, on the condition that privacy issues are addressed. The benefits may also include enhanced data-driven R&D.

Policy responses: A new deal for innovation and more attractive ecosystems

A 'new deal' for innovation. Governments have initiated a "new deal" for innovation that raises the status of innovation in the policy portfolio, while seeking to leverage private funding for innovation and increase the impact of public action.

- **Innovation policy is increasingly challenge-driven**, focusing on mobilising innovation actors and entire systems to address "grand challenges".
- **Adjustments in the design and governance of STI policies** include streamlining and consolidating public programmes in a view to lower administrative and application costs, make support schemes more efficient and leverage private funding for innovation.
- **Strengthening evaluation practices** and building knowledge of STI policies has also been the focus of efforts, such as the US research programme on the Science of Science and Innovation Policy (SciSIP). "Big data" offer new possibilities for increasing the knowledge base and reducing evaluation costs.

Building attractive national STI ecosystems is another imperative. GVCs introduce a dimension to STI policy design that is beyond the scope of national innovation policies. With globalisation, national innovation policies seek to improve domestic conditions in order to attract the innovation-related segments of GVCs (R&D, design, etc.) that contribute most to value and job creation.

- **Particular attention is thus paid to the attractiveness of national education and research systems.** OECD countries are reinforcing the capacity and international component of their education and research systems. They have engaged in long-term planning for public research infrastructures through roadmaps and master plans, better co-ordination of research units and increased investment in research capacity and platforms. Canada, Denmark, Germany and the UK have recently launched national strategies or plans to internationalise higher education, proposing job opportunities, branding activities, or improved learning environments.

- **Skills policies are of growing importance.** A number of recent policy measures attempt to address the wider skills required for innovation (e.g. entrepreneurship spirit, creativity and so-called "soft" skills). There is a growing trend to shape school and university curricula and teaching methods to encourage the development of these skills in addition to subject-based knowledge. Efforts are also made to boost participation in science, technology, engineering and mathematics disciplines at all levels of education, to introduce technology into the classroom and to reform doctoral programmes, for instance to improve ability to work across disciplines.

- **Governments reinforce intellectual property (IP) rights frameworks.** A series of reforms have been introduced to improve IP enforcement (e.g. in the UK), improve patent quality (e.g. in Australia), accelerate the processing of patent applications (e.g. in the US), make the process more transparent (e.g. in Germany), or reduce the cost for applicants and simplify procedures (e.g. in Japan). Emerging countries have also implemented policies to improve IP systems.

- **There is evidence of tax competition between countries to attract foreign R&D.** R&D tax incentives have become a way to increase the attractiveness of the national research ecosystem and to engage in competition to attract foreign R&D. Some governments have combined R&D tax incentives with so-called "patent boxes" to encourage the collocation of R&D and manufacturing activities. Since 2013, the UK government has spent USD 1.3 billion PPP annually for the patent box, in addition to the USD 1.2 billion PPP foregone through its R&D tax credit. Belgium, China and the Netherlands are among the other countries to have implemented tax breaks on IP.

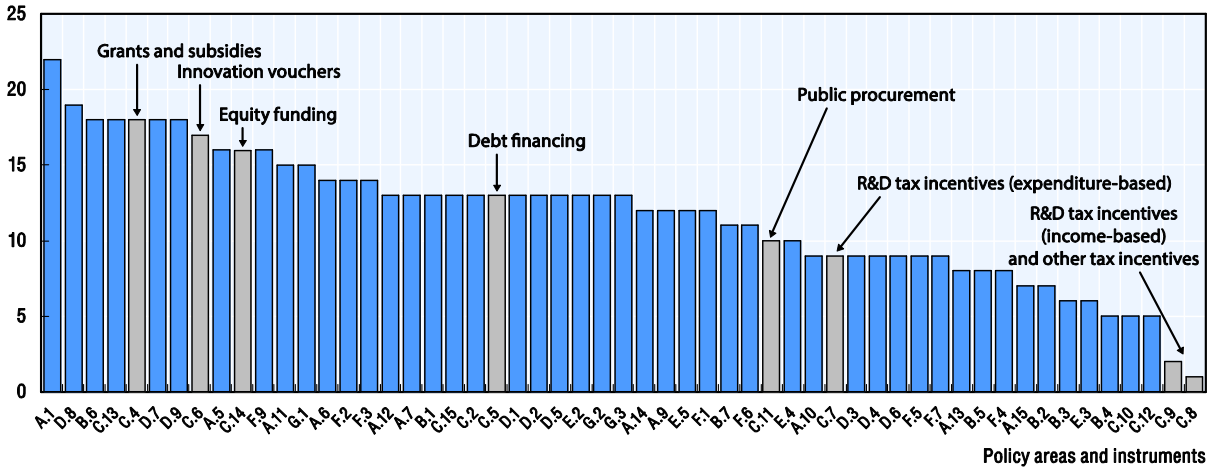
Policies for business R&D: Indirect support and entrepreneurship

Governments have maintained their support for business R&D, through various instruments and targets. In most countries, 10% to 20% of business R&D is funded by public money. The total volume of public support provided to firms, combining direct grants, debt financing, public procurement and tax incentives, has increased in most countries since 2006. This increase has been driven by R&D tax arrangements, as legal restrictions (e.g. through the World Trade Organisation) capped the volume of direct state aid. R&D tax incentives have been simplified, made more generous and more accessible to a larger number of firms. They have also been gradually redesigned to target specific populations (e.g. SMEs) or types of R&D (e.g. collaborative R&D).

Direct funding is provided through an increasing variety of tools for an increasing variety of purposes (e.g. knowledge transfer, growth of high-technology start-ups, green innovation), reflecting the diversity of innovation and innovators. Recent developments apply more market-friendly approaches, encourage competition-based selection and streamline public support schemes.

Figure 5. Major areas of STI policy intervention, 2012-14: how does the funding of business R&D and innovation compare with other policy areas?

Based on country self-assessment



Note: The x-axis presents all areas of STI policy covered in the OECD STI Outlook policy questionnaire 2014 (the codes presented in the chart refer to the question code in the questionnaire).

Source: Country responses to the OECD STI Outlook policy questionnaire 2014.

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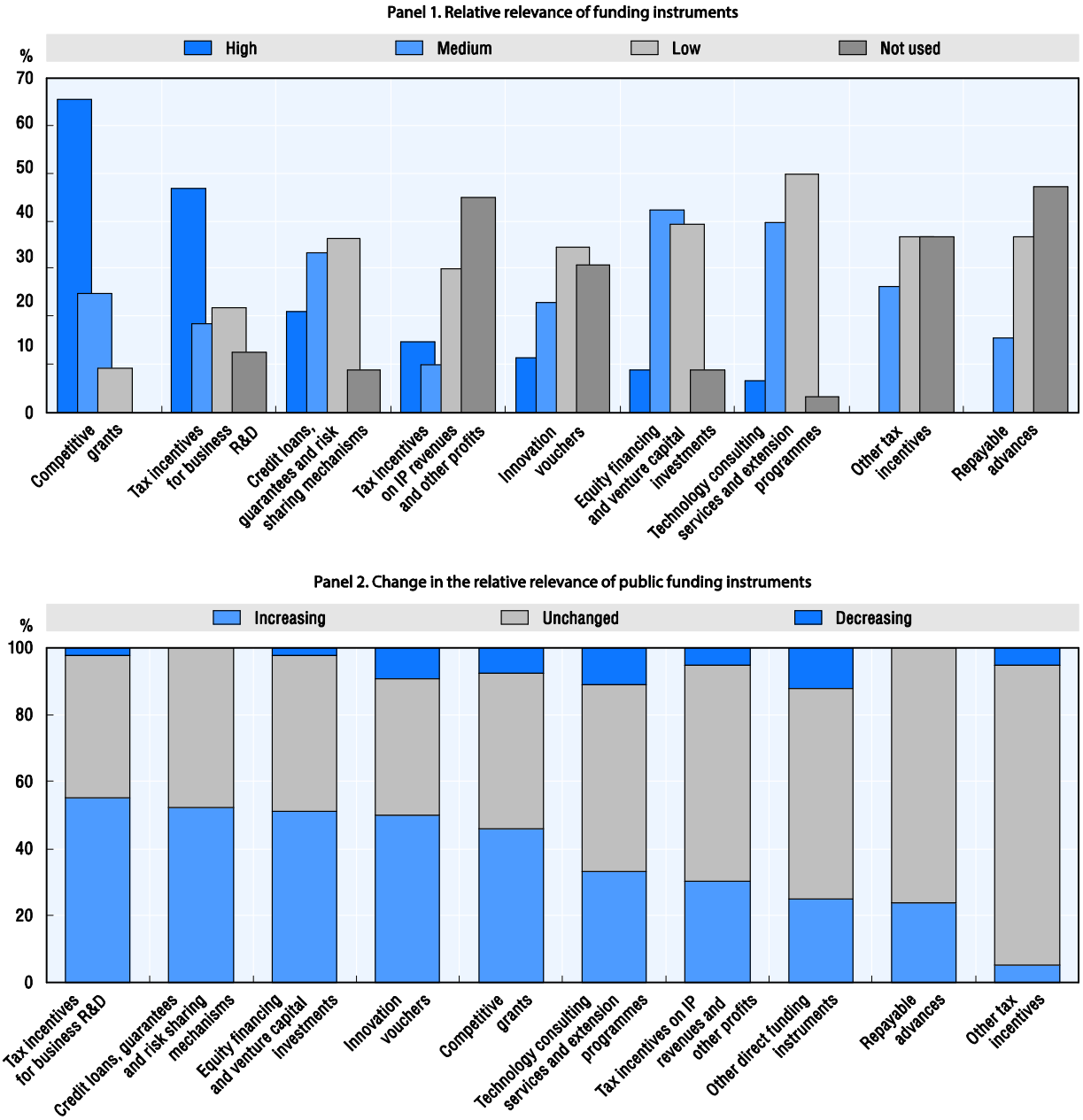
Promoting innovative entrepreneurship through better access to finance remains an issue for OECD economies. Competitive grants remain the main channel of public support to business R&D in many countries. The US, for instance, expects an increase in the share of R&D investments for competitive R&D grants to small businesses and small business-led consortia over the next few years. Governments have responded to the credit difficulties faced by SMEs by injecting capital into direct lending and loan guarantee programmes (See Figure 5). Equity financing instruments are of increasing relevance in the policy mix of most countries (see Figure 6). A common approach has been to support the venture capital industry through public venture capital funds, co-investment funds with private investments and "funds of funds". Various public initiatives encourage and regulate crowdfunding around the world.

Certain governments are making greater use of public procurement. Many countries surveyed indicate that the next five years will see increased emphasis on demand-side instruments, though the majority expect supply-side instruments to remain dominant.

The policy debate on the legitimacy of industrial policy has recently resurfaced. The crisis has highlighted the need for countries to find new sources of growth. Concerns about a loss of manufacturing capabilities and growing competition from emerging economies have contributed to a surge in interest, as have the prospects for a "new industrial revolution". Policy attention has focused on improving framework conditions, supporting entrepreneurship, attracting foreign multinationals and strengthening the role of domestic companies in GVCs.

Figure 6. The policy mix for business R&D and innovation



Source: Country responses to the OECD STI Outlook policy questionnaire 2014.

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Policies for public research: Excellence and openness

Public research plays a pivotal role in innovation systems, notably in areas of public interest or in which businesses are not suited or motivated to invest. **The target and focus of public research have evolved** to respond to wider socio-economic and political developments and to strengthen competitiveness. The interdisciplinary component – a key element of the new EU Horizon 2020 – has been reinforced in governance, evaluation and funding arrangements, as cross-disciplinary platforms are implemented worldwide.

Research excellence requires new forms of funding and a right balance between competition and stability. Current budgetary conditions call for greater selectivity in funding. To increase efficiency, public research has increasingly relied on project funding, often on a competitive basis, at the expense of institutional core funding. But research also requires some stable funding. Research excellence initiatives have emerged, mostly within the past decade, to encourage outstanding challenge-led research. They combine elements of institutional and project funding, by providing large-scale long-term funding and by supporting complex, high-risk research agendas, in particular in interdisciplinary fields. Governments have also developed legal, tax or financial frameworks to help public research access new channels of funding, e.g. science philanthropy.

As "open science" progresses, far more is at stake than access to IT infrastructures and skills. Governments are increasingly developing frameworks, guidelines and initiatives to encourage greater openness in science. But new policy approaches will be needed to fund, perform, monitor, exploit and evaluate public research in the open science context. For instance, new funding arrangements between governments and institutions often include mandatory public access to research results or cover the costs of open access publishing procedure.

Technology transfer is attracting greater policy interest. Knowledge transfer and commercialisation is now a central objective of public research. Policy initiatives have introduced a market perspective in upstream science, e.g. by fostering public-private partnerships, faculty mobility or academic consulting. Recently, more integrated and strategic policies encourage downstream support for the commercialisation of publicly funded research results, by up-scaling and professionalising technology transfer offices, and involving students in commercialisation. Universities and PRIs are encouraged to protect and commercialise results, and publications in digital format, open research data repositories, free-of-charge licenses are widespread. Many commercialisation programmes now include support for prototype development and early-stage funding. Likewise, innovation vouchers allowing businesses to access public research are more common across the OECD and emerging economies (see Figure 5).