OECD Science, Technology and Industry Outlook 2014

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BETTER POLICIES FOR BETTER LIVES

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Foreword

The OECD Science, Technology and Industry Outlook 2014 *is the tenth in a biennial series designed to review key trends in science, technology and innovation (STI) in OECD countries and a number of important non-member economies: Argentina, Brazil, Colombia, Costa Rica, India, Indonesia, Latvia, Lithuania, Malaysia, the People's Republic of China, the Russian Federation and South Africa. Its aim is to inform policy makers responsible for STI policies, business representatives and analysts about recent and anticipated changes in the global patterns of science, technology and innovation and to understand current and possible future implications for national STI policies both at global and national level.*

The STI Outlook 2014 *considers the future of STI policies in light of the recent and fragile economic recovery, growing fiscal pressure, globalisation and major global and societal challenges (green growth, ageing societies, inclusive development). The first chapter presents an overall assessment of recent developments and trends in science, technology and innovation and in countries' STI policies. It provides, in a series of thematic STI policy profiles, a cross-country comparison of specific STI policy orientations, instruments and governance in the OECD area and beyond. The STI country profiles offer insight into national innovation systems: their structural characteristics, their STI performance benchmarked against selected harmonised indicators and recent important national STI policy developments. The focus of the publication is on national STI priorities and initiatives introduced between 2012 and 2014.*

The STI Outlook 2014 *draws on the OECD's most recent empirical and analytical work in areas related to innovation and innovation policy. It makes use of member and non-member country responses to the biennial STI Outlook policy questionnaire. It builds on a statistical framework of over 300 STI-related indicators based on the OECD's long-term efforts to build a system of internationally comparable metrics to monitor STI and STI policy and on recent efforts to develop some experimental STI indicators.*

Finally, the STI Outlook 2014 *is one of the first pillars of the OECD-World Bank Innovation Policy Platform (IPP), a web-based interactive space that provides access to open data, learning resources and opportunities for collective learning on innovation policy.*

Acknowledgements

The *STI Outlook* is prepared under the aegis of the OECD Committee for Scientific and Technological Policy (CSTP) with input from its working parties. CSTP Delegates contributed significantly through their responses to the biennial STI Outlook policy questionnaire and their comments on the draft chapters.

The *2014 STI Outlook* is a collective effort and takes a horizontal approach, co-ordinated by the Country Studies and Outlook Division (CSO) of the OECD Directorate for Science, Technology and Industry (DSTI). It is produced under the guidance of Dominique Guellec. Sandrine Kergroach served as the overall co-ordinator and Nils de Jager as the administrative co-ordinator.

Part I, "Overall innovation performance and policy trends", was prepared by Sandrine Kergroach under the guidance of Dominique Guellec, with assistance from Nils de Jager and Chiara Petroli. Mario Cervantes provided input based on work currently conducted by the OECD Working Party on Innovation and Technology Policy (TIP). Caroline Paunov (inclusive innovation) and Dimitrios Pontikakis (OECD Country Reviews on Innovation Policy) contributed in their respective areas of expertise. Koen de Backer (open innovation, global value chains) provided input on areas related to the programme of work of the Committee on Industry, Innovation and Entrepreneurship (CIIE). Laurent Bernat (cybersecurity) and Elettra Ronchi (ageing) provided input on the basis of work conducted by the Committee for Information, Computer and Communications Policy (ICCP). Chapter 1 was reviewed by and received valuable comments from Giulia Ajmone Marsan, Mario Cervantes, Dominique Guellec, Michael Keenan, Caroline Paunov, Dimitrios Pontikakis and Gang Zhang.

Chapter 2, "STI policy profiles: Governance", was prepared by Mario Cervantes, Michael Keenan, Sandrine Kergroach, Fabio Manca, Dimitrios Pontikakis and Tomomi Watanabe, based on work currently conducted by the TIP and experience gained through the OECD Country Reviews on Innovation Policy.

Chapter 3, "STI policy profiles: Globalisation of innovation policies", was prepared by Koen de Backer on areas related to the programme of work of the CIIE, by Richard Scott and Stephan Vincent-Lancrin of the Centre for Educational Research and Innovation (CERI), and by Dimitrios Pontikakis for experience obtained from the OECD Country Reviews on Innovation Policy.

Chapter 4, "STI policy profiles: Facing new social and environmental challenges", was prepared by Mario Cervantes and Caroline Paunov on the basis of TIP activities and OECD activities on inclusive innovation.

Chapter 5, "STI policy profiles: Innovation in firms", was prepared by Mario Cervantes, Jin Joo Ham, Nils de Jager, Michael Keenan, Sandrine Kergroach and Daniel Kupka based on work conducted by the TIP, the OECD Working Party on National Experts of Science and

Technology Indicators (NESTI) and experience gained through the OECD Country Reviews on Innovation Policy. Marco Marchese, Jonathan Potter and Virginia Robano of the OECD Centre for Entrepreneurship, SMEs and Local Development (CFE) prepared the STI policy profile on start-ups and entrepreneurship. Thanks to Jacek Warda for his input and feedback on R&D tax incentives. Thanks also to Chiara Criscuolo and Fernando Galindo-Rueda for their comments.

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Part III

Assessing STI performance

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Acronyms

BERD	Business enterprises expenditure on R&D
CO_2	Carbon dioxide
CSTP	OECD Committee for Scientific and Technological Policy
EPO	European Patent Office
EU	European Union
FDI	Foreign direct investment
FTE	Full-time equivalent
GBAORD	Government budget appropriations and outlays for R&D
GDP	Gross domestic product
GERD	Gross domestic expenditure on R&D
GHG	Greenhouse gas
GOVERD	Government intramural expenditure on R&D
GVCs	Global value chains
HERD	Higher education expenditure on R&D
HRST	Human resources in science and technology
HEI	Higher education institution
ICT	Information and communication technology
IA	Impact assessment
IMF	International Monetary Fund
IP	Intellectual property
IPC	International patent classification
IPRs	Intellectual property rights
ISCED	International Standard Classification of Education
ISCO	International Standard Classification of Occupations
ISIC	International Standard Industrial Classification
IT	Information technology
JPO	Japan Patent Office
MFP	Multifactor productivity
MNE	Multinational enterprise
OHIM	Office for Harmonization in the Internal Market
PCT	Patent Cooperation Treaty
PPP	Purchasing power parity
PPPs	Public-private partnerships
PRI	Public research institution
R&D	Research and development
RTA	Revealed technological advantage
S&E	Science and engineering
S&T	Science and technology
SME	Small and medium-sized enterprise
SSS	Smart specialisation strategy (also known as 3S)
STEM	Science, technology, engineering and mathematics

STI Science, technology and innovation
USD United States dollar
USPTO United States Patent and Trademark Office
VC Venture capital
WIPO World Intellectual Property Organization
3S See SSS

Abbreviations

ARG	Argentina	Argentine peso	ARS
AUS	Australia	Dollar	AUD
AUT	Austria	Euro	EUR
BEL	Belgium	Euro	EUR
BRA	Brazil	Brazilian real	BRL
CAN	Canada	Dollar	CAD
CHE	Switzerland	Franc	CHF
CHL	Chile	Chilean peso	CLP
CHN	People's Republic of China	Yuan renminbi	CNY
COL	Colombia	Peso	COP
CRI	Costa Rica	Colón	CRC
CZE	Czech Republic	Koruna	CZK
DEU	Germany	Euro	EUR
DNK	Denmark	Krone	DKK
EGY	Egypt	Egyptian pound	EGP
ESP	Spain	Euro	EUR
EST	Estonia	Estonian kroon	EEK
EU	European Union	Euro	EUR
FIN	Finland	Euro	EUR
FRA	France	Euro	EUR
GBR	United Kingdom	Pound	GBP
GRC	Greece	Euro	EUR
HUN	Hungary	Forint	HUF
IDN	Indonesia	Rupiah	IDR
IND	India	Indian rupee	INR
IRL	Ireland	Euro	EUR
ISL	Iceland	Króna	ISK
ISR	Israel	New Israeli sheqel	ILS
ITA	Italy	Euro	EUR
JPN	Japan	Yen	JPY
KOR	Korea	Won	KRW
LTU	Lithuania	Lithuanian litas	LTL
LUX	Luxembourg	Euro	EUR
LVA	Latvia	Latvian lat	LVL
MEX	Mexico	Peso	MXN
MYS	Malaysia	Malaysian ringgit	MYR
NLD	Netherlands	Euro	EUR
NOR	Norway	Krone	NOK
NZL	New Zealand	Dollar	NZD
POL	Poland	Zloty	PLN
PRT	Portugal	Euro	EUR
RUS	Russian Federation	New Russian ruble	RUB
SVK	Slovak Republic	Koruna	SKK
SVN	Slovenia	Euro	EUR
SWE	Sweden	Krona	SEK
TUR	Turkey	Lira	TRY
USA	United States	Dollar	USD
ZAF	South Africa	South African rand	ZAR

Country groupings

BRIICS	Brazil, Russian Federation, India, Indonesia, People's Republic of China, South Africa
EU28	European Union (Austria, Belgium, Bulgaria, Croatia, Cyprus,[1, 2] Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovak Republic, Slovenia, Spain, Sweden, United Kingdom)
OECD	Total OECD

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Executive summary

After the crisis

The impact of the recession and the moderate pace of recovery on innovation and innovation policies has been considerable. At 1.6%, gross expenditure on R&D in OECD countries over 2008-12 was half the rate for the years 2001-08.

The challenges facing OECD governments include sluggish economic growth, and pressing societal and environmental issues. However, fewer public resources can be harnessed in response – the impact of fiscal consolidation is already felt in green R&D budgets. Governments have therefore initiated a "new deal" for innovation that raises the status of innovation in the policy portfolio while adapting to this new context. Current prospects of slow GDP growth and tight government budgets point to a continuing strategy to harness innovation to achieve social goals over the coming years.

The evolving landscape

China is now a major driver of global R&D, doubling spending on R&D over 2008-12, despite a slowdown in growth compared to 2001-08. In a bid to escape a "middle-income trap", emerging countries like Brazil or India are making innovation a major engine of economic growth and must upgrade their capacity to innovate. European countries have increasingly diverged, with some moving towards their R&D-to-GDP targets while others fall further behind.

With greater globalisation and inter-dependence in the fields of science, technology and innovation, national innovation policies increasingly seek to improve domestic advantages in global value chains (GVCs) to attract the innovation-related segments (R&D, design, etc.) that contribute most to value and job creation. Because talent and other knowledge-based assets are particularly valuable and mobile, countries compete to attract and retain them, through national research "ecosystems" that encourage foreign direct investment, or by integrating new firms and SMEs into GVCs. Particular attention is paid to the attractiveness of national research systems, by strengthening universities' capacity, research infrastructure and international openness, including job opportunities for foreign researchers, branding activities, mobility schemes, educational products and improved learning environments. There is also evidence that tax incentives lead to competition between countries to attract foreign R&D centres.

Recent technology developments have focused on global issues (climate change, ageing societies, food security) and on productivity growth (e.g. new manufacturing processes), and environmental and social concerns raise specific challenges and opportunities for STI policies.

The need to address them has made STI policies more mission-oriented. With increasing income inequality following the crisis, for example, innovation is mobilised to ensure that the benefits from "islands of excellence" (the best universities, firms or cities) reach less-favoured companies, universities or regions. A more systemic approach to innovation policy has been developed, in light of the variety of stakeholders and trade-offs and potential synergies between policy areas (regulation, tax, education, etc.).

Meeting these challenges will require technological breakthroughs, rapid deployment of existing or new technological solutions and system-level changes (in policies, regulation, behaviours, etc.). Innovation for an ageing society for example can lead to new growth industries, but suffers from insufficient finance and policy coherence. 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.

Here, the convergence of IT, bio, nano and cognitive sciences has the potential to lead to "the next industrial revolution", and already, the increase in the service component of innovation, a part of this evolution, is influencing countries' competitiveness.

Business R&D

Business spending on R&D has regained its pre-crisis annual growth rate of 3% since 2011, but from a lower base than before the 2009-10 cuts. The prospects for growth here are better than for investment in physical assets because companies, anticipating weak demand, are improving products and processes, but are not expanding production capacity.

Substantial public support to business R&D helped cushion the impact of the crisis. It remains at significantly higher levels than a decade ago, mainly owing to more generous R&D tax relief. Together, direct funding and tax relief represent 10-20% of countries' business R&D expenditure, sometimes more. Indirect support is equal to or more than direct support in 13 out of the 32 countries that report data. However, as public debt soared, many governments reduced innovation-related expenditures, or undertook more systematic evaluation of existing policies, streamlining existing programmes and reducing overlapping policies.

Direct public funding of business R&D is increasingly awarded through competitive grants and contracts, while debt financing (loans, loan guarantees) and equity funding (venture capital, funds of funds) are becoming more popular. Many countries are channelling funding towards particular industries or categories of firms (notably SMEs) as part of their "new industrial policies".

In many countries, credit conditions have been severe for SMEs in particular (higher interest rates, shortened maturities, increased request for collateral). European venture capital investment is significantly lower than before the crisis, whereas it has fully recovered in the United States. This has led governments to increase their funding, and new sources of finance (crowdfunding, other forms of non-bank financing), while marginal, are spreading fast.

Public R&D

Public R&D plays a pivotal role in innovation systems. R&D expenditure by universities and public research institutions held up well during the crisis, owing to a sustained public commitment to R&D, with higher education representing 61% of public R&D in 2012 against 57% in 2000.

To increase excellence and relevance, public research has increasingly relied on project funding, often on a competitive basis, at the expense of institutional core funding, owing in part to difficult budgetary situations. Most countries have implemented research excellence initiatives that combine institutional and project funding mechanisms to encourage outstanding research and support challenge-led research.

Knowledge transfer, notably commercialisation, is now a central objective of public research. Policy initiatives have introduced a market perspective in upstream science (e.g. industry-science co-operation on R&D). Recently, more integrated and strategic policies have encouraged downstream support for the commercialisation of publicly funded research results, by up-scaling and professionalising technology transfer offices, and involving students in commercialisation.

As “open science” progresses, new policy approaches will be needed to determine how public research is funded, research is undertaken, research output is exploited, research results are accessed and protected, and to shape how science and society interact.

PART I

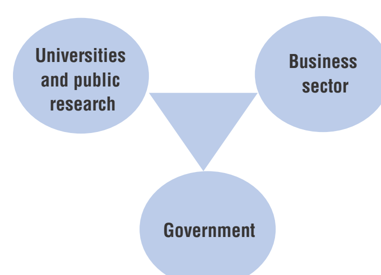
Overall innovation performance and policy trends

PART I

Reader's guide

Innovation comes out of the activities of many diverse actors, businesses, multinational firms, start-ups, but also public research institutes or universities. These actors co-operate and compete with each other. Their activity is determined by the availability of financial and human resources and by demand from markets or for addressing environmental or societal challenges. Government plays a key role in dynamising and orienting this system, by influencing framework conditions and setting innovation policies. The ability of a country to generate and benefit from innovation depends primarily on this complex system. The STI Outlook attempts to reflect this complexity by analysing major trends in STI and STI policies. The diagram presented below is specific to the *OECD STI Outlook 2014* and aims to help readers visualise the composition and working of the innovation system. It will be used to introduce each relevant section of the following chapter.

The actors

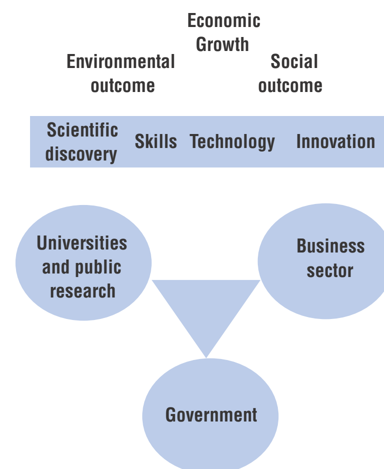


As they are more likely to turn ideas into economic value, firms are seen as the main actors of innovation. The ***business sector*** accounts for the largest share of domestic research and development in many countries. Start-ups can exploit unused or underused knowledge and steer the emergence of new markets.

While public-sector research is considerably smaller, ***universities and public research institutions*** (PRIs) play a central role in innovation systems by providing new knowledge, especially in areas in which economic benefits are uncertain or less immediate. In addition universities contribute to skills formation and may inspire talented young people to enter research careers or innovation-related occupations.

Government is the third main type of actor. First, there is room for innovation in public administration. Improvements in public services delivery, in terms both of the content of these services and of the instruments used to deliver them (e.g. e-government), are required to address an increasingly sophisticated public demand and new challenges due to fiscal pressures. Second, as investment decisions of individuals and firms respond to economic incentives and therefore policies and institutions (OECD, 2010a), firms' propensity to innovate and to be successful in doing so depend on timely and efficiently governed mix of policy initiatives (OECD, 2010b, Chapter 4). Third, the public research agenda is designed at a high policy level and public research budgets shape the national research landscape.

Input/output and outcome

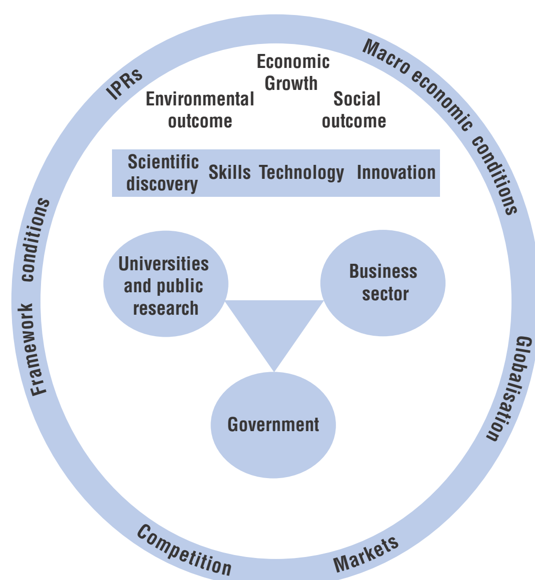


The business sector, universities, PRIs and government perform innovative activities, including R&D, that both generate and make use of knowledge-based capital, technological or not, tangible or intangible. Crucial to their development and performance is access to ***skills***, ***technology***, new ***scientific developments*** and ***innovation***.

When successful, firms, universities, PRIs and governments help increase the stock of knowledge-based capital by advancing the knowledge frontier, developing new technologies, improving the supply of the diverse and complex skills required for innovation, and introducing innovations.

Innovation is a major driver of productivity and ***economic growth*** and is seen as a key way to create new business values. As innovation output has benefited people and the planet, the ***environmental and social outcome*** of innovation is increasingly acknowledged.

The context: Macroeconomic, framework and global conditions for innovation



Business decisions on innovation investment depend on firms' anticipation of future innovations and the profitability of current innovations. Promising market prospects are key determinants but opportunities arise also from favourable ***macroeconomic conditions***, the financial robustness of actors and ***markets***, ***competition*** regulations in product and labour markets and sound ***intellectual property rights*** (IPRs) such as patents, copyright or trademarks.

Globalisation of trade, investment in science and technology (S&T) and research systems is changing the conditions under which national innovation systems perform. Countries and firms engage in international co-operation in STI with a view to tapping into global pools of knowledge, human resources and major research facilities, to sharing costs, to obtaining more rapid results, and to managing the large-scale efforts needed to address challenges of a regional or global nature effectively.

PART I

Chapter 1

The future of science, technology and innovation policies

This chapter describes recent developments and the outlook for science, technology and innovation (STI) and STI policies. As economic growth gains momentum, STI activities should increase. However, the recovery remains uneven. The crisis caused lasting damage to public finances, creating a "new deal" for STI policies, which must consider the risks and opportunities raised by the continuing globalisation of STI activities: global value chains and the international circulation of people and knowledge. Innovation should help address global, environmental and societal challenges and raise new policy challenges.

This chapter is based on OECD work in science, technology, industry, education, innovation, migration, trade, environment, finance, tax systems, public governance and statistics. It draws on country responses to the OECD STI Outlook questionnaire 2014, a unique source of country-specific information on national innovation policies. While high-quality macroeconomic, competition, regulation, tax and labour market framework conditions matter for innovation, this chapter focuses on STI and entrepreneurship policies.

Introduction: The future of STI policies

Research and innovation policy will remain a key domain of public action in support of sustainable and inclusive growth in the coming years. However, fiscal consolidation weighs on the capacity of governments to maintain their financial commitment. Public research and development (R&D) budgets have started to level off or even decline in many OECD countries.

Innovation and technology are now expected to help restore competitiveness, boost productivity, upgrade industrial structure and address global challenges. The rise of global value chains (GVCs), the now central role of entrepreneurship, the search for new sources of growth, and the challenges raised by environmental and social issues have introduced new objectives and instruments for policy intervention. Recent interest in "systems innovation" illustrates a shift in the policy paradigm of certain countries towards innovation policies that support large-scale socio-economic transformations. Such expectations can have profound implications for the policy mix and governance arrangements. The greening of science, technology and innovation (STI) policies is particularly noticeable, as technology and innovation are increasingly seen as ways to mitigate climate change.

More countries now explicitly target most of their research towards competitiveness and environmental and social challenges, while basic (untargeted) research is strictly fitted into an "excellence" (i.e. highly selective) framework. In this context, broader and denser ties are being formed between public and private actors, beyond traditional intellectual property (IP) links and incubators, with a view to exploit more fully the potential synergies between the two sectors.

As a consequence of the broader scope of STI policy, STI matters are now managed by a variety of ministries and departments in charge of economic policy, competitiveness, employment or global challenges (e.g. environment and social issues). Innovation policies now require a "whole-of-government" approach.

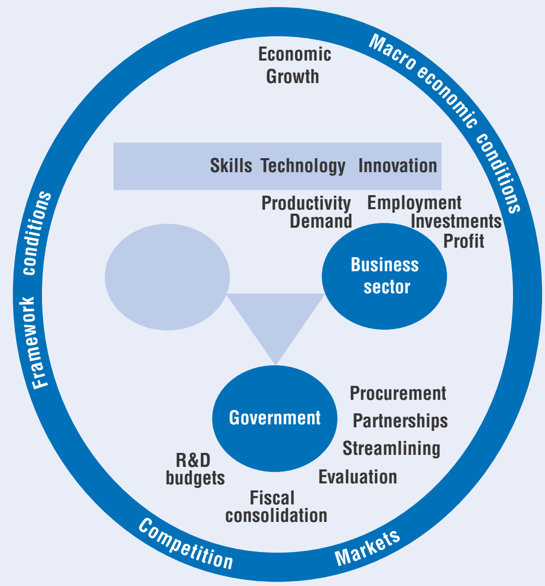
STI policy has also increased in complexity. A larger toolbox of STI policy instruments and the involvement of new actors in innovation policy design and delivery are complicating the policy landscape. This raises the issues of optimising the policy mix and multi-level governance. The "silo" approach caused by thematic and vertical segmentation, which has underpinned STI policy developments, is being questioned. Significant efforts are made to integrate STI policies at different levels (regional, national, supra-national) and in different fields (research, industrial innovation, etc.). Evaluation plays a key role as an instrument for public authorities to monitor policy developments in an integrated fashion.

In search of greater efficiency, innovation policies evolve. In many countries, new governance arrangements pool resources from various sources, public as well as private, e.g. strategic public-private partnerships for innovation. In addition, governments are taking steps to rationalise their interventions and consolidate STI programmes.

RECOVERY: A NEW DEAL FOR STI POLICIES

This section considers the macroeconomic conditions under which national innovation systems and national innovation policies have evolved over the past decade and are likely to evolve in the coming years in the aftermath of the 2008 crisis.

It focuses on the impact of an uneven recovery on regions and countries and on the capacity of governments and the business sector to engage in innovative activities. It addresses issues such as the decline in corporate profits and corporate investment, the impact of high unemployment on the skills market and on households' demand for technology and innovation, and the loss of firms' productivity. It also addresses issues such as fiscal consolidation and its impact on public R&D budgets and public support for innovation. It sketches a "new deal" for STI policy makers that calls for new partnerships, a more strategic use of public procurement, strengthened policy evaluation and a streamlining of STI policy action.



The economic recovery is gaining momentum, but STI activities are likely to increase only slightly over the coming years

The recovery remains fragile and contrasted

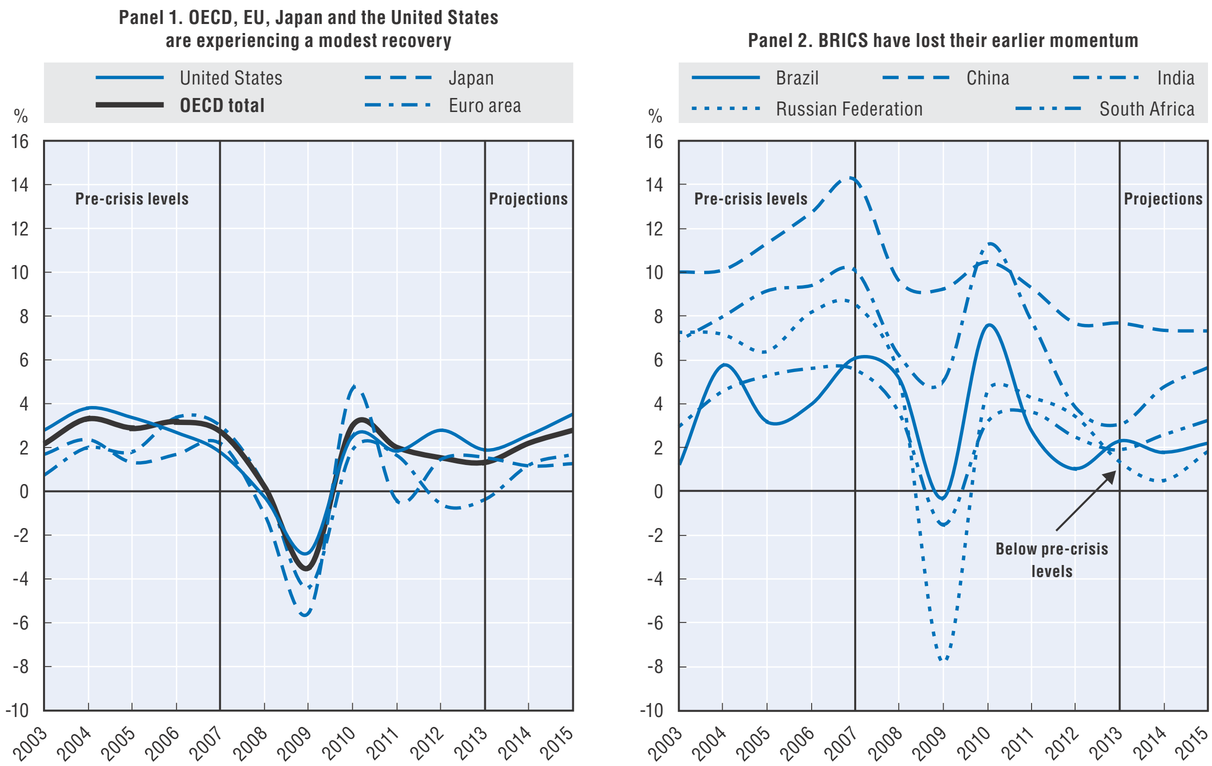
Growth in world real gross domestic product (GDP) is estimated at 3.5% and 3.9% in 2014 and 2015, respectively, with a lower 2.4% and 2.8% in the OECD area (OECD, 2014a). Economic activity and world trade have recovered slowly since 2011 and are expected to strengthen gradually over the next two years, driven by the dynamism of non-OECD economies (5.0% and 5.3%, respectively), particularly the People's Republic of China (7.4% and 7.2%, respectively).

Within the OECD, the recovery is uneven (Figure 1.1). The recent acceleration in the United States signals a global return to growth, but the tightening of US monetary policy and the federal debt create uncertainty about the stability of US GDP growth (1.9% in 2013). Growth prospects in Japan (1.5% in 2013) are constrained by the level of public debt. Some southern and central European countries have yet to recover and should have modest growth of less than 2% in the next two years. Their structural deficiencies also affect the entire European Union. Few European countries are expected to grow faster than 2% in 2014 and 2015. Even the most dynamic OECD countries (Chile, Israel, Korea and Turkey), which grew by more than 2.5% in 2013, are expanding more slowly than before the crisis.

The BRICS (Brazil, Russian Federation, India, China and South Africa) have lost their earlier momentum. In 2013, some major emerging economies showed the first signs of an economic slowdown and revealed their sensitivity to fluctuations in US financial markets. While their dynamism steered global growth during the crisis, this slowdown put a brake on the recovery: global GDP growth has been revised downwards by half a percentage point

Figure 1.1. **Growth is back, but at an uneven pace across countries**

Annual growth rate of GDP, 2003-13 and projections for 2014 and 2015



Source: OECD, *Economic Outlook No. 95 Database*, May 2014. Data retrieved from IPP.Stat on 8 July 2014, *http://stats.oecd.org//Index.aspx?QueryId=57863.*

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for 2013 and 2014 (OECD, 2013a). In addition, the development of the BRICS remains constrained by structural rigidities (e.g. infrastructure and education), heavy dependence on foreign direct investment (FDI), and demographic challenges that set limitations on growth over the medium term.

The economic outlook in emerging Southeast Asia (excluding China and India) remains robust (OECD, 2013b). GDP growth over 2014-18 should be about 5.4%, broadly similar to pre-2007 rates. Africa's economy was very resilient during the global economic turbulence (OECD, 2014b). GDP grew by 4.2% in 2012 and is projected to accelerate to 4.5% in 2013 and to 5.2% in 2014. Latin America's economic slowdown is likely to persist (OECD/ECLAC/CAF, 2013). Exports will play a diminishing role in driving growth, giving way to stronger domestic demand, supported by wage growth and an expanding middle class.

The impact of the crisis has not yet been fully absorbed. Investment and employment remain below pre-crisis levels

Business investments are down. Profits are firms' main source of funding and play a key role in investment decisions, particularly for innovation. In a well-functioning economic context, firms normally reinvest profits to support future development. In the currently uncertain climate, the decline in profit margins signals an easing in investment (Figure 1.2). There is also evidence that many profitable firms are not investing, as they do not see a strong economic recovery soon, hence the global accumulation of cash reserves.

Figure 1.2. **Corporate margins have deteriorated and firms wait to reinvest**

Change in firms' profit margin rate[1] and investment rate,[1] percentage points, 2012 compared to 2007

1. The profit margin rate is the gross operating surplus as a percentage of value added. The investment rate is gross fixed capital formation as a percentage of gross operating surplus. Data refer to non-financial corporations only, except for the United States which includes financial corporations. On 31 July 2013, the United States published a new series of national accounts according to the 2008 SNA. However, all data are not yet available. The increase in the US profit rate may be overestimated. The increase in some countries' profit rate may be due to a GDP effect (a faster decrease in GDP than in the corporate profit margin). Total OECD was converted into USD using purchasing power parities (PPP) and includes OECD countries for which data were available. The difference in profit margins and investment rates is the difference between 2012 and 2007 rates expressed in percentage points.

Source: OECD, *National Accounts Database*, April 2014. Data retrieved from IPP.Stat on 8 July 2014, *http://stats.oecd.org//Index.aspx?QueryId=57863*.

StatLink *http://dx.doi.org/10.1787/888933151360*

In many countries unemployment rates have been slow to decline. A wait-and-see attitude in business is reflected in persistently high unemployment; in some countries it is at historical highs. At the peak of the crisis, nearly 50 million people were looking for a job in the OECD area and in 2013 more than 48 million people were unemployed (OECD, 2013a). The OECD unemployment rate is still above its pre-crisis level at 7.9% (OECD, 2014a).

In addition, although higher education ensures higher employability, tertiary graduates have not been completely spared (OECD, 2014c). On average 4.8% of 25-64 year-olds with tertiary-level education were looking for a job in 2011, compared with 3.3% in 2007. The southern European countries (Greece: 12.8%, Spain: 11.6% and Portugal: 8.0%) have been the hardest hit. In Germany (2.4%), however, unemployment of tertiary graduates has steadily declined; in 2011 it recorded one of the lowest unemployment rates in the OECD area, along with Norway (1.5%) and Austria (2.3%).

Employment levels determine households' propensity to consume and their appetite for innovative and more expensive products. In difficult times, households increase precautionary savings. Final demand, the main engine of growth in mature economies, is therefore weaker, and firms are reluctant to spend on high-risk activities. In addition, over the long term, the unemployed risk skills erosion. More broadly, the loss of highly skilled human capital can negatively affect the capacity of firms to engage in R&D and innovation.

The issue is of particular concern for the young labour cohort, because skills learned in the early years of professional life are decisive for future careers. Youth unemployment could have long-term effects on economic and fiscal sustainability, by encouraging informal economic activity, reducing tax revenues or increasing public health outlays.[1] Historically, 15-24 year-olds are more likely to be unemployed than older employees. They have been hit particularly hard by the crisis (OECD, 2013c), as the generation gap has widened in most countries.[2] In 2012, more than 50% of young people aged 15-24 were unemployed in Greece, Spain and South Africa, compared with 20-22% of 25-64 year-olds (OECD, 2013c). With the recovery, these differences have narrowed, but it will be a challenge for governments to rehabilitate young people who were not in education, not employed, or not active during the downturn.

The deterioration of public finances has challenged public policy generally, and STI policy in particular. Yet many governments intend to maintain or reinforce their commitment to STI

The state of public finances determines the capacity of governments to shape STI policy. It also affects investor confidence, the inflow of foreign capital and integration in the global economy.

Public finance challenges remain, despite countries' efforts to restore their financial health (OECD, 2013e). Falling tax revenues and extraordinary government expenses during the crisis have led to higher public deficits. Public debt as a percentage of GDP has reached very high levels, and some countries' indebtedness will continue to rise, despite the recovery of GDP. Although fiscal pressure is likely to ease from 2015 in most countries, few countries will be able to reduce their deficits to pre-crisis levels by then.

Policy trends

Fiscal consolidation typically forces governments to increase the tax burden and reduce public spending. Strategic choices regarding specific areas of policy intervention, general or targeted tax burdens or concessions and government budget appropriations and outlays for R&D (GBAORD) can affect innovation systems. The risk is that a higher tax burden will further curb sluggish demand, reduce the net return on capital, and subsequently discourage private investment in R&D and innovation. While governments have shown the value they place on education, research and innovation by preserving, or even reinforcing, their STI budgets during the crisis (OECD, 2009), budgetary discipline could force them to reconsider their commitments to STI and to reduce the leverage potential of public procurement for research and innovation. Some countries may therefore find it difficult to maintain STI budgets at current levels. Resources allocated to education have declined since 2009, as teachers' salaries were frozen in half of OECD countries, and more cuts are expected in education over the next two years (OECD, 2013f).

R&D budgets have levelled off in many countries and have started to decline in others. From 2009, GBAORD began to shrink markedly in France, Finland, Spain, the Russian Federation and the United Kingdom (Figure 1.4). In 2011 rapid GBAORD growth in Chinese Taipei was sharply halted, and notable slowdowns were observed in Denmark and Switzerland.

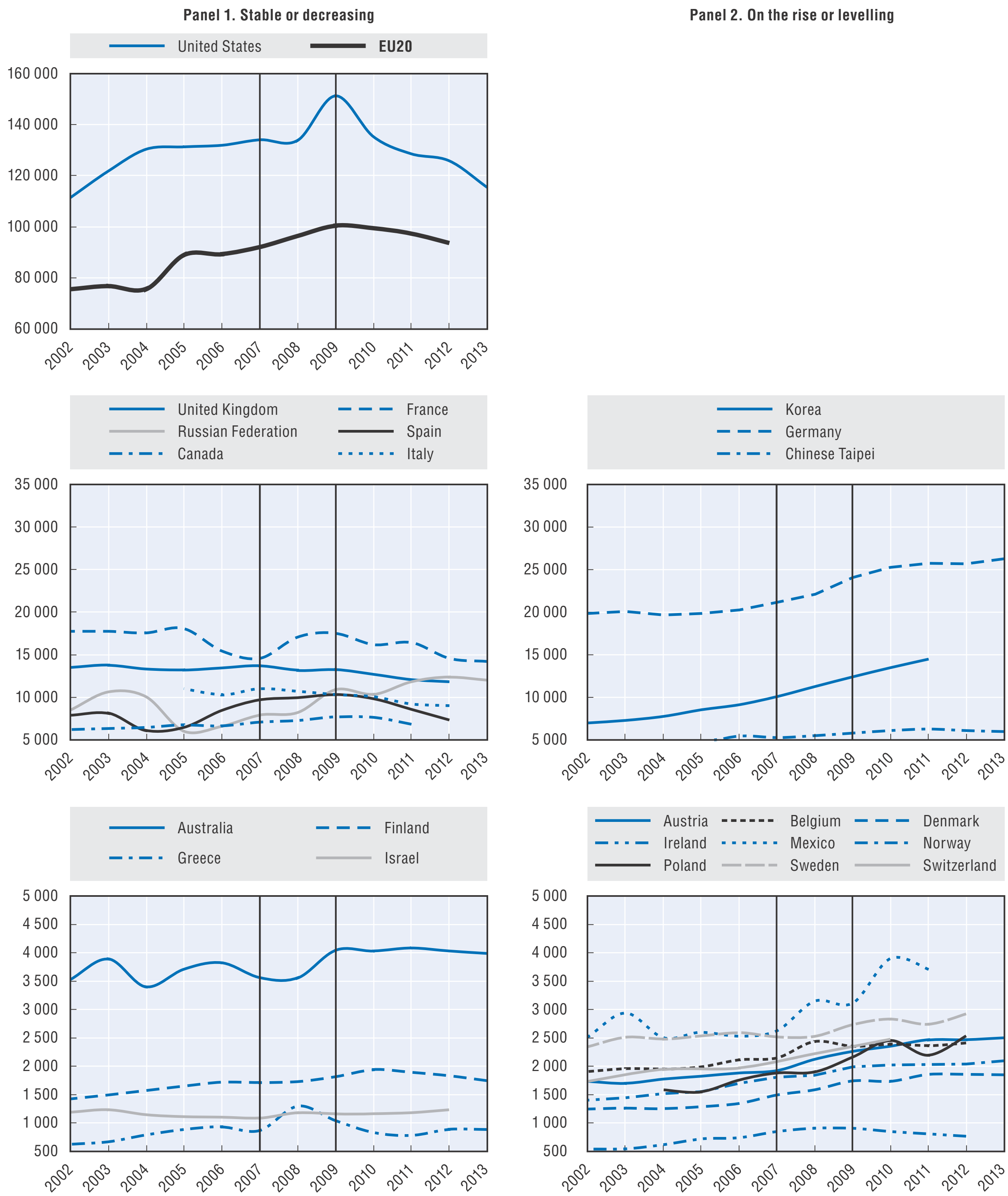
Yet, OECD countries and non-OECD economies have confirmed their commitment to STI and their intention, either to preserve (Italy, United States) or, in most cases, to increase national R&D budgets (see the policy profile on "National strategies for science, technology and innovation"). France is implementing the second phase of its "Investment for the Future" programme with funding of USD 14 billion PPP (EUR 12 billion), mainly as capital endowment. The United Kingdom plans to unlock additional funding and will prioritise long-term infrastructure spending. Germany puts "top priority" on public spending on R&D and innovation and the draft 2014 budget of the Federal Ministry of Education and Research provides an additional USD 402 million PPP (EUR 313 million) for education and research. China will continue to enhance, at a slower pace, government S&T appropriations and plans to set up budgetary mechanisms to encourage local governments to invest in S&T.

As business R&D expenditure depends on business expectations, it is particularly affected by the economic cycle. In contrast, public research and public R&D are usually counter-cyclical and have a buffering effect during periods of economic downturn (Figure 1.4). This is in part a reflection of the rise in importance of STI policy. However, the lingering crisis and the unsustainability of public debt may mean that this is no longer the case in some countries. Over the past two decades, gross domestic expenditure on R&D (GERD) has grown faster than GDP, leading to a rise in R&D intensity in the OECD area. In 2008-09, the volume of GERD decreased as a result of a sharp decline in private investment. Governments partially offset this drop through higher support for the national R&D effort. In view of the current budgetary outlook and recent developments in public R&D budgets, the recovery in R&D is likely to be primarily driven by business investment in the coming years.

Budgetary pressures have also encouraged governments to adjust the design and governance of their policies (e.g. demand-side policies), to streamline and consolidate their policy programmes, and to systematise and strengthen their evaluation practices. Governments are generally making greater use of public procurement. In recent years, STI policy makers have increasingly focused on demand-side instruments in search of stronger and better-articulated public demand for innovative solutions and products (OECD, 2012a). Following a series of reviews of federal procurement, Canada developed its National Procurement Strategy to leverage R&D procurement and streamline procurement processes. Germany has reinforced its general framework for innovative public procurement with a new German Procurement Law and the creation of a Centre of Excellence for innovative procurement in 2013. Since 2011, the UK Innovation and Research Strategy for Growth has emphasised the key role of government as a lead customer for innovative products and services. The budget of the Small Business Research Initiative (SBRI) has therefore been expanded for 2013-14 and again for 2014-15 (see the policy profile on "Stimulating demand for innovation").

Figure 1.3. **Public R&D budgets are levelling off, or have started to recede**

Government budget appropriations and outlays for R&D, million USD 2005 PPP, 2002-13



Note: 2012 data for Germany are OECD estimate and provisional.

Source: OECD, *Main Science and Technology Indicators (MSTI) Database*, June 2014, *www.oecd.org/sti/msti*. Data retrieved from IPP.Stat on 8 July 2014, *http://stats.oecd.org//Index.aspx?QueryId=57863*.

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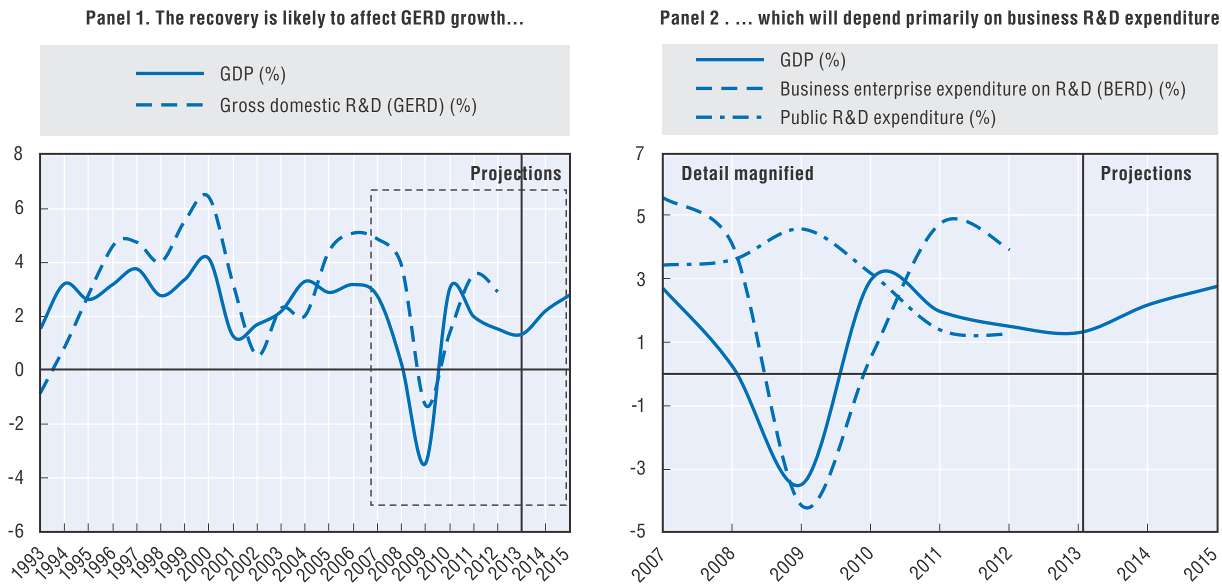
Figure 1.4. **The buffer effect of public R&D has faded in the aftermath of the crisis**

Annual growth rate of GDP and GERD, BERD and public sector R&D, at constant prices, 1993-2013 – and projections to 2014 and 2015



Note: R&D expenditure by the public sector aggregates R&D expenditure by the government and higher education sectors.

Source: OECD, *Economic Outlook No. 95 Database*, May 2014; OECD, *MSTI Database*, June 2014, *www.oecd.org/sti/msti*. Data retrieved from IPP.Stat on 8 July 2014, *http://stats.oecd.org//Index.aspx?QueryId=57863*.

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Governments are attempting to reduce the fragmentation of public support to business R&D and innovation and to improve and simplify access to public programmes. By streamlining and consolidating public programmes, they seek to lower administrative and application costs for both public administration and firms and to leverage private funding for innovation. Canada and Chile have recently simplified eligibility criteria and application procedures for their R&D tax incentive schemes. Costa Rica and Norway have made changes to the overall application process and qualification requirements for venture capital and entrepreneurship programmes. Finland has a new Tekes strategy to foster a customer approach to delivery of public support and to centralise and streamline financing for entrepreneurship. Germany has bundled R&D and innovation support activities into large framework programmes in recent years. In 2013 New Zealand established Callaghan Innovation to simplify interactions between business and research institutions and to function as a one-stop shop. The Czech Republic (Technology Agency), Denmark (Innovation Fund) and Slovenia (Spirit Slovenia) have also reduced fragmentation by merging various institutions in charge of technology and entrepreneurship policy into a single agency. Turkey has established an R&D, Innovation and Entrepreneurship Co-ordination Council to streamline support mechanisms and ensure integrity, coherence and a targeted approach in policy delivery.

A sharper focus on the evaluation and impact assessment of STI policy is also becoming more apparent (see the policy profile on "Impact assessment in STI policies"). While fiscal constraints have increased the need to demonstrate value for public expenditure, the resources potentially available for evaluation declined. Nevertheless, some countries have recently engaged in broad evaluations to assess the performance of the national STI system or parts thereof, through national reviews (Canada, Chile), international reviews (Denmark, Finland), or OECD reviews of innovation policy (France, Norway, Slovenia, Sweden).

A number of countries have initiatives to strengthen evaluation institutions (i.e. agencies, legal frameworks, methodologies) and encourage knowledge building for STI policy. In 2013 Chile established an S&T advisory committee to review the national STI governance system. France has set up a Strategic Research Council to manage the design and implementation of its National Research Strategy. In 2013 Australia announced the establishment of the independent National Commission of Audit to review and report on the performance, functions and role of the Commonwealth government. In addition, the new Australian *Public Governance, Performance and Accountability Act 2013* has a stronger focus on measuring and assessing performance, and the department in charge of science and industry policy is building capacity through staff training and new data collection methods. Efforts have also been made to build knowledge of STI policies, such as the US research programme on the Science of Science and Innovation Policy (SciSIP), while "big data" offer new possibilities for increasing the knowledge base and reducing evaluation costs. Japan and the EU are also developing SciSIP-type initiatives.

Innovation policy is increasingly challenge-driven, focusing on mobilising innovation actors and entire systems to address social and economic challenges. One of the lessons of decades of innovation studies is that innovation systems, although dynamic, can become locked into trajectories that make it difficult to mobilise or shift resources to address new goals. The policy challenge is to move large-scale socio-technological systems along more sustainable paths, in other words, to promote "system innovation".

It has several aspects. The first is to redefine the innovation actors. Innovation policy has long focused on addressing market and co-ordination failures that affect the producers of knowledge and innovation, namely firms and public research institutes, with some attention to the surrounding environment. But system innovation requires engaging the demand side, including consumers and citizens. Second, challenge-driven innovation requires rebuilding entire systems, not simply with a view to new products and new processes that can boost productivity, but to new structures, new institutions, and new ways of working or co-operating among the actors in the system. Third, governance structures need to manage the transition from one system to another, such as moving from a transport system based on fossil fuel to one based on an energy mix, including renewables. The complexity of system innovation also implies that national governments may not be best placed to break social and technological lock-ins. Regions and cities may become more important for steering innovation systems. Cities in particular have emerged as laboratories for solutions to social and economic problems, from education to waste management. Finally, in a system innovation approach, learning processes and outcomes are just as important, if not more important than outcomes in terms of new products and processes.

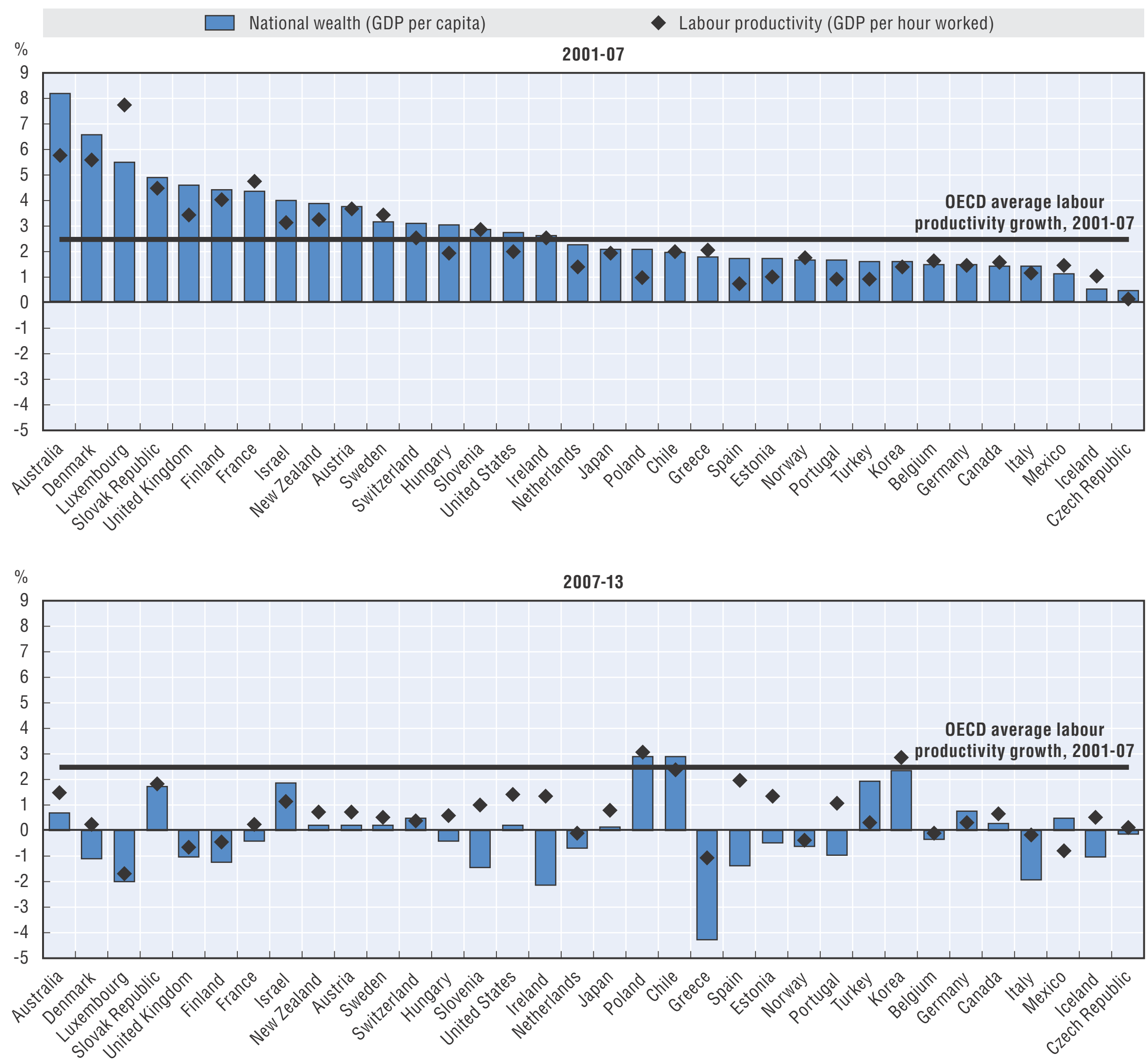
Productivity is the top economic challenge for many countries and innovation remains the driving force behind improved performance

In the recent turmoil, most countries have lost productivity and capacity to implement structural changes. OECD countries have seen a decline in their national wealth, as measured by GDP per capita, between 2007 and 2013, with Germany, Israel and Korea among the few exceptions (Figure 1.5). In the last 15 years, differences in the growth of wealth across OECD countries have been mainly attributed to differences in labour productivity. In turn, most of the growth in labour productivity has reflected the implementation of new technology and other factors of change in the economy, as measured by multifactor productivity (MFP) (OECD, 2013g). Innovation has been a major factor in productivity growth over the medium to long term, through new technology-based manufacturing processes, products that provide more value to customers, improved service delivery, etc. In addition, maintaining economic growth in open economies requires competitiveness and the national economy's ability to exchange and compete with other economies.

Between the pre-crisis (2001-07) and crisis and post-crisis (2007-13) periods, labour productivity growth has slowed in nearly all OECD countries (Figure 1.5). Some countries have experienced a sharp decline in productivity performance, among which Greece and Italy, along with traditional innovation leaders (e.g. Finland, Norway and the United Kingdom).

Figure 1.5. **Labour productivity deteriorated significantly during the crisis**

Average annual growth rate in GDP per capita and GDP per hour worked, constant prices, 2001-07 and 2007-13



Note: Changes in GDP per capita result from changes in labour productivity, as measured by GDP per hour worked, and labour utilisation, as measured by hours worked per employee and employment per capita (OECD, *OECD Science, Technology and Industry Scoreboard 2013: Innovation for Growth*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/sti_scoreboard-2013-en*). Annual growth in labour utilisation is not represented in the chart.

Source: OECD, *Productivity Database*, May 2014.

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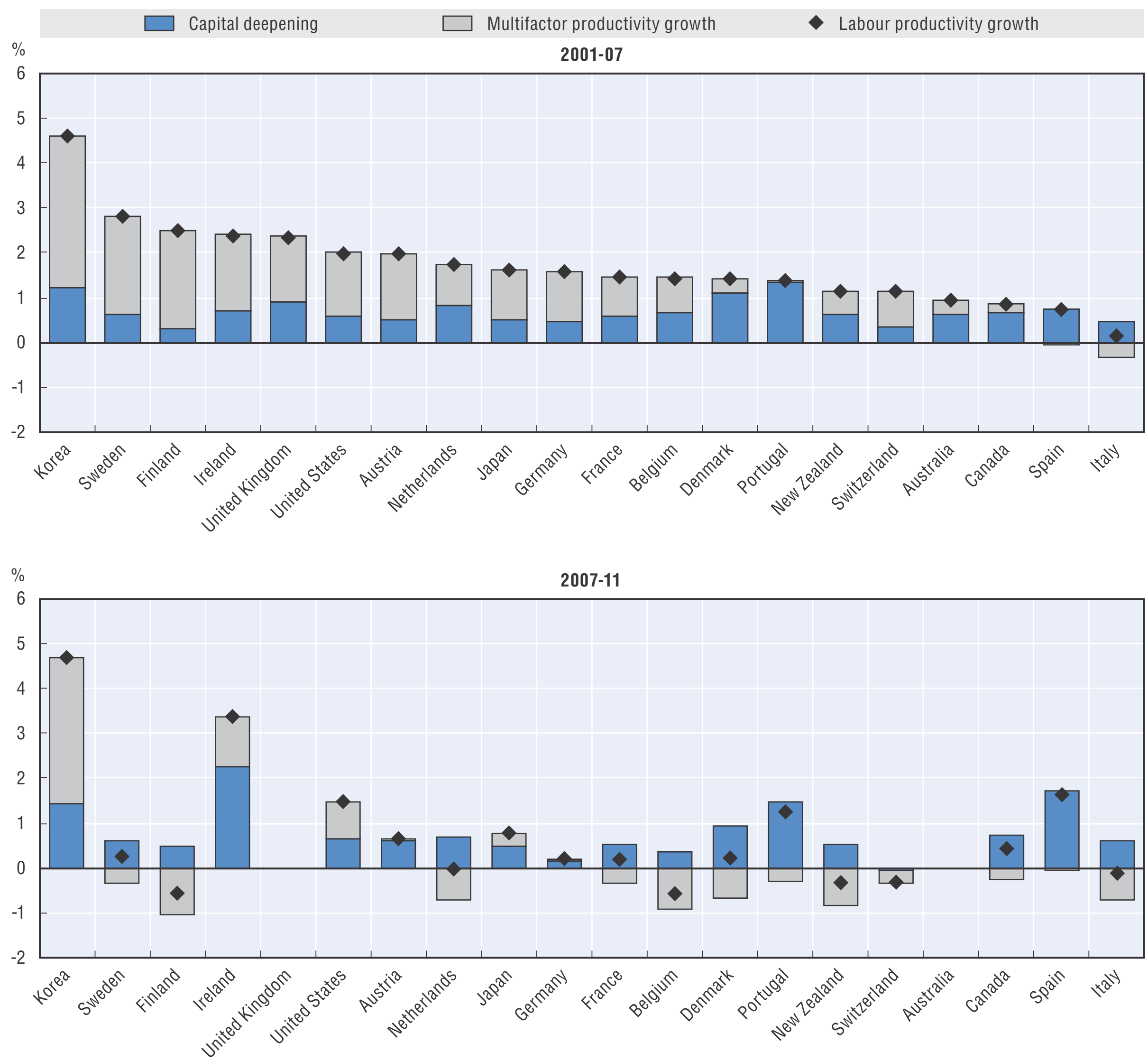
The deterioration of labour productivity has mostly been due to a decline in multifactor productivity, i.e. countries' capacity to adjust to technological change and implement structural changes (Figure 1.6). After positive growth in all OECD countries – except Italy – in 2001-07, MFP plummeted in 2007-12. Few countries, including Korea, Ireland, Japan and the United States, have been able to maintain positive growth rates over 2007-11.

Figure 1.6. **Many countries have lost capacity to implement structural changes in the turmoil**

Average annual growth rate in capital deepening and multifactor productivity, constant prices, 2001-07 and 2007-11



Note: Labour productivity growth can be achieved if more capital, such as machinery or software or better vintages of it (capital deepening) is used in production. Labour productivity can also grow by improving the overall efficiency with which labour and capital are used together, i.e. higher multifactor productivity (MFP) growth. Traditionally, the MFP residual is seen as capturing technological progress, but in practice, it should be interpreted in a larger sense. MFP also captures factors such as adjustment costs, changes in capacity utilisation, economies of scale, effects from imperfect competition, shift towards more skill-intensive production, etc.

Source: Based on OECD (2013), *OECD Compendium of Productivity Indicators 2013*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/pdtvy-2013-en.*

StatLink http://dx.doi.org/10.1787/888933151406

Policy trends

A sustainable recovery from the economic crisis requires faster productivity growth. Countries can only motivate investment and job creation to sustain economic growth by improving productivity. Equally important, higher productivity is needed to address social challenges, such as the environment (greening the economy, ensuring the energy transition) and ageing (paying for pensions). As a result, many governments have assigned innovation a central role in their policy agenda in recent years (see the policy profile on "National strategies for science, technology and innovation").

During the crisis, recovery plans in many countries contained a strong research and innovation component. More recently, national innovation strategies have been included as a major pillar in post-crisis growth strategies. These strategies must be implemented in tight fiscal environments, they must be efficient, and they must give value for money. The prospects in this regard are discussed below in terms of business innovation, global aspects and the contribution of public sector.

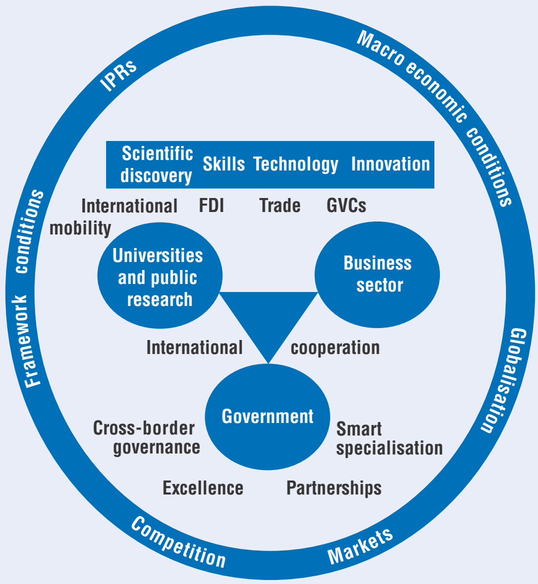
The main policy areas mobilised by governments to increase productivity include:

- Focusing support for public research and innovation on economic, social and environmental challenges beyond R&D and technological innovation so that society will benefit more directly from new knowledge and innovation.
- Structuring the public research sector around centres of excellence to increase the quality and relevance of scientific production while containing costs and to ensure performance-based as well as long-term funding for research.
- Encouraging the commercialisation of public research to increase its economic and societal impact. Many countries are implementing a more integrated and professional approach after years of policy learning.
- Facilitating the restructuring of industry and implementing new policy approaches to support innovation, by building on new or refined policy instruments, e.g. by leveraging private funding via public-private partnerships or crowdfunding.
- Fostering entrepreneurship, a major source of radical innovation in new activities by strengthening capabilities (management support and training, incubators) and by facilitating funding (by providing capital to venture capital funds or through lower tax rates on the relevant capital or income).
- Fostering the capacity of firms and public research institutions to integrate global knowledge networks and absorb knowledge flows, e.g. by attracting international S&T investments, encouraging international mobility of researchers and students and promoting cross-border governance of STI.
- Strengthening the supply of S&T and "soft" skills for innovation through education, mobility and lifelong learning schemes and ensuring optimal participation of skilled workers in the labour market.
- Streamlining innovation support programmes and focusing on instruments that provide the highest leverage. Some countries have terminated programmes with limited impact and concentrated more resources on fewer instruments.
- Developing a more systematic evaluation of policies to increase efficiency.

GLOBALISATION: THE GROWING COMPLEXITY OF INNOVATION POLICIES

This section focuses on the rise of global value chains driven by international trade and foreign direct investment and the fragmentation of business activities worldwide, including R&D activities.

It explores the growing worldwide competition for and availability of talent and knowledge-based assets and the increasing international mobility of such assets. It looks at the emergence of globally interconnected innovation hubs that are based on strong local "knowledge triangles" involving the science base, the business sector and state actors and that are integrated into international cooperation networks. It addresses issues such as competitiveness and offshoring, outsourcing, internationalisation of universities and higher education, and the attractiveness of research systems. It explores policy implications for STI and the rising complexity faced by STI policy makers seeking to implement cross-border STI governance and to create favourable framework conditions for innovation and cooperation while fostering excellence and smart specialisation.



The crisis has pushed many countries to seek to raise their competitiveness. Innovation is more than ever important for strategic positioning in global value chains

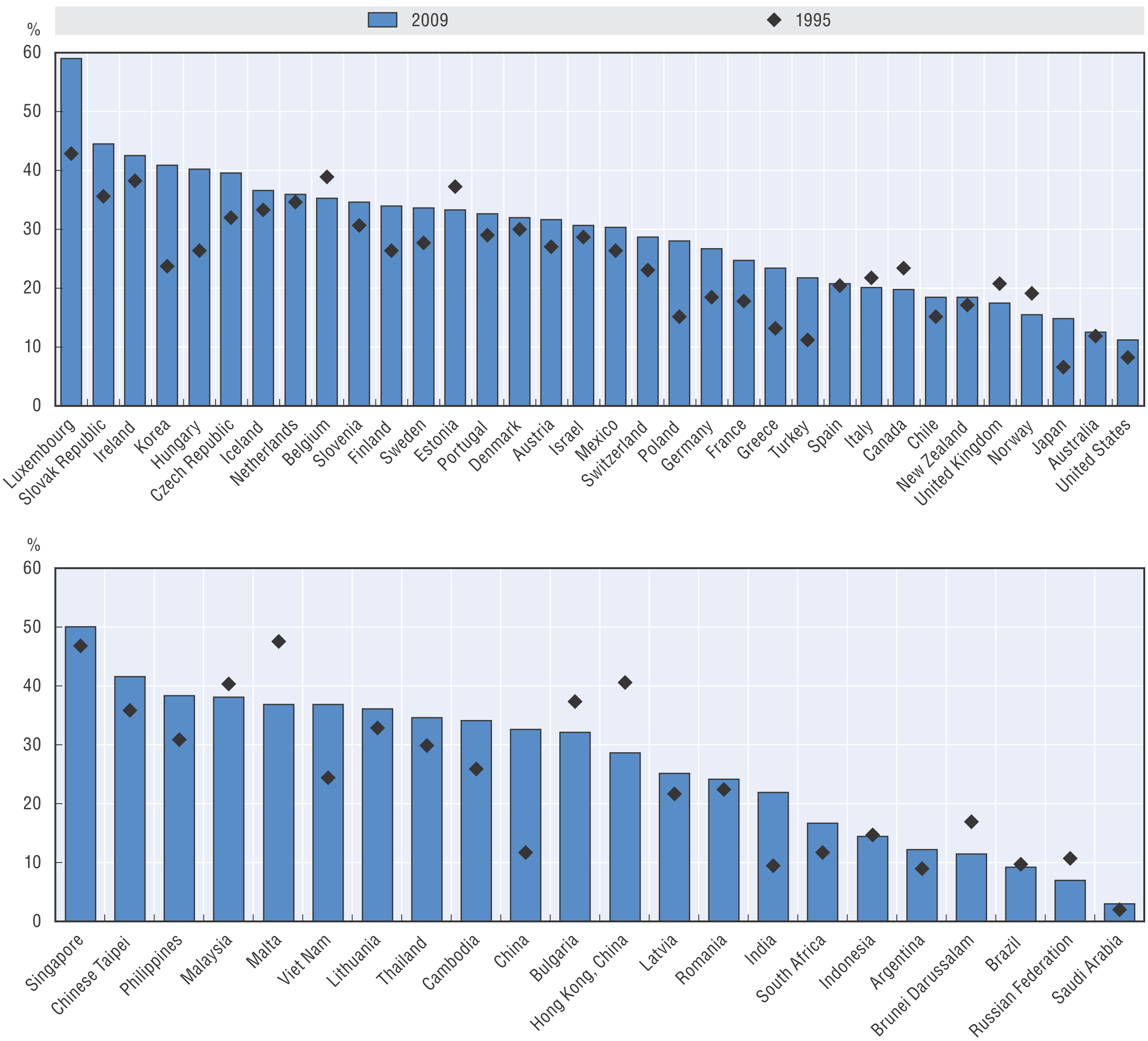
A country's prosperity depends on its participation in the global economy, which in turn depends on its integration in global value chains (OECD, 2013h). Integrating GVCs helps countries strengthen their productive capacities, access a broader portfolio of technologies, skills or knowledge-intensive assets and supports growth. Countries enter GVCs through FDI and trade in goods and services.

As economic globalisation progresses, national economies increase their specialisation. Economies participate in GVCs both as users of foreign inputs and as suppliers of intermediate goods and services used in the exports of other economies (Koopman et al., 2011). Production processes have become more geographically fragmented and production is "sliced and diced" into fragments that are dispersed globally (OECD, 2007; WTO and IDE-JETRO, 2011). Owing to their investments and international trade, in particular intra-firm trade, multinationals (MNEs) are leading actors in GVCs.

The increasing interdependence of the global economy is reflected in the general increase in the foreign content of exports (OECD, 2013i). Foreign value added clearly depends on the size of economies and their patterns of specialisation (Figure 1.7). Smaller economies tend to have higher shares of foreign value added embodied in their exports, while larger economies have a wider variety of domestically sourced intermediate goods available and are therefore less reliant on foreign imports of intermediates. Countries with substantial natural resources typically have lower ratios of foreign value added in their exports, as mining activities require fewer intermediate goods in the production process.

Figure 1.7. **OECD and non-OECD economies are increasingly interdependent in the global economy**

Foreign value-added content of exports, as a percentage of total exports of goods and services, 2009 and 1995



Note: Caution is warranted when comparing 1995 and 2009 figures for China, since data availability only allows distinguishing between processing and non-processing exports from 2005 onwards; this is likely to affect the results.

Source: OECD (2013), *Interconnected economies: Benefiting from Global Value Chains*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/9789264189560-en*, based on OECD-WTO, Statistics on Trade in Value-Added (TiVA) (database), 2013.

StatLink http://dx.doi.org/10.1787/888933151417

Innovation makes it possible to reach segments with higher value added in GVCs. The most value creation in a GVC is often found in upstream activities, such as the development of a new concept, R&D, or the manufacturing of key parts and components, or in downstream activities, such as marketing, branding or customer service (OECD, 2013h). Final assembly, which is often offshored to emerging economies, represents only a small part of value generation. This is generally the case for industries characterised by high degrees of modularity (e.g. electronics) as international standards guarantee that the output of one production stage closely matches the input requirements of the subsequent stage (OECD, 2014d). It is less frequent in industries with important feedback effects between R&D, design and actual manufacturing/assembly (e.g. automotive, pharmaceuticals).

The crisis has affected both the volume and the distribution of international capital flows. A slowdown in cross-border mergers and acquisitions, declines in "greenfield" investment, suspension of intra-firm loans and repatriation of retained benefits has resulted in shrinking stocks of FDI. Although GDP slowed at the same time, FDI stocks slipped from an historic high of 32.2% of world GDP in 2007 to 25.4% in 2008 (UNCTAD, 2013). Trade in goods and services has also experienced a decline, reflecting a general "contamination" of GVCs.

Global FDI flows recovered in 2010 and grew modestly in 2011 before dropping again in 2012. Global FDI flows increased by only 4.5% in 2013, to USD 1 333 billion, and remain over 30% below the pre-crisis levels reached in 2007 (OECD, 2014e).

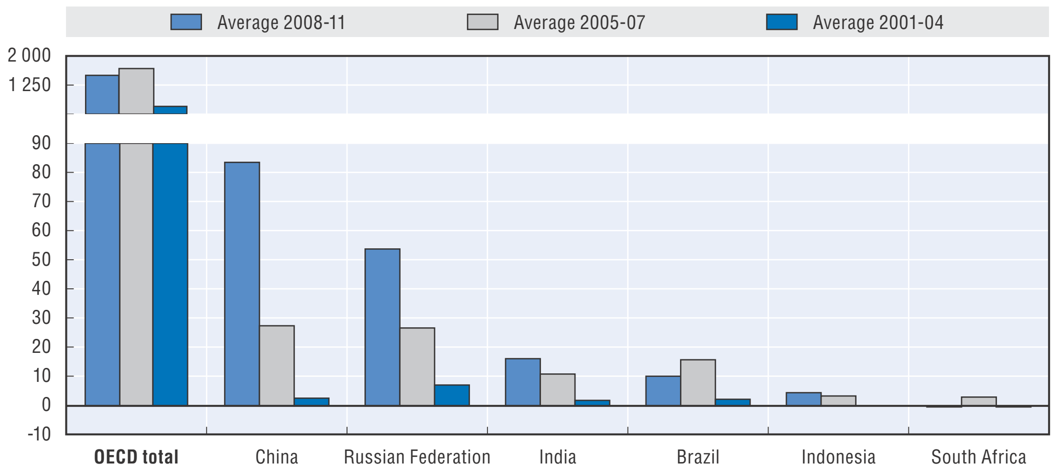
A slowdown in FDI can seriously affect the productive and technological capacity of host economies. It raises the question of the sustainability of FDI-financed jobs, particularly in a context of high unemployment. The aim of FDI is often to establish a lasting interest in an enterprise (OECD, 2008b) and signals the long-term engagement of multinationals, which may be difficult to reverse. MNEs are also among the most important means of transferring technology across countries and a significant part of foreign MNEs' value added, labour compensation and investment "sticks" to the host economy (OECD, 2014d). A slowdown in FDI could also affect the productive capacity of investors negatively, because their competitiveness depends on their ability to tap into foreign reservoirs of labour and resources.

The FDI landscape is changing. In 2012, BRIICS (Brazil, Russian Federation, India, Indonesia, China, South Africa) were the main recipients of FDI, accounting for over a quarter of total FDI flows (UNCTAD, 2013). Developing countries received more than half of global capital. European countries have been particularly affected by a sharp decline in FDI inflows. Stocks were maintained, however, indicating a wait-and-see attitude on the part of foreign investors. The same scenario applies to European outward investments: sluggish European markets slowed FDI outflows, but European MNEs have not abandoned their equity abroad.

The BRIICS also confirmed their emergence as major international investors (Figure 1.8). Although rising global FDI outflows are largely driven by OECD countries, the BRIICS substantially increased their investments over the past decade. Chinese and Russian multinationals invested USD 85 billion and USD 55 billion abroad, respectively, in 2008-11. The large emerging economies tend to focus on neighbouring regions and developing countries; in 2011, 43% of their international investment was "nearshoring" and reflected their progression in regional value chains (UNCTAD, 2013). Their growing equity in Africa, while small in volume, is particularly interesting. Most of their recent investments have been in manufacturing and services, reflecting their industrial modernisation. Access to natural resources has long been a major driver of international investments by emerging economies. Declining growth potential from technological catch-up and some weakening competitiveness because of rising domestic wages create new incentives for multinationals to offshore production activities in lower-income countries. To escape the "middle-income trap", the BRICS are attempting to switch to higher value-added activities and move upstream and downstream the value chain (OECD, 2013h). Innovation is the key.

Figure 1.8. **The multinationals of emerging economies are increasingly offshoring their activities**

Foreign direct investment, outward flows, OECD and selected countries, USD billions, current exchange rates, yearly averages, 2001-04, 2005-07 and 2008-11



Notes: For Indonesia, the 2001-04 average is not available.
The IMF (2009), *Balance of Payments and International Investment Position Manual*, 6th edition definition of FDI is used for 2005-07 and 2008-11, the IMF (1993), *Balance of Payments and International Investment Position Manual*, 5th edition definition for 2001-04.
Source: Adapted from OECD (2013), *OECD Science, Technology and Industry Scoreboard 2013: Innovation for Growth*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/sti_scoreboard-2013-en*, based on IMF, *Balance of Payments Database*, June 2013.
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Policy trends

Position in the value chain is an important policy issue. GVCs have changed the nature of global competition, as companies and countries no longer only compete for market share in high value-added industries, but also increasingly for high value-added activities within GVCs. This alters the rationale of government policies in areas related to globalisation, investment, competitiveness, innovation and upgrading (OECD, 2013h). GVCs introduce a dimension to STI policy design that is beyond the scope of national innovation policies. Governments can support upgrading in GVCs in various ways, by strengthening product market competition, fostering a dynamic business sector, investing in productivity-enhancing public goods such as education, research and infrastructure, and providing the framework conditions that support business investments in such areas (OECD, 2013h).

Global competition for talent and knowledge-based assets is on the rise

Socio-economic activities are increasingly global, and research and innovation are no exception. Innovation emerges from an accumulation of human, technological, financial and organisational capital. The worldwide distribution of skills and knowledge-based assets has changed as the volume of financial and human capital allocated to research and innovation evolves differently across countries, changing the terms and nature of competition for knowledge assets. At the same time, the growing availability and mobility of knowledge assets have markedly increased the pool of skills and resources each country can expect to tap into.

The advantage of advanced economies in higher education is shrinking

A skilled labour force is a pillar of knowledge-based economies, and its size, more than the density of talent, is a key location factor for multinationals (OECD, 2011a) and a determinant of integration in GVCs. Training skilled workers and enlightening consumers is a public mission. A more educated population is more likely to adopt new technological or innovative products. Higher educational attainment facilitates broader adoption of technological innovations and ensures that the benefits of innovation are more widely enjoyed. This can result in greater equity and social cohesion. The democratisation of education therefore supports the democratisation of innovation (see the policy profile on "Innovation for social challenges").

The crisis has not slowed the expansion of higher education systems in major emerging economies. At the same time, demographic trends are likely to affect both teacher and student populations in OECD higher education systems. In 2011, the BRICS granted more than 7.3 million university degrees, compared with 8.5 million in the OECD area (OECD, 2014f), the Russian Federation trained more engineers than the United States, and Indonesia trained more engineers than Germany. According to national sources,[3] Chinese universities delivered over 27 000 doctorates in science and engineering in 2011, possibly more than their American counterparts (24 792) (OECD, 2014f). The doctoral graduation rate in all disciplines in China (2.2%) is now equivalent to that of Denmark (2.2%) and Austria (2.1%) (OECD, 2014c).

In addition, university programmes in large emerging economies meet international standards, and in some cases, are equivalent to those of the world's best universities. According to the Shanghai ranking, China had five universities among the top 200 universities in 2013, similar to, regardless of country size, Australia (7) and Canada (7) (see Chapter 9, methodological annex, for further details on the ranking of the top 50 and top 100). Universities in Argentina, Brazil, the Russian Federation and Singapore were also included in the top 200 ranking (ARWU, 2013). Educational opportunities in emerging economies are also improving: Shanghai and Hong Kong, China, appear at the top of the PISA 2012 ranking and have a large share of top 15-year-olds in science (OECD, 2013j). Singapore and Chinese Taipei recorded scores equivalent to, or higher than, the OECD average.

The circulation of new talent is likely to affect skills labour markets

While they accounted for only 3.2% of the world population in 2013 (OECD/UNDESA, 2013), international migrants have a disproportionate impact on economic and STI systems. Most are of working age and play an important role in shaping skilled labour forces throughout the OECD area (OECD, 2008c). In 2010-11, around 30% of international migrants – more than 27 million individuals – had a tertiary degree (OECD/UNDESA, 2013). Moreover, migrants appear to have a positive effect on entrepreneurship and innovation. They are more likely to create firms, tend to file more patents, publish more research articles and are more inclined to commercialise and license research results. Census data for 2000 showed that skilled migrants from Asia played a critical role in bridging the skills gap in the health professions and in science, technology, engineering and mathematics fields in the OECD area (OECD, 2011b, 2012b, 2013k, 2014e). They are an essential pool of labour in ageing economies. International mobility can also give smaller or lower-income countries, to the extent that talented workers return home, the opportunity to integrate international knowledge networks and capture knowledge flows.

Over the past decade, Asia has been the source of an unprecedented migration of talent. Asian immigrants are on average more skilled than other migrants and, for newcomers, even more skilled than OECD nationals (OECD, 2012b; OECD/UNDESA, 2013). South-South migration has in fact become as common as North-South migration. Poor employment conditions in southern Europe have also pushed residents to leave for more resilient European markets. Spanish and Portuguese migrants have found job prospects outside Europe in former Spanish- and Portuguese-speaking colonies. Finally, a growing share of international talent is coming from Africa. Between 2005 and 2010, 450 000 immigrants with tertiary degrees entered the OECD area from Africa, and more than the 375 000 from China (OECD/UNDESA, 2013).

There is as yet not enough evidence to draw conclusions about the duration and impact of these migration flows on skills stocks. However, improved socio-economic conditions and the adoption of active policies to attract talent in emerging economies should change the situation *vis-à-vis* countries in which ageing dynamics are depleting the stocks of skilled labour. In addition, the selective nature of migration, i.e. the propensity of the more skilled or more highly educated to be more mobile, tends to reinforce international competition for talent, and reduces skills scarcities in the most attractive destinations.

The internationalisation of higher education has also played a role in the global competition for talent. International students contribute significantly both to the cultural mix and to the creation of international knowledge networks. They are an additional source of funding for education institutions during their studies and may have a long-term impact on the host country's economy if they settle after graduation.

Indeed, the research systems of major R&D players depend increasingly on international students. The United States, the largest training system for research in the world, awarded 73 000 doctorates in 2011, and 29% of its international students were in advanced research programmes (OECD, 2014c). International students account for over half of the doctoral students in Switzerland and over 40% in New Zealand and in the United Kingdom. More than 42% of doctoral students in France are not French.

More generally, the internationalisation of higher education helped drive the expansion of higher education (OECD, 2013l). There were twice as many international students worldwide in 2011 than in 2000, with nearly 4.5 million at the tertiary level. In recent years, new players in the international education market include Australia, New Zealand, the Russian Federation, Spain and, most recently, Korea (OECD, 2013l). Although the market share of Germany and the United States in international education has declined since 2000, both countries were still among the top three destinations for international students in 2011. The international mobility of students largely reflects inter- and intra-regional migration patterns but is also influenced by the attractiveness of higher education systems in terms of prestige, quality and cost. A preference for English-speaking countries is noticeable.

In addition, more and more institutions are creating offshore campuses or double degrees (OECD, 2012c) or offer Internet courses as part of their internationalisation strategy. They seek to increase their reputation and revenues (e.g. tuition fees), to access a wider pool of high-potential students, and to promote cross-faculty fertilisation. Massive open online courses (MOOCs), in particular, are changing higher education by radically expanding the reach of existing campuses and by launching a new field of learning informatics that could provide an unprecedented level of feedback for universities

(Waldrop, 2013). This also raises the global competition for talent as demand for these new educational programmes and products is strongest in disciplines that are central to innovation, such as science, engineering and business management (OECD, 2012c).

Innovation activities, including R&D, are increasingly offshored or outsourced

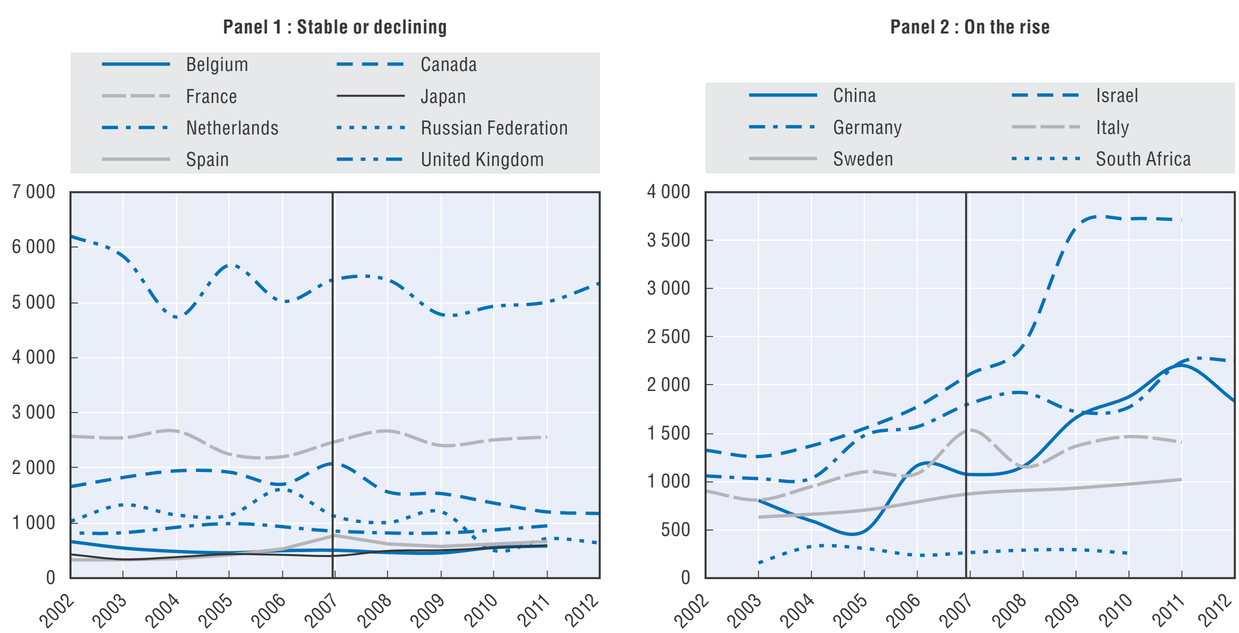
GVCs are changing the international division of labour and the greater mobility of talent has accelerated the internationalisation of R&D. The size and growth of markets were traditionally the most important attractions for FDI (OECD, 2011a). More recently, access to strategic assets, such as technology, knowledge, expertise or the presence of suppliers, competitors and lead users has been a key determinant of the location of innovation activities (OECD, 2008d).

Many large international companies have supplemented their internal R&D efforts by collaborating with external suppliers, competitors, customers, PRIs and universities (OECD, 2008d). The internationalisation of R&D is reflected in the relative importance of foreign sources of funding for business R&D (BERD). In the EU about 10% of business R&D is funded from abroad (OECD, 2014g), although some European countries are more attractive than others. In Ireland, the United Kingdom and Austria, funding from abroad accounts for around a quarter of total business expenditure. Israel (50%) and Korea (0.3%) are the two extremes.

Trends in foreign-funded business R&D reflect the changing landscape of global R&D. Since 2007, the volume of funding from abroad (at constant prices) has declined in Canada, the Netherlands, Russia and the United Kingdom (Figure 1.9). It has increased significantly in Israel and China, reinforcing a trend over the decade. Within Europe, foreign funding increased in Germany and Sweden.

Figure 1.9. **The landscape of global R&D is changing**

Business enterprise R&D financed from abroad, million 2005 USD PPP, 2002-12



Note: Funding of BERD from abroad includes sums transferred by multinationals, paid by international organisations or by other governments. Details are not always available.

Source: OECD, *Research and Development Statistics (RDS) Database*, March 2014, *www.oecd.org/sti/rds*. Data retrieved from IPP.Stat on 8 July 2014, *http://stats.oecd.org//Index.aspx?QueryId=57863*.

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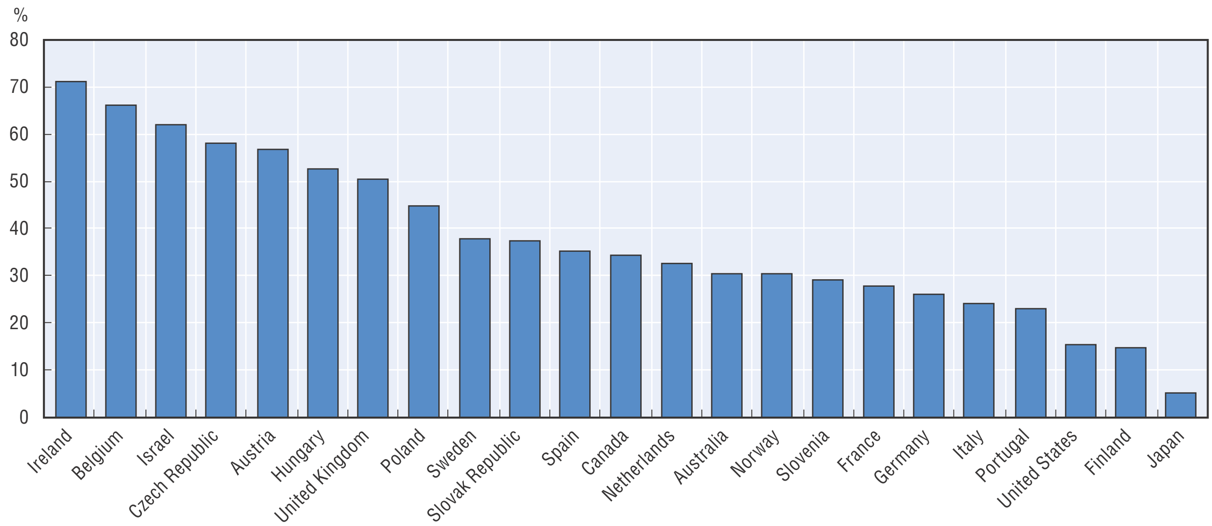
Multinationals have played a key role in the internationalisation of R&D. Foreign affiliates account for up to 71% of business R&D in Ireland and over 55% in Belgium, Israel, the Czech Republic, Austria, Hungary, and the United Kingdom (Figure 1.10).

Figure 1.10. **Multinationals play a major role in domestic R&D in many countries**

Share of foreign-affiliated R&D in total BERD (%), 2011 or latest available year



Note: Data for Japan refer to 2010; data for Austria, Belgium, the Czech Republic, Finland, Hungary, Israel, the Netherlands, Poland, Slovenia and Spain refer to 2009; data for Norway, Portugal and the Slovak Republic refer to 2007.

Source: OECD, *MSTI Database*, June 2014, *www.oecd.org/sti/msti*. Data retrieved from IPP.Stat on 8 July 2014, *http://stats.oecd.org//Index.aspx?QueryId=57863*.

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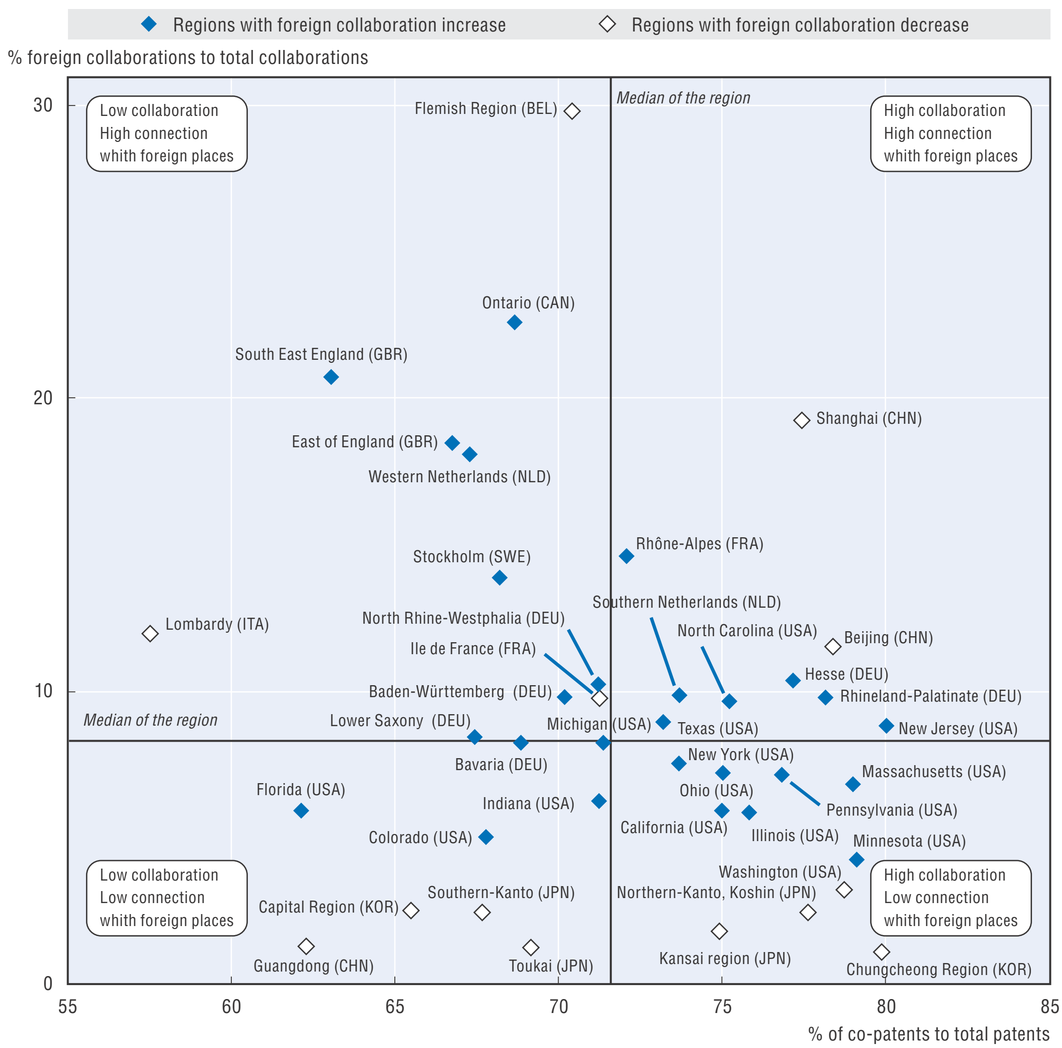
National innovation hubs are increasingly connected to global innovation networks

The internationalisation of R&D is also affected by the growing internationalisation of science through co-operation networks. Firms, universities and STI actors have clustered around geographical areas, industries or groups of related technologies in order to improve networking and generate more spillovers from open and collaborative innovation. Spatial clustering is strong in knowledge-driven sectors where important local knowledge spillovers occur. These local business linkages and networks are particularly critical for innovation by new and small firms.

Among the world's 40 most innovative regions (as measured by Patent Cooperation Treaty patent applications), patterns of collaboration differ, but foreign collaboration is intensifying almost everywhere (Figure 1.11). The Flemish region (Belgium), Ontario (Canada), the east of England (United Kingdom) and the western Netherlands have a high share of collaboration with foreign hubs and are comparatively less connected to other hubs in their own country. Some states in the United States show weak (but increasing) international connections, and strong national connections. In Japan and Korea, both domestic and international propensities to collaborate are low, while the reverse is true for Shanghai and Beijing in China. Country size appears to matter for shaping collaboration patterns.

Figure 1.11. **National innovation hubs increasingly engage in international co-operation**

Percentage of regional and international co-patents in the top 40 regions with the highest PCT patent applications, 2008-10 compared to 1995-97



Notes: The percentage of regional patent applications with co-inventors from another region, whether or not they belong to the same country, is an indicator of co-operation activity in innovation between the two regions (X axis). The number of foreign co-inventors is defined as the number of co-inventors that reside/work in a TL region outside national borders (Y axis). Data refer to overall PCT applications.

Source: OECD (2013), *OECD Regions at a Glance 2013*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/reg_glance-2013-en*, based on OECD, *REGPAT Database*, 2013.

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Policy trends

Globalisation of STI raises questions about the efficiency and sustainability of national innovation policies. They include the appropriateness of national policy frameworks to encourage STI activities shaped by a more global context, the risk of leakages of public money, the suboptimal appropriation of the benefits of STI-related public investments, and an erosion of the tax base due to the profit-shifting strategies of MNEs. While STI networks extend beyond national frontiers, many international policy co-operation frameworks are in their infancy (tax, cybersecurity, etc.) or do not yet exist (e.g. environment).

Attracting knowledge-based assets and human capital requires building supportive ecosystems that will be enriched and flourish with the entry of new talent, technologies and knowledge. Governments can initiate and feed this virtuous circle by ensuring the quality and absorptive capacity of the domestic science base and increasing the attractiveness of the STI system through research excellence initiatives, R&D and intellectual property tax policies, and immigration laws. Canada revised its immigration laws in 2013 to streamline access for highly qualified applicants and plans to introduce changes in study and work permit regulations for international students during 2014. Germany introduced the EU Blue Card in 2012, which offers highly qualified professionals more flexible immigration opportunities, and in 2013 launched a new service for S&T professionals in India, Indonesia and Vietnam that provides advice and support for moving to Germany. The 2012 *Recognition of Qualifications Act* establishes a nationally standardised system to assess foreign professional qualifications.

For many countries, the attractiveness of their higher education and research systems, particularly at the doctoral level, is crucial. Retaining young researchers after their studies is critical, as young researchers tend to be most productive during their early professional years. In the United States, the number of doctorates in science and engineering awarded to foreign students (with temporary visas) has dropped significantly since 2007, while a growing number of doctorates were granted to US citizens (or permanent residents) (NSF, 2014). In addition, the proportion of Chinese graduates who declared their intention to stay in the United States after their PhD dropped from 90% to 83% between 2006 and 2012 (NSF, 2014). Early return of Chinese graduates could have a significant impact on US research capacity, particularly in science and engineering, where they are strongly represented.

OECD countries are reinforcing the capacity and international component of their education and research systems. Canada, Denmark, Germany and the United Kingdom have recently launched national strategies or action plans to internationalise higher education. These address branding, inward and outward mobility of students and academics, and better learning environments. In 2011, Denmark launched "Top Talent Denmark", a one-stop shop branding Danish firms and higher education institutions to Chinese students interested in pursuing a career or studies in the country. Germany offers several new international study and mobility programmes at universities, as well as double degree programmes to promote academic mobility. The United Kingdom established an International Education Council to support its strategy implementation and provide leadership and effective communication between government and the education sector. An outward mobility strategy for students is also currently under development. A Memorandum of Understanding was signed by the Baltic countries to promote closer co-operation on higher education and research (see the policy profile on "Internationalisation of public research").

Some countries have also created new job opportunities for researchers. Japan's New Growth Strategy aims to provide young researchers with career prospects to ensure full employment of S&T doctorate holders. It aims to create over 4 million new jobs in life innovation and green innovation. The 2013 French Research Law foresees the creation of 1 000 jobs in higher education and research between 2012 and 2016 in a context of an overall decline in public employment. Austria's programme for 2013-18 foresees the creation of 2 500 new positions for doctoral training and post-docs. Norway adopted an action plan in 2011 to reduce the share of fixed-term positions at universities. In addition, new measures to strengthen women's position in academia will be considered in 2014.

International collaboration implies the pooling of financial resources, the sharing of large-scale research infrastructures, and the improvement of the global knowledge base (OECD, 2012d). While it is increasingly vital to collaborate globally in order to reap the benefits of STI, most of the available resources for research are still programmed, spent, monitored and evaluated at the national level (OECD, 2012d). Cross-border STI governance means shifting part of the policy initiative from the national to the supranational level. However, building international co-operation and networks means higher transaction costs, greater risks of failure and the inclusion of a broader range of actors (OECD, 2012d). Effective governance mechanisms, in terms of priority setting, funding and spending arrangements, knowledge sharing and IP, and capacity building, can help to address such problems.

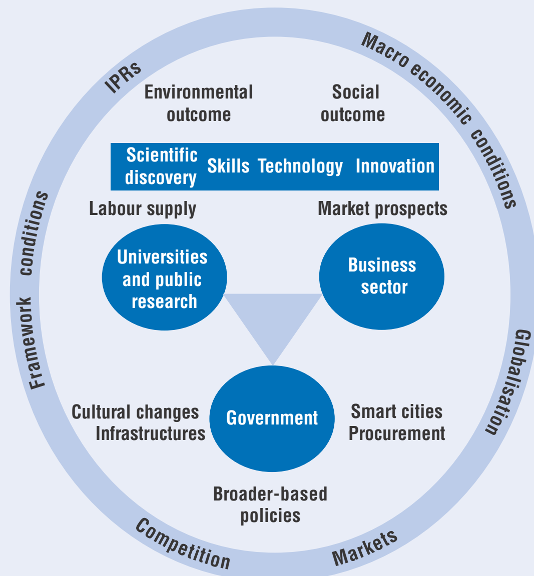
Global markets are not solely the preserve of large firms. As small and medium-sized enterprises (SMEs) integrate global supply chains and entrepreneurial ventures seek growth potential and access to knowledge, skills and networks, opportunities for internationalisation have become important for all types of enterprises, including young innovative firms. Governments increasingly promote global knowledge flow initiatives to support cross-border alliances of firms and research organisations, in order to create linkages between SMEs and FDI ventures and to attract highly skilled labour from abroad. Costa Rica has several programmes to link SMEs to MNEs and to upgrade their capabilities. To support the internationalisation of SMEs, UK Trade & Investment (UKTI) runs a series of new support programmes, including the Technology Partnerships Unit, which helps UK technology-intensive SMEs to identify and qualify for supply-chain opportunities with global companies and funding opportunities with venture capitalists and business angels. A programme has also been established to support and advise mid-sized businesses looking to grow in international markets (see the policy profile on "Attracting international S&T investments by firms"). While most governments promote a cluster-based approach to innovation, many OECD countries and regions have tended to combine cluster policies and specialisation strategies (OECD, 2012a). Governments have long encouraged the location of knowledge producers, transformers, assemblers and first users in special zones in order to accelerate technology transfer and social return on public investments in research. Recently, governments have considered a more bottom-up approach and focused support on accompanying "entrepreneurial discovery" at regional levels. This is the core of the new EU approach, called "smart specialisation", that will apply to the structural funds to be spent in European regions in 2014-20 (around EUR 80 billion). Specialisation strategies have also been defined in areas of research strengths. In 2013 the Brussels Capital Region (Belgium) included a smart specialisation strategy in its new regional innovation plan and Wallonia implemented a Trends Observatory. Estonia is considering the implementation of a smart specialisation strategy, with an emphasis on future co-operation schemes (see the policy profile on "Cluster policy and smart specialisation").

The potential impact of agglomeration dynamics on social cohesion has also emerged as an important policy issue. Globally connected innovation "hotspots" that are better integrated in GVCs than in the rest of the country may tend to enlarge social and cultural divides. Some STI policies could be prejudicial to "territorial" inclusiveness if they are not linked to policies that ensure that knowledge and the associated benefits trickle down to other geographical regions.

ENVIRONMENTAL AND SOCIAL ISSUES CREATE CHALLENGES AND OPPORTUNITIES

This section looks at global challenges that affect the whole world and the global innovation landscape. It highlights environmental stresses, demographic pressures in ageing societies, and potential for equity, social cohesion and innovation risks caused by non-inclusive innovation.

It explores business opportunities raised by climate change, the "silver service economy" and the democratisation of innovation in terms of knowledge sourcing, labour supply and market prospects. It addresses the sustainability of green public R&D investments, deployment of clean technologies and enabling infrastructures, the role of smart cities and the need for cultural and behavioural changes. It discusses the recent shift towards broader-based policies and considers the role of STI policies in overcoming technological lock-in through system innovation and in ensuring that the benefits of science and innovation trickle-down to the society as whole.



As economic growth resumes, public policy will pay more attention to environmental and social challenges.

Progress has been made on the environmental front, but further progress requires technological breakthroughs and systemic change

Demographic trends, urbanisation and modern lifestyles have placed many societies on an unsustainable growth path. Innovation and technology can play a key role in the transition to a greener economy.

The current growth model is altering the environment, and natural systems are already undergoing irreversible changes. Air pollution is set to become the world's top environmental cause of premature mortality, ahead of lack of clean water and poor sanitation (OECD, 2012e). OECD projections to 2050 forecast that a global economy four times larger may see energy needs increase by 80%, greenhouse gas (GHG) emissions by 50%, mainly due to energy-related emissions of carbon dioxide (CO_2), and water demand by 55%. The increase in the atmospheric concentration of GHG could result in average global warming of 3°C to 6°C. More than 40% of the world's population would live in areas subject to "water stress". Climate change could become a major driver of mass migration (OECD, 2013k).

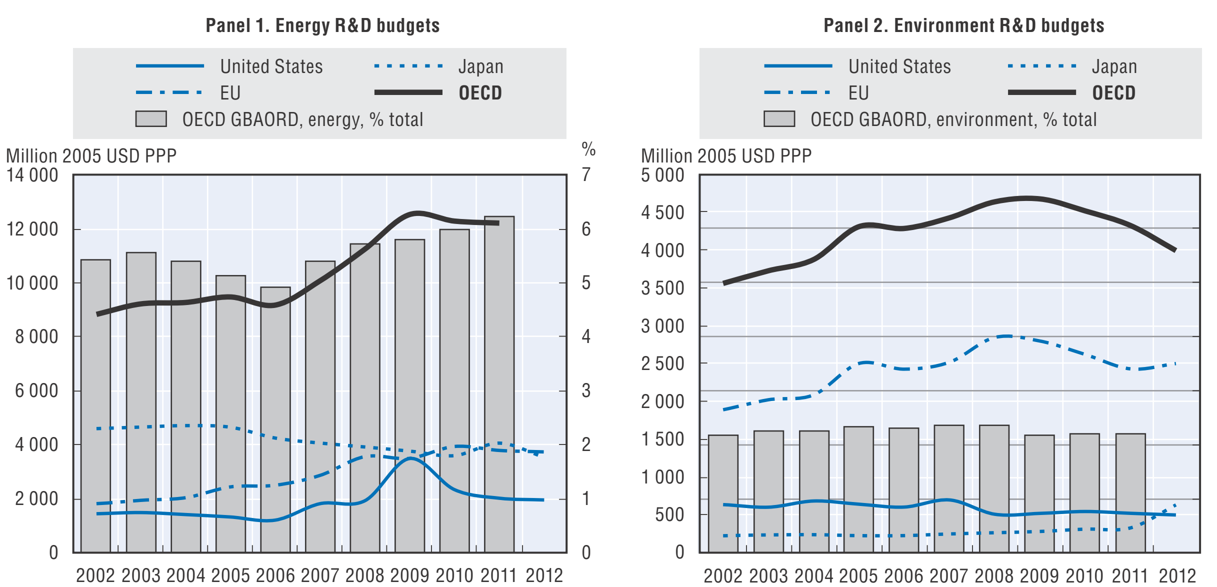
The challenge for our society is the transition to a low-carbon economy and the preservation of natural resources. Progress has been made, but not enough. Many countries have managed to decouple CO_2 emissions or freshwater abstractions from GDP growth (OECD, 2013m) but have not yet done enough. In many other countries, the situation continues to deteriorate as emissions continue to rise.

At the last meeting of the International Energy Agency (IEA) in November 2013, member countries at Ministerial level agreed that progress on clean technologies is too slow, that considerable energy efficiency potential remains untapped, and that energy-related R&D and demonstration need to be faster (IEA, 2013). OECD countries are still more than 80% reliant on fossil fuels (OECD, 2013m).

The crisis has had a mixed impact on environmental conditions. Economic and trade contraction helped to lower CO_2 and GHG emissions temporarily. Many governments also introduced a green component in their recovery plan in order to deploy new green investments and modernise infrastructures (OECD, 2009). Both the volume and the relative share of public R&D budgets for energy-related purposes increased significantly between 2007 and 2009 (Figure 1.12). But lower raw materials prices dampened financial incentives to turn to alternative energy sources and more efficient use of natural resources. Government efforts to support green technology markets found little support from private demand, which was less responsive to more expensive products. The fiscal austerity that prevails in many countries may also delay the implementation of a greener agenda. The impact on R&D budgets is already being felt. The volume of funds allocated to energy and environmental issues has slowed since 2009 in the OECD area (Figure 1.12).

Figure 1.12. **Growth in public R&D budgets for energy and the environment is easing**

Million 2005 USD PPP and as a percentage of total GBAORD



Note: Total EU is an OECD estimate and includes Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, Netherlands, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden and United Kingdom.
Source: OECD, *RDS Database*, March 2014. Data retrieved from IPP.Stat on 8 July 2014, *http://stats.oecd.org//Index.aspx?QueryId=57863*.

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Policy trends

The transition to a low-carbon future requires technological solutions and radical changes to the global energy system.

A 2°C scenario, i.e. a scenario that holds global warming below what is perceived to be the tipping point of natural systems, requires a portfolio of new technologies, including production of renewables, end-use fuel and electricity efficiency, technologies for carbon capture and storage (CCS) and even nuclear energy. China and the United States place increasing policy emphasis on innovation for sustainable and green growth. China's 12th Five-Year Plan has paid particular attention to energy and climate change and has established a set of targets and policies for 2011-15 to reduce CO_2 emissions and fossil-energy dependency and to increase energy efficiency. The US government announced a Climate Action Plan in 2013; its ambition is to lead the world in R&D and demonstration and deployment of clean energy technology. USD 7.9 billion is proposed for clean technologies and an additional USD 2.7 billion for global climate change research.

Existing technologies already offer significant potential to achieve a sharp reduction in CO_2 emissions, e.g. in the building and construction sector. Residential energy consumption has been relatively static since 1990, despite substantial improvements in energy efficiency and residential space heating, and offers the greatest potential for energy and emission savings (IEA, 2013). Hybrid-electric (HEV) and electric vehicles (EV) also show encouraging progress, so long as electricity is generated from low-carbon sources, but deployment must be accelerated to be on track to meet a 2°C scenario. This entails a projected increase in sales by around 80% (EVs) and 50% (HEVs) a year up to 2020. The 2014 US Budget proposal includes provisions to improve clean-vehicle technologies and to move closer to one million advanced vehicles on the road. The Norwegian Strategy for Environmental Technology will fund experimental development, with particular attention to green transport and offshore wind production facilities. In January 2013, the Canadian government announced the renewal of the Automotive Innovation Fund (AIF), which provides repayable contributions to automotive firms that undertake large-scale R&D projects focused on greener and more fuel-efficient vehicles.

The decoupling of economic activity and energy intensity cannot be achieved solely with technologies, whether new or not. It requires structural and behavioural changes (IEA, 2014) as well as significant investments in infrastructure (e.g. smart grids) to improve the system as a whole (IEA, 2013). Clean energy solutions, such as electric vehicles and solar photovoltaic (PV) systems, depend on smart infrastructure that enables system-wide gains. The United Kingdom created the Green Investment Bank with USD 5.5 billion PPP (GBP 3.8 billion) in 2012 in order to invest in green infrastructure projects.

In addition, the complexity of the links between energy, water and food requires a holistic approach and better integration of innovative solutions and policies in these three areas. In Germany, the Energiewende Research Forum provides a platform for dialogue among stakeholders involved in transforming Germany's energy system. In Denmark, the Fund for Green Business Development promotes green industrial symbiosis, in which the waste of a given resource, e.g. water or materials, of one company becomes a resource for another.

Environmental pressures also require radical changes in lifestyles and behaviours. Governments have a key role to play in this respect. Household consumption patterns and behaviour have a profound effect on stocks of natural resources and the quality of the environment (OECD, 2011c). A 2008 OECD survey of over 10 000 households studied household responses to various measures in five policy areas (energy, waste, organic food, water and personal transport) in ten countries.[4] The survey responses highlight the importance of providing the right incentives to spur behavioural change, and show that price-based incentives encourage energy and water savings, increase recycling volumes, and lower car ownership and use. The mere fact of metering and introducing a price on the use of environment-related resources affects people's decisions, even if the price is very low. In addition, the survey findings indicate that "softer" instruments, based on the provision of information to consumers and on public education, can substantially help to induce changes on the demand side.

Box 1.1. **Smart cities: tackling social and global challenges at the local level**

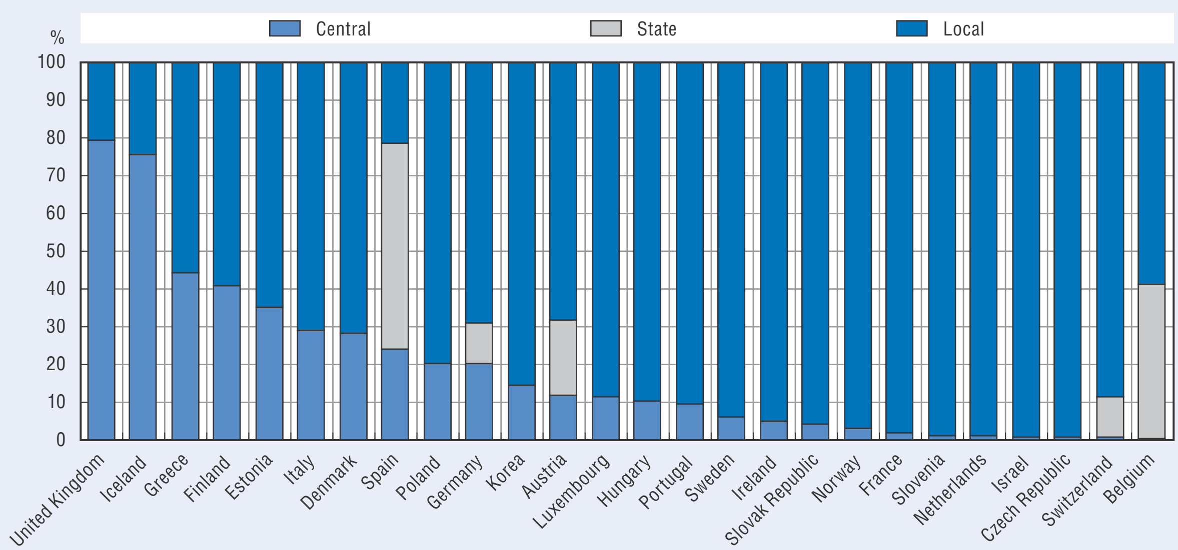
For the first time in history, more than half of the world's population lives in urban areas.

Cities are critical sources of national growth and play disproportionately large roles in countries' economies, knowledge generation and environmental performance (OECD, 2013n). Compared to higher levels of government, cities offer more easily identifiable policy synergies and complementarities. Urban policy makers are more likely to identify and combine complementary climate policies within and across sectors, given the interconnectedness of urban systems such as transport, land-use planning, and economic development (OECD, 2010c). Cities are responsible for a significant share of green infrastructure investments (Figure 1.13) (OECD, 2013o).

Cities are therefore the places in which smart innovative approaches, driven by information and communication technologies (ICTs), analysis of (big) data and machine-to-machine communication, naturally arise. Smart cities often target different aspects of urban development, such as transport, electricity grids, buildings, or the delivery of public services in fields such as health care or education. Beyond governance challenges raised by the many levels of government and of stakeholders involved, smart cities are likely to improve citizens' well-being and increase the efficiency of the urban system as a whole.

Figure 1.13. **Cities make a major contribution to green public investment**

Gross capital formation in environmental protection by level of government, percentage of total, 2012



Note: State government data only for Austria, Belgium, Germany and Spain.

Source: OECD, *National Accounts Database*, April 2014 based on OECD (2013), *OECD Regions at a Glance 2013*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/reg_glance-2013-en*.

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In 2014, Brussels Capital (Belgium) will launch a tender for public procurement to develop a smart city project around transport and mobility. In 2013 France devoted new funding to "tomorrow's city" in the framework of its Investments for the Future. Sustainable smart cities are becoming a prominent feature of the Swedish Challenge Driven Innovation Programme and a part of its emerging Strategic Innovation Areas. In 2011 Costa Rica included smart cities and smart grids in its roadmap for renewable energies. Also in 2011, the Finnish government, Tekes and private companies set up a test environment for about 400 electric vehicles in the Helsinki metropolitan area to develop the infrastructure and transport system, services for users and business models.

Source: OECD (2013), *Green Growth in Cities*, OECD Green Growth Studies, OECD Publishing, Paris, and country responses to the OECD STI Outlook policy questionnaires 2014 and 2012.

Innovation for an ageing society offers new market opportunities and new growth industries

The share of the population over 65 years of age has been increasing in OECD countries over the past few decades (OECD, 2013p). In 2010, around 15% of the OECD population was over 65 years old. This ratio is expected to increase to 26% by 2050, and the increase in the share of the population aged 80 years and over will be even more dramatic. Outside the OECD area, while less developed regions still have young populations, some of the larger emerging economies are likely to be converging with OECD population-ageing profiles by mid-century.

Ageing will generate a range of serious challenges due to growing pressures on economic performance, social and health care, and public finances. Not only will ageing place a greater burden on health services, long-term care systems and public finances, it will also take its toll on economic and productivity performance, as labour forces age in some countries and shrink in others (OECD, 2012a). Ageing societies will face critical policy challenges related to maintaining and enhancing health and social services for the elderly. The increasing elderly population, combined with societal changes such as rising female labour market participation, declining family sizes, and the continuing growth of the stepfamily, will increase demand for care at a time when shortages of public health workers are forecast and have already affected the pool of care providers (OECD, 2012f; OECD, 2011d).

Dementia and Alzheimer's disease, in particular, already constitute a significant public health challenge. An estimated 36 million people worldwide suffered from dementia in 2010, of whom 42% in high-income countries (OECD, 2013q). They could number as many as 115 million worldwide in 2050. Addressing the challenges raised by dementia has become a major endeavour at international level. A landmark G8 Summit on dementia, held in London in December 2013, concluded with a call for countries to accelerate research, promote open science and greater data sharing at international level, and improve quality of care of those with dementia (*www.oecd.org/health/dementia.htm*). This is not a challenge for OECD countries alone. An estimated 58% of the people with dementia in 2010 worldwide were in middle- and lower-income countries.

In light of such long-term prospects, it is essential that the elderly remain as healthy, independent and active as long as possible, so that they can play a part in family life, society and the economy. Science and technology, and particularly ICT applications, will play an important role in reaching this objective (OECD, 2012a).

Policy trends

Today it is important to promote services innovation in health care and nursing, education, transport, and urban development. Ageing societies require public services to address demand and priorities. In particular, innovative home- and community-based services provide a good starting point for smart ageing approaches. Housing design that supports independence, access to adaptations and technology that support ageing, flexible support at home, and integration of housing services with health and care to create integrated teams on a neighbourhood basis can all play a role.

In addition, new technologies can help improve conditions for people working in the care sector and help to make care work more attractive in the future (EC, 2010). The aged-care services sector, while diverse, faces common policy challenges. Although institutional investors such as pension funds or insurance companies have shown increased interest in financing R&D for ageing in recent years, funding remains a major constraint. On the one hand, the public good nature of innovation for the health and well-being of older populations, as well as uncertainty and insufficient awareness of market opportunities (including reimbursement, adoption by users and unclear business models), lead to under-investment by the market. Yet governments are increasingly constrained by fiscal consolidation. Some national policy programmes around public-private partnerships (Denmark) and "silver" public procurement (Denmark, Finland, Sweden and the United Kingdom) have been initiated to stimulate investments and demand for smart ageing projects.

Other barriers to innovation may arise from systemic failures. In this case the issue is less investment in goods and services than the preparedness of the innovation system itself. Barriers to transformative changes in health and social care services include lack of policy coherence, poor articulation of demand and regulatory uncertainty. In most OECD countries the political, regulatory and funding structures for health care, for example, differ from those for social care. Also, although they are interdependent, governance and funding structures are often poorly co-ordinated and integrated, and care provision and delivery is often fragmented. Sweden is currently moving towards a challenge-driven innovation strategy for health, well-being and medical care. A national initiative, Strategic Innovation Areas (SIA), has strong financial support in order to advance innovation agendas, public-private partnerships and institutional change.

The need for more efficient, effective and sustainable services for health and well-being requires rethinking traditional models in order to redefine the boundaries between state and market and state and society on the basis of greater social responsibility and collaboration between the public and private sectors.

Education and ICTs play a key role in fostering the democratisation of innovation for the benefit of all

The role of innovation as a driver of growth is widely recognised. The relation between innovation and inequality, however, is more complex. Innovation can increase inequalities in income and opportunities among different groups in society (the "social inclusiveness" issue) owing to differences in skills, social capital and access to finance. "Industrial inclusiveness" can be hampered if "islands of excellence" concentrate high-performance innovators and co-exist with groups of poorly performing firms and institutions or even the informal economy, particularly in emerging and developing economies. So-called "territorial inclusiveness" cannot occur if industrial and social inequalities underpin inequalities between urban and rural areas or among city neighbourhoods. These different dimensions of inclusiveness are related. Differences in access to and participation in innovation can result in substantial intra-country gaps in productivity and income distribution.

Wider participation in higher education and broader access to the Internet, social networks and online community platforms have all contributed to broaden innovation processes. Knowledge and resource sharing for innovation has gone beyond science and industry boundaries; final users and society at large are increasingly involved in innovation. Extended communities are mobilising to contribute ideas, content and funding. Crowd-voting, crowdfunding and Internet-based idea competitions are examples of different forms of crowd-sourcing to tap into global knowledge and resources accessible in cyberspace.

Information and communication technologies offer opportunities to support inclusive innovation by "democratising innovation" and by extending the circle of individuals and businesses that engage in innovation activities. ICTs have facilitated access to knowledge and improved the means of communication available to society, including rural communities in developing and emerging countries. The potential of ICTs is clear when one looks at the importance of ICT-based products and services among the successes of inclusive innovation initiatives.[5] Some of these products have provided market information to farmers, training to unskilled groups and improved business conditions for disadvantaged groups. Many of the most successful applications have involved local entrepreneurs as part of the development process. Such examples illustrate the potential of ICT-based applications to support the innovative activities of entrepreneurs and small businesses (OECD, 2013s).

Policy trends

Innovation policies are usually designed without attention to their impact on inclusive growth. For example, fiscal incentives only benefit taxable firms and so exclude loss-making firms (such as start-ups) and the informal sector. Innovation grants and public procurement usually go to larger firms with closer links to government. If government expenditure focuses on particular domains or sectors (often high-technology), more basic, lower-technology innovations that would address social challenges, such as poverty, may be disregarded. Expenditure might better be concentrated on particular actors and be less conditional so that a larger number of firms or individuals could become innovators and promote the democratisation of innovation.

The policy debates about the "digital divide" show that the Internet and ICTs are not always an obvious integrating factor. Lower-income groups are often at a disadvantage in terms of access and therefore less likely to reap the benefits. This is because skills, innovation and technical change are complementary. Skills help exploit the opportunities ICTs offer and are generally necessary to widen the circle of innovators. Skills and training policies will be essential to avoid exclusion. In 2013, the Australian government made USD 130 million PPP (AUD 192 million) available to universities to increase access and participation for people from low socio-economic backgrounds, including indigenous Australians. South Africa's equity targets in human development projects aim to increase the representation of blacks and women in the S&T and engineering sectors. Costa Rica provides rural and vulnerable communities with access to intelligent community centres that offer Internet access and have become centres of learning, particularly for digital technologies.

A variety of innovative products and services, some of which rely on ICTs, have substantially improved the welfare of lower-income groups. However, many have had limited aggregate impact owing to their small scale. Success stories, such as Kenya's mobile banking service M-PESA, which now reaches an estimated 15 million users, indicate the potential to upscale such innovations.

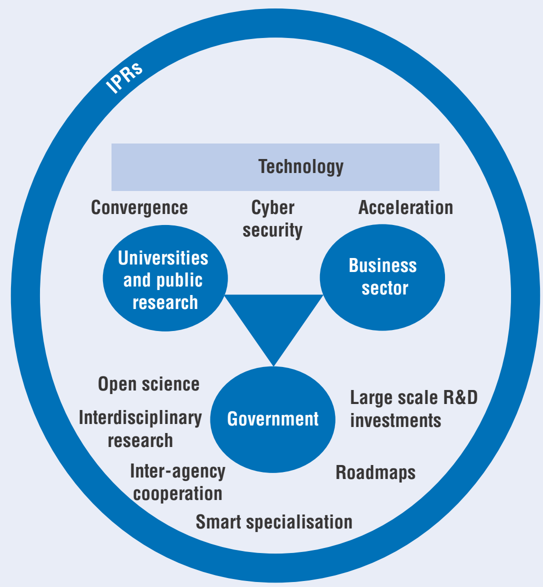
The critical policy issue is the potential trade-offs between policies that support innovation and information technology (IT) and can increase aggregate efficiency and growth, on the one hand, and the distribution of benefits, on the other. While innovation can increase inequality, as benefits accrue to the innovators, the diffusion process can equalise the benefits over time. In this respect, it is important to consider the prioritisation of economic activities (e.g. ICTs, biotechnology or agriculture).

Different economic activities have different patterns of employment, skills and wages. They also differ in how they are connected to other activities through sales, purchases or knowledge circulation. The promotion of certain activities can therefore affect the distribution of income or have more widespread economic impacts. This affects not only growth but also industrial inclusiveness and, via wages, social inclusiveness. This issue is of particular interest at a time when countries are reconsidering the benefits of industrial policies.

LOOKING INSIDE THE GLOBAL RESEARCH SYSTEM

This section considers the expansion of the global research system under the present conditions of economic recovery.

It describes the changing landscape of global R&D with the rise of Asia and the growing cost of technological catch-up to world-class standards of research. It explores recent and expected technology developments through patent application "bursts" and R&D investments by the world's largest corporate investors. Policy implications of S&T acceleration, technology convergence and cybersecurity requirements are also considered. It addresses issues such as large-scale public R&D investments, smart specialisation and research roadmaps, inter-agency co-operation, interdisciplinary research, open data and open science, and the changing conditions of doing and commercialising public research.



Many of today's innovations would have been impossible without the developments enabled by scientific and technological research.

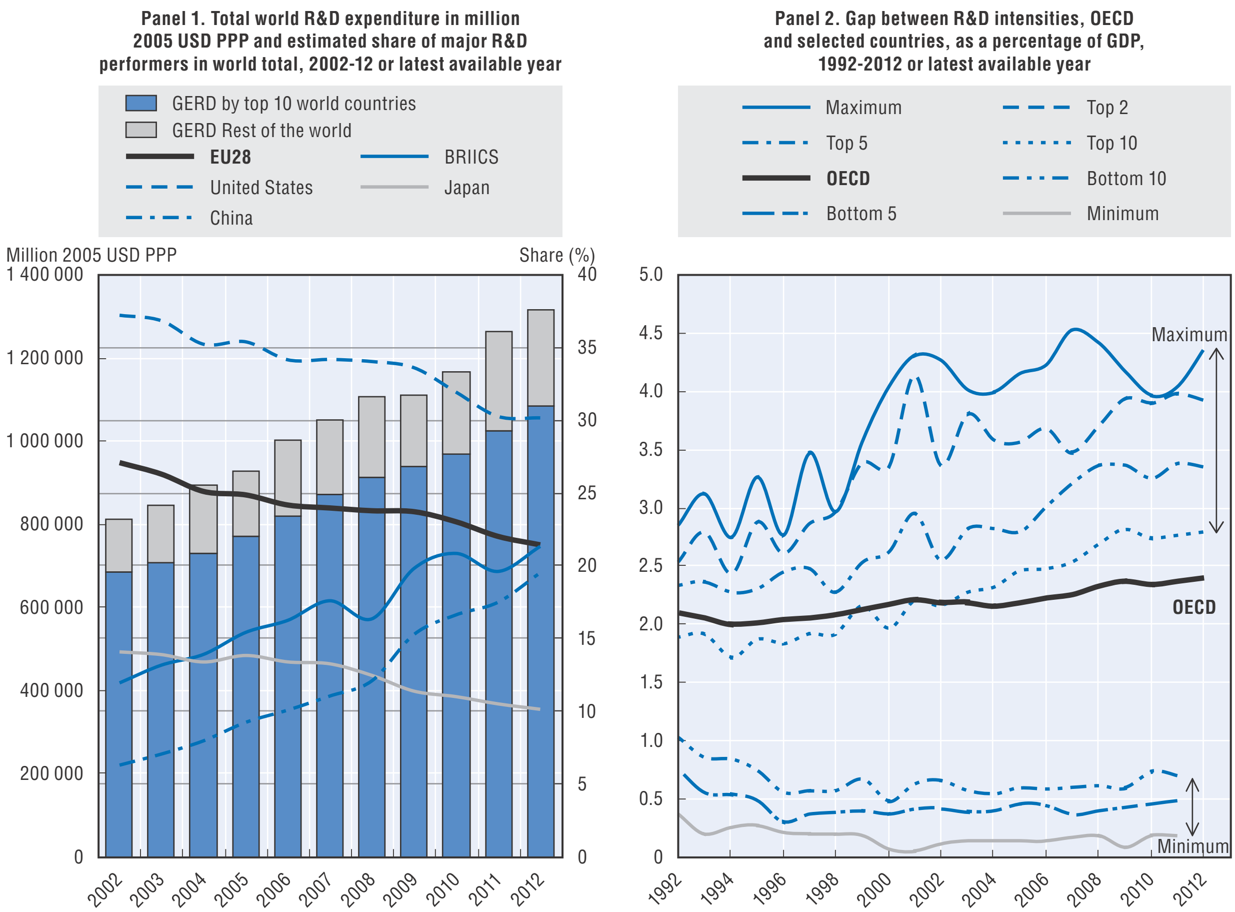
The global research system is expanding

Research and innovation are on the rise in Asia

In spite of the economic downturn, world investment in R&D has increased steadily since 2007 (Figures 1.14 and 1.15). OECD R&D spending reached over USD 1.1 trillion in 2012[6] (OECD, 2014g). R&D expenditures by Brazil, the Russian Federation, India, Indonesia, China and South Africa amounted to an additional USD 330 billion. World R&D expenditure in 2012 could be some USD 1.4 trillion, of which about 80% attributable to ten countries (OECD estimate). The OECD would account for 70% of world R&D expenditure, compared to about 90% ten years ago (Figure 1.14).

The 2008 crisis has reinforced on-going shifts in the global research landscape. The top ten R&D-performing economies have changed since 2007, with the entry of Chinese Taipei and the exit of Canada. Since 2009, China has been the second largest R&D performer, behind the United States and ahead of Japan (Figure 1.14). The share of global R&D investments has decreased over time in the United States (an estimated 28% in 2012), Japan (10%) and the European Union (20%).

Figure 1.14. **World[1] R&D efforts have weathered the turmoil and remain concentrated in a few major global players**



1. Global gross expenditure on R&D (GERD) is estimated as the sum of GERD performed by OECD countries, the BRIICS, and Argentina, Colombia, Costa Rica, Egypt, Latvia, Malaysia, Romania, Singapore and Chinese Taipei. A world estimate would amount therefore to some USD 1 260 billion PPP in 2011 and USD 1 400 billion PPP in 2012.

Source: OECD, *MSTI Database*, June 2014, *www.oecd.org/sti/msti*; UNESCO Institute of Statistics (UIS), *Science, Technology and Innovation Database*, June 2014. Data retrieved from IPP.Stat on 8 July 2014, *http://stats.oecd.org//Index.aspx?QueryId=57863*.

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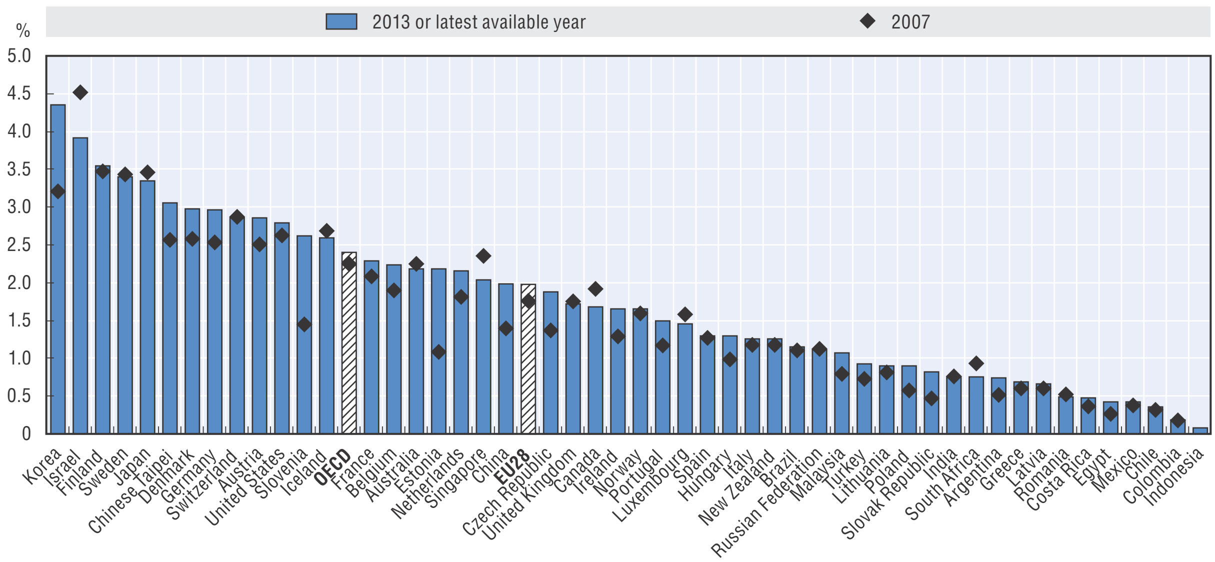
Korea became the world's most R&D-intensive country in 2012, overtaking Israel,[7] where R&D spending incurred by firms and government slowed during the crisis (Figure 1.15; see also Figures 1.21 and 1.26). When considered as a proportion of GDP,[8] OECD R&D expenditure rose slightly from 2.25% in 2007 to 2.40% in 2012. This sustained commitment to R&D is broadly based. R&D intensity increased in most economies, with a sizeable upward shift in some, notably Korea (+1.15%) and Estonia (+1.09%).[9] In the United States, R&D intensity rose from 2.63% to 2.79% over the period. From a lower base, the EU28 GERD/GDP ratio rose slowly, by 0.22 of a percentage point to 1.98% in 2012.

Some countries have experienced a decline in R&D intensity since 2002, and in most cases, it occurred before the crisis. Sweden (-0.40%), Iceland (-0.35%), Israel (-0.34%) and Canada (-0.30%) have recorded the sharpest falls.

Figure 1.15. **Gross R&D expenditure, 2013 and 2007**

As a percentage of GDP



Note: Data for Austria refer to 2013. Data for Colombia, Costa Rica, Iceland, Malaysia, Mexico, New Zealand and South Africa refer to 2011 instead of 2012; data for Australia and Brazil refer to 2010 instead of 2012; data for Indonesia refer to 2009 instead of 2012; data for Switzerland refer to 2008 instead of 2013; data for Australia, Malaysia and Switzerland refer to 2008 instead of 2007. For Slovenia, a change in methodology in 2011 introduced a break in the series.

Source: OECD, MSTI Database, June 2014, *www.oecd.org/sti/msti*; UNESCO Institute for Statistics (UIS), Education database, June 2014. Data retrieved from IPP.Stat on 8 July 2014. *http://stats.oecd.org//Index.aspx?QueryId=57863*.

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Outside the OECD area, Chinese Taipei (+0.91%) and China (+0.91%) showed the sharpest increases in R&D intensity. In 2012, Chinese Taipei spent 3.06% of GDP on R&D, and ranked between Japan (3.35%) and Denmark (2.98%), while China's R&D intensity is now on par with that of the EU28.

The relative cost of accessing world-class research is increasing

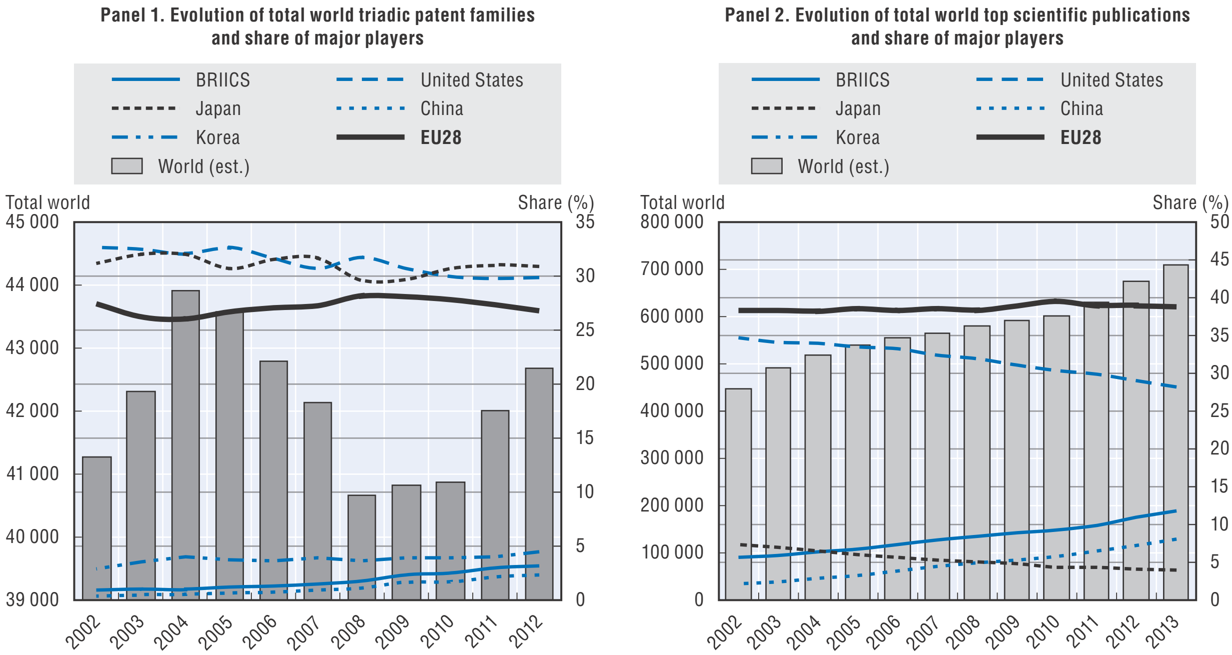
The global R&D system remains centred on a handful of economies. The top ten economies have maintained their share of global R&D expenditure since 2007, but the gap between the ten most R&D-intensive economies and the rest of the world has widened. As research spending appears to be stagnating in OECD countries, convergence with leading economies tends to occur in non-OECD economies.

The concentration of R&D around big players and economies with more mature research infrastructure (i.e. with higher GERD intensity) changes the conditions under which smaller and lower-income countries access world-class research. As the gap widens, lagging countries' technological catch-up costs rise, which increases the risk of their exclusion from GVCs and global knowledge flows.

S&T output has been recovering gradually

The crisis has slowed scientific and technological output worldwide. While scientific production, as measured by scientific publications, was less adversely affected and has been accelerating since 2010, technological production, as measured by patenting activities, has decreased significantly, and is still slow to recover (Figure 1.16). This reflects to some extent the different impacts of the downturn on parts of the R&D system, in particular public research and business R&D.

Figure 1.16. **Patenting activities have suffered and are slow to recover**



Note: Panel 2 – Publications in the top 10% of journals are drawn from the SciVal Elsevier database. Ranking is based on the Scientific Journal Ranking (SJR), an impact-factor normalised index that takes journal prestige into account as a measure of quality. Scientific production is based on whole counts of documents by authors' institutional affiliation in the country. The EU28 share is overestimated as it includes publications with several European co-authors.

Sources: Panel 1 – OECD, *MSTI Database*, June 2014, *www.oecd.org/sti/msti*. Data retrieved from IPP.Stat on 8 July 2014, *http://stats.oecd.org//Index.aspx?QueryId=57863*; Panel 2 – Elsevier B.V. (2014), *SciVal*. Data retrieved from SciVal (Scopus – Elsevier) on 31 January 2014.

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Triadic patent family[10] data show that the steady growth of patenting activities during the first half of the 2000s slowed before the 2007-09 downturn. The crisis reinforced this trend, as depressed economic conditions discouraged firms from engaging in innovative activities. The number of patents filed at the three patent offices has increased since 2009, but remains low by earlier standards.

Changes in the global R&D landscape described above are already reflected in global S&T production. The share of the United States and Japan in total world patents and scientific publications is on the decline, slowly giving way to S&T production by the BRIICS, especially China (Figure 1.16). The BRIICS produced about 12% of top-quality scientific publications globally in 2013, compared to 28% in the United States. The share of the BRICS is almost twice what it was ten years ago. This shift in scientific leadership is also apparent in patents, although it is less striking.

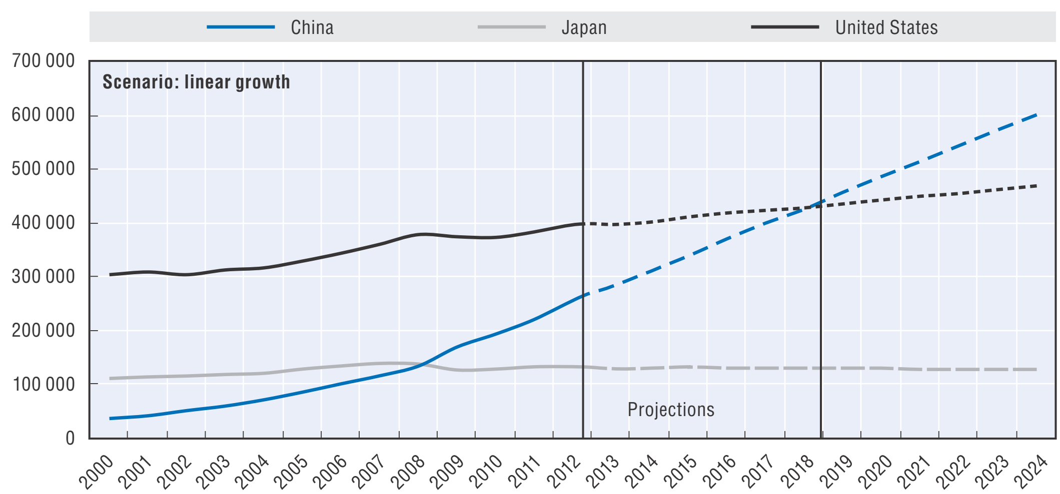
The outlook is for a gradual strengthening of the global research system

Under current economic conditions, a strong resurgence of R&D and innovation over the next two years is unlikely, but prospects could improve by 2015. Macroeconomic prospects and the business climate should improve, owing to a renewed appetite for risk, more favourable financial conditions and growing demand (OECD, 2013a). Public debt is projected to peak in 2015, and the pace of fiscal consolidation should slow gradually after 2015 (OECD, 2013a). The benefits of the rationalisation of STI policy and the deployment of more systematic evaluations should become apparent. Improvements in macroeconomic conditions and lower tax burdens should help restore confidence in public institutions, and should have a positive effect on the involvement of civil society in STI activities.

The current uneven economic recovery is expected to widen the gap between countries that experience flat or slow growth (and may have difficulty maintaining R&D expenditure) with those with strong economic momentum (and thus good conditions for expanding national R&D). The rise of China, driven by its economic dynamism and its long-term commitment to STI, should continue. China's Medium and Long-term National Plan for S&T Development (2006-20) targets R&D spending of 2.5% of GDP by 2020. Assuming linear growth in Chinese and US R&D expenditure, China should outpace US R&D spending by about 2019 (Figure 1.17). However, China's recent economic slowdown may delay this scenario. The situation in the European Union will be more varied, and several countries will struggle to achieve a 3% target by 2020.

Figure 1.17. **China should outpace the United States as the leading R&D performer in the coming years**

GERD, million 2005 USD PPP, 2000-12 and projections to 2024



Note: Trends are projected on the basis of US, Japanese and Chinese GERD data from 2000.
Source: Based on OECD, *MSTI Database*, June 2014, *www.oecd.org/sti/msti*. Data retrieved from IPP.Stat on 8 July 2014, *http://stats.oecd.org//Index.aspx?QueryId=57863*.

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With the development of technologies, new issues arise

Technology is accelerating in certain fields

The acceleration of scientific discovery and technological development is a well-known feature of modern societies. Access to inventions and innovations is faster, cheaper and better, with technology now a part of mass culture. Two types of data make it possible to capture changes in technological developments: one is changes in R&D investments by large companies[11] that anticipate market prospects and align their research strategy, and the other is changes in patenting activities that signal research results and an intention to exploit them commercially. Both approaches show converging results.

Industrial R&D investment by the world's 2 000 largest investors remains concentrated in a few sectors, with pharmaceuticals and biotechnology, technology hardware and equipment, and automobiles and parts accounting for half of total R&D investment (EC, 2013). Investment in software and computer services (+11.7%), automobiles and parts (8.9%), and technology hardware and equipment (8.8%) has increased rapidly. Other sectors with high R&D growth are industrial engineering (9.8%) and the health-care equipment and services sectors (8.3%).

The accelerated development of new successful technologies ("bursts") is apparent in patent filings. Experimentation in the form of R&D or inventive activity over several years is sometimes followed by a sudden and marked increase in innovative activity, which is typical of the development of successful new technologies (OECD, 2013i). Early developments generally occur in patent classes that are later abandoned in favour of new technological solutions in different patent classes (Figure 1.18). Depending on the field, the shift from one technology to another may take place in a continuous fashion (e.g. in data processing and storage), or as simultaneous bursts followed by relatively flat patenting activity, and then by later bursts as different technologies emerge (e.g. in chemistry and biotechnology, phone and wireless communication).

Areas of acceleration are new technologies related to:

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

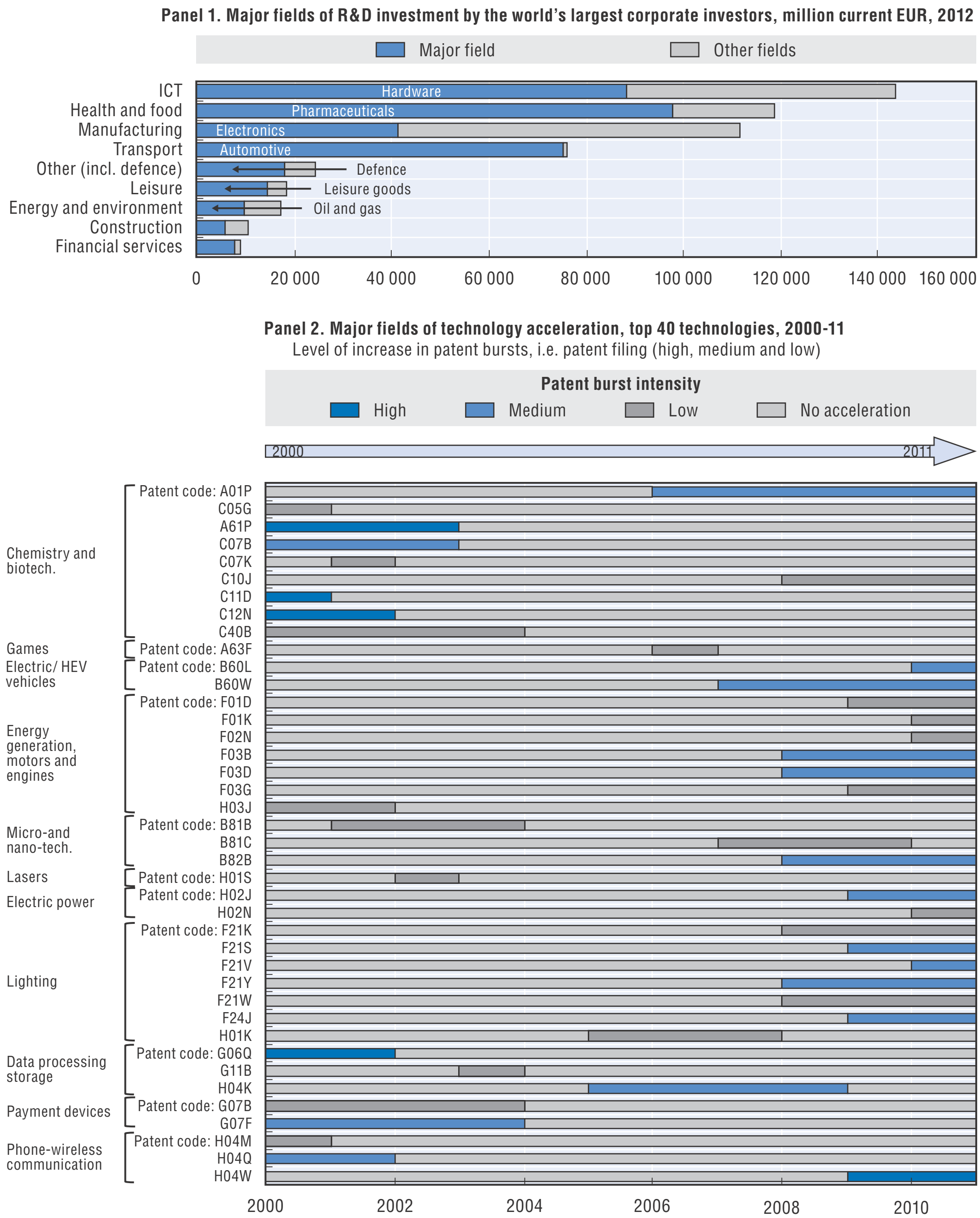
Policy trends

Countries are making new large-scale R&D investments in promising technology fields. Under its new Industrial Strategy, the United Kingdom granted USD 865 million PPP (GBP 600 million) in 2013 to its Eight Great Technologies, which cover the four areas of technology acceleration mentioned above.[12] Turkey has launched two mission-oriented programmes in the priority areas of its National STI Strategy 2011-16, including ICT, automotive, machinery and manufacturing, energy, and health.

Ageing, health and food security. The United States has increased federal investment and interagency co-operation in neuroscience to improve health and learning. The USD 100 million Brain Initiative aims to advance knowledge of brain disorders, such Alzheimer's disease. China has identified the development of agricultural technologies as an emerging STI policy issue and will promote entrepreneurship in this field.

New manufacturing processes. The 2014 US Budget focuses R&D and innovation on next-generation manufacturing technologies, including robotics and advanced materials, with funding of USD 2.9 billion across multiple agencies and sectors. In 2013 France issued a new plan for 34 key industries that focuses on manufacturing and is planning expenditures of USD 4 billion PPP (EUR 3.4 billion) in the coming years. Canada is providing USD 160 million PPP (CAD 200 million) over five years for the creation of an Advanced Manufacturing Fund that will support investments by manufacturing firms in activities such as prototyping and product testing, as well as USD 130 million PPP (CAD 165 million) over five years for a new Aerospace Technology Demonstration Programme.

Figure 1.18. **Technology acceleration**



Notes:

Panel 1 – The world's largest corporate investors in R&D are the world's top 2 000 companies ranked by R&D investments. The sample consists of 527 companies based in the EU and 1 473 companies based elsewhere. The total R&D investment of these companies is estimated at more than 90% of the total expenditure on R&D by businesses worldwide.

Panel 2 – Patent "burst" refers to periods characterised by the sudden and persistent increase in the number of patents filed. Data relate to patent applications filed under the Patent Cooperation Treaty (PCT). Patent counts are based on the application date, the International Patent Classification (IPC) codes (patent codes) and fractional counts. The top patent bursts are identified by comparing the filing patterns of all 4-digit IPC classes. The intensity of a patent burst refers to the relative strength of the observed increase in filing patterns. Only IPC classes featuring a positive burst intensity in the 2000s are included.

Sources: Panel 1 – EC (2013), *The 2013 EU Industrial R&D Investment Scoreboard*, European Commission, Brussels. Report and full dataset accessible on line *http://iri.jrc.ec.europa.eu/scoreboard13.html*; Panel 2 – OECD (2013), *OECD Science, Technology and Industry Scoreboard 2013: Innovation for Growth*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/sti_scoreboard-2013-en*; Based on the EPO, *Worldwide Patent Statistical Database*, April 2013.

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Technology convergence creates challenges

The convergence of key emerging and enabling technologies – nanotechnology, biotechnology, information technology and cognitive sciences – and the combination of different disciplines into new R&D fields have the potential to lead to important changes in industries and societies and to provide new ways to address global and social challenges (e.g. managing megacities, clean water production, food security).

Interdisciplinary research supports convergence in scientific research. New fields of research emerge from S&T disciplines that follow a mix of approaches to research and use a variety of analytical instruments and evaluation methods. Technology platforms connect data, models and actors to integrate knowledge, identify gaps and support co-ordination of global research. The concentration of science actors in convergence hubs, e.g. around technology platforms, can enable the sharing of facilities, equipment and skilled technicians by different technology and research fields. However, platforms are difficult to map and are likely to have few commercial or publishable outputs.

Policy trends

Keeping up with S&T developments requires increasing investments, while technological acceleration tends to reduce the time during which R&D investors can expect to maintain their advantage and reap the benefits of discoveries. Scarce funding should prompt large and smaller players to increase participation in co-operative projects, support "smart specialisation" and encourage technology monitoring and foresight analysis in order to identify technological niches and long-term technology developments. In 2012 Germany adopted an interdisciplinary approach and a demand perspective ("demand pull") that better integrates technology-oriented results and results from the social sciences and humanities.

Enthusiasm for specific areas of convergence provides a stimulus to adopt a new technology policy agenda, develop roadmaps and establish dedicated research centres. But technology convergence covers a wider area, including the actual convergence of scientific communities to produce knowledge, exploitation and commercialisation of research, convergence of manufacturing and product development infrastructures, and embedding these technologies into society.

As the Internet expands, the importance of cybersecurity increases

The pace of technological change on the Internet, and in the ICT sector in general, is extremely rapid. High-speed networks, devices (e.g. tablets, mobile phones) and Internet-based services (e.g. apps) have emerged as some of the most promising Internet developments in recent years (OECD, 2012g). Cloud computing has also shown great potential as a platform for innovative new services. In particular, it has significantly reduced IT barriers for SMEs, allowing them to expand faster and innovate (OECD, 2012a). Not only are ICTs essential to innovation processes, but the Internet is affecting nearly all sectors of the economy and reshaping the way people live (OECD, 2012g). The future of the Internet economy also depends on whether individuals, businesses and governments trust the Internet for applications and service delivery.

As dependency on the Internet increases, security, privacy and consumer protection become more essential than ever (OECD, 2014h). Over only a few years, information flows across jurisdictional borders have increased, without imposing significant additional cost.

The open and interconnected nature of the digital environment have made it more vulnerable to cybercriminals, ranging from organised criminal and terrorist groups to "hacktivists", whose actions undermine the economic and social interests of an organisation (e.g. loss of competitive advantage, damage to reputation and image, or financial loss due to breaches of confidentiality, breaches of integrity and unavailability of knowledge-based capital).

From an economic and social perspective, security has two conflicting aspects. On the one hand, it can reduce uncertainty and increase trust so as to make innovation and other economic and social activities possible. On the other hand, it can impose inhibiting constraints (e.g. financial cost, system complexity, loss of performance, usability and user convenience, lengthier time to market, and loss of privacy). The traditional cyber-security approach is to create a secure digital environment inside a strong security perimeter that prevents intrusion, but also limits information flows. However, innovation requires an open digital environment and the free flow of information.

Policy trends

With the multiplication of high-profile media reports on cybercrime and cyber-espionage, decision makers in public and private organisations increasingly recognise the need to protect their digital assets.

An effective security framework should adapt the level of security measures to the level of the potential economic and social damage to each asset. Since the adoption of its Security Guidelines in 2002, the OECD has been calling for a new "culture of security" to support innovation, productivity and growth in a globally open and interconnected digital environment, by promoting a risk-based management approach to digital security (OECD, 2002a).

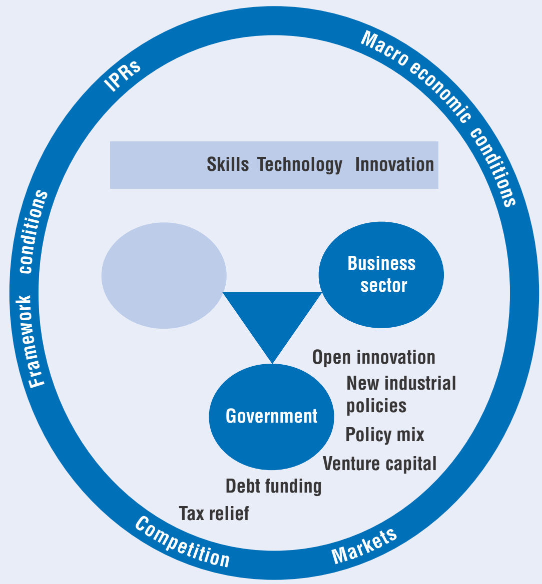
A new generation of national cyber-security strategies in ten OECD countries reveals that cyber-security policy making is at a turning point (OECD, 2012h). In many countries, it has become a national policy priority with strong leadership. Cyber-security policy making has economic, social, educational, legal, law-enforcement, technical, as well as sovereignty considerations, such as the use of offensive cyber-capabilities in armed conflicts, and norms of state behaviour in cyberspace, for example in intelligence-related activities. Several national cyber-security strategies consider cyber-security R&D (OECD, 2012h) a high priority and are adopting initiatives to stimulate cyber-security innovation in SMEs (UK Cabinet Office, 2011). The US federal government continues to invest in a robust research cyber-infrastructure. Norway adopted a Cyber Security Strategy in 2012, which includes a new societal security research programme and measures to increase the use of ICT research results for information security efforts.

Challenges for cyber-security policy making include the co-ordination of government agencies with different roles and the development of appropriate incentives to foster cyber-security risk management across a variety of public and private actors, including self-regulation, regulation and legislation. Policies are also needed to address the cyber-security skills shortage and to stimulate international co-operation and the development of the cyber-security industry. The cyber-security marketplace may evolve with the entry of military and aerospace industry players, which have an innovation culture different from that of the traditional ICT sector.

BUSINESS INNOVATION WILL BE THE DRIVER OF A SUSTAINABLE ECONOMIC RECOVERY

This section focuses on one of the main parts of national innovation systems: the business sector.

It describes recent trends and a possible future for business R&D expenditure in light of macroeconomic conditions. It examines the changing modes of innovation and of innovation funding, as well as recent developments in innovative entrepreneurship. It considers the growing openness of business innovation, especially through greater collaboration along production chains, and the agglomeration of firms in globally connected nodes. It outlines growing public funding of business innovation through shifting policy mixes, more generous R&D tax incentives, new debt funding and risk-sharing mechanisms, and greater public support to venture capital markets. It addresses issues regarding the role of governments in the financing of business innovation, e.g. in fostering non-bank intermediation or enabling crowdfunding. It also addresses the revival of industrial policy and the strengthening of framework conditions for innovation, e.g. the enforcement of IPRs.



Business R&D has been preserved compared to other investments and has partially recovered

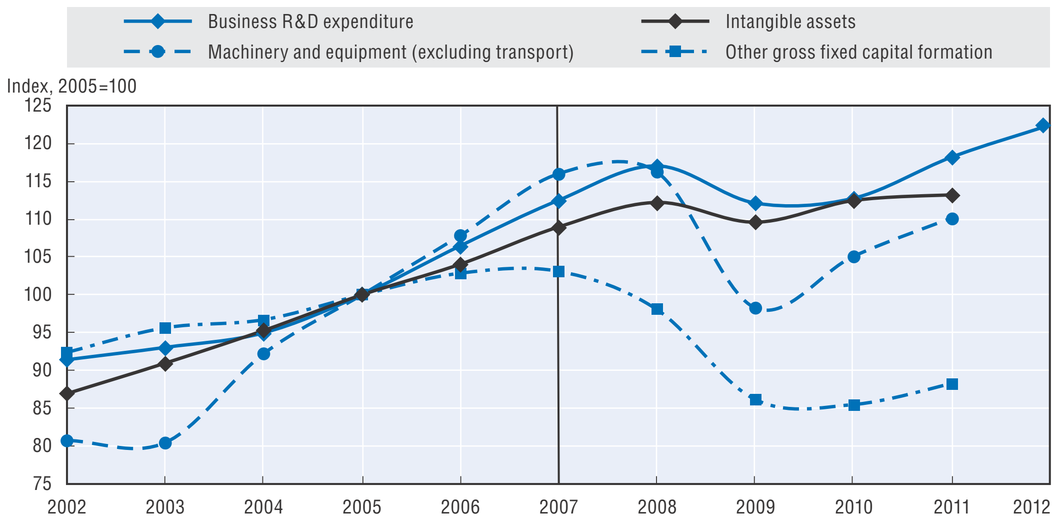
Firms are at the heart of the global R&D system. Business enterprises account for the bulk of R&D performed in OECD countries (68% of OECD area R&D in 2012) (OECD, 2014g). In 2012, OECD firms spent nearly USD 752 billion on R&D. The United States accounted for 42%, Japan for 15% and the EU28 for 28% of the OECD total. In the same year, Chinese firms invested over USD 224 billion in R&D, over a fifth of the OECD total.

The global economic crisis had a strong negative impact on innovation worldwide and total OECD BERD declined by a record 4.2% in 2009 (Figure 1.19). However, business knowledge-intensive investments, such as R&D investments and investments in intangible assets (e.g. software), were more resilient than other types of investments (Figure 1.19). Investment in machinery and equipment dropped sharply during the crisis; OECD R&D spending recovered to pre-2007 levels in 2012.

In addition, data on the 2 000 companies[13] that invest the most in R&D worldwide[14] show resilient R&D investments over the three years since 2009. This reflects the strategic importance companies attach to R&D even in times of economic uncertainty. The world's top R&D investors increased their investment efforts in R&D by 6.2% in 2012. They did so in a global context marked by a general slowdown of net sales growth (4.2% in 2012 compared with 9.9% in 2011) and a decline in operating profits (-10.1%) (EC, 2013).

Figure 1.19. **Business investment in knowledge assets weathered the crisis better and recovered earlier**

OECD, index 2005 = 100



Note: In national accounts, spending on R&D activities is treated as expenditures and not as investment, and is therefore not capitalised. R&D capitalisation should be effective from 2014. For further information, please refer to OECD (2010d), *Handbook on Deriving Capital Measures of Intellectual Property Products*, OECD Publishing, Paris *www.oecd.org/std/na/44312350.pdf*.

Intangible fixed assets are non-financial fixed assets that mainly consist of mineral exploration, computer software, entertainment, literary or artistic originals intended for use for more than one year. Other gross fixed capital formation includes dwelling and transport investments.

Source: OECD, *MSTI Database*, June 2014, *www.oecd.org/sti/msti*; OECD, *National Accounts Database*, April 2014. Data retrieved from IPP.Stat on 8 July 2014, *http://stats.oecd.org//Index.aspx?QueryId=57863*.

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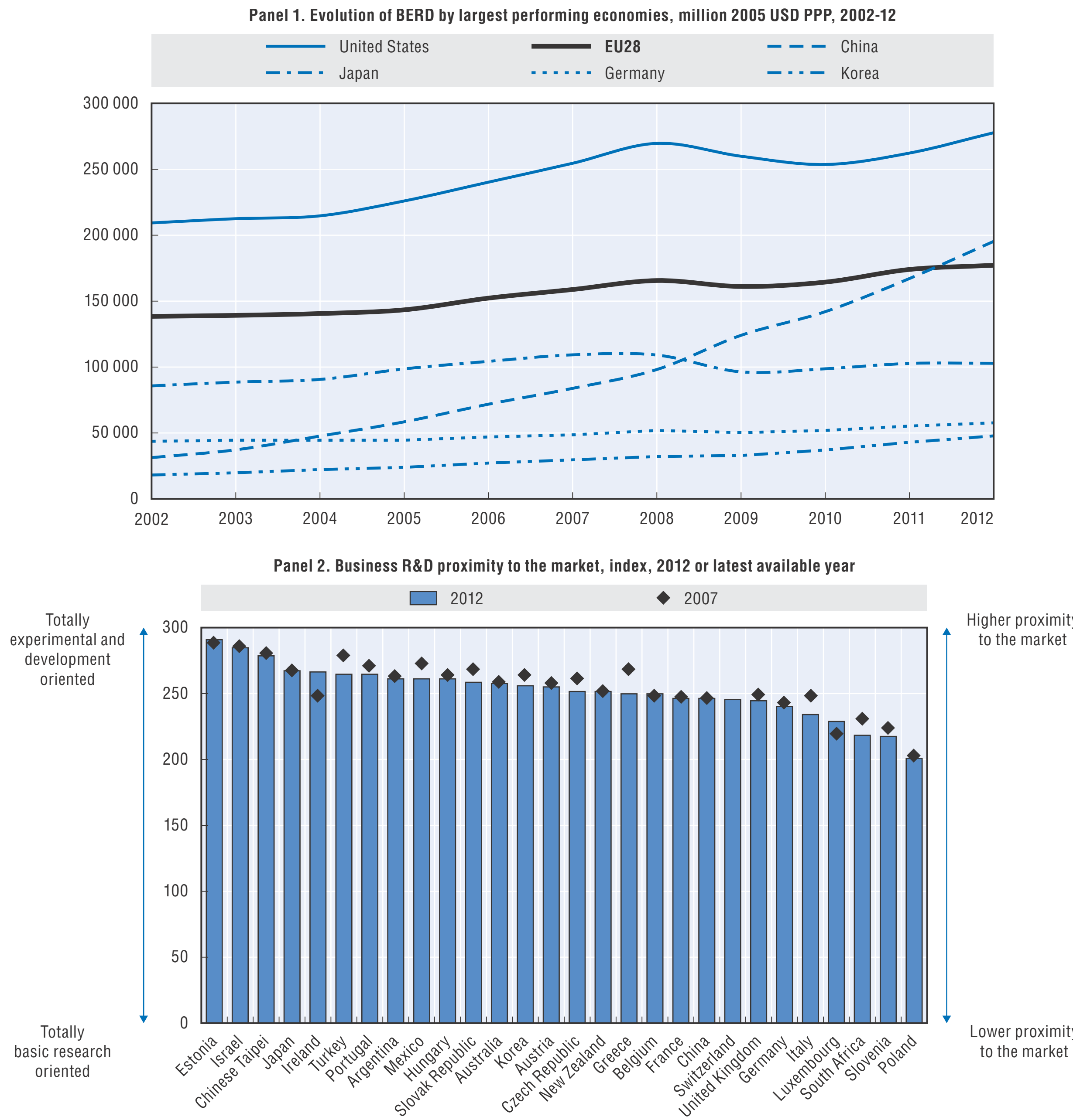
Recent growth in OECD BERD has been driven by US firms, whose R&D investments are back to pre-crisis levels (Figure 1.20). In the EU, the situation has improved gradually, although a new decrease in private research spending in 2012 suggests that the recovery may not be robust. Japanese firms have difficulty rebuilding their R&D capacities and Japan's BERD remains at 2007 levels (USD 116 billion). Outside the OECD, Chinese companies have deployed their research facilities more rapidly since 2008; as a consequence China overtook Japan as the second largest country for industrial research in 2009.

Business expenditure on R&D tends to be more closely linked to the creation of new products and techniques than R&D performed in the government and higher education sectors (OECD, 2010b). Experimental development is the segment of business R&D that is most likely to turn into rapid innovation, as it is "directed to producing new materials, products or devices, to installing new processes, systems and services, or to improving substantially those already produced or installed" (OECD, 2002b). In most countries for which comparable data are available, little business R&D is spent on basic research; applied research and experimental development comprise the lion's share of BERD. When considering an aggregate index of BERD shares by type of research (basic, applied and experimental), firms in Switzerland, China and Chinese Taipei appear more likely to be engaged in R&D and have a closer connection with end-use products and markets (Figure 1.21).

Figure 1.20. **Business research capacity has been relatively preserved**



Notes:

Panel 2 – The index "business R&D proximity to the market" roughly illustrates in a single figure the breakdown of business R&D expenditure by type of research. Three types of research are distinguished: basic research, applied research and experimental development (OECD, 2002b). The share of total BERD devoted to basic research is weighted 1, that of applied research is weighted 2 and that of experimental research is weighted 3. The closer countries are to 300, the more domestic firms spend in relative terms on experimental development.

Data for the Czech Republic refer to 2011. Data for Austria, Mexico, South Africa and Chinese Taipei refer to 2009. Data for Australia, Iceland, Switzerland and the United Kingdom refer to 2008. Data for Norway and Poland refer to 2005.

Source: Panel A – OECD, *MSTI Database*, June 2014, *www.oecd.org/sti/msti*. Data retrieved from IPP.Stat on 8 July 2014, *http://stats.oecd.org//Index.aspx?QueryId=57863*; Panel B – Based on OECD, *RDS Database*, March 2014, *www.oecd.org/sti/rds*. Data retrieved from IPP.Stat on 8 July 2014, *http://stats.oecd.org//Index.aspx?QueryId=57863*.

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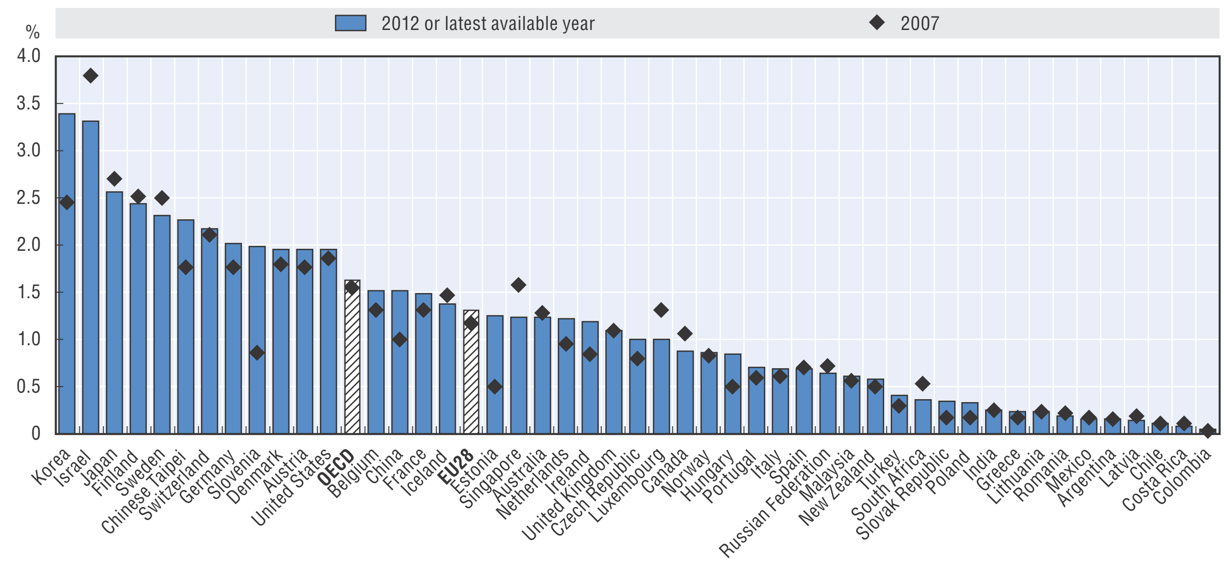
Figure 1.21. **Business R&D expenditure has intensified in most countries**

BERD, as a percentage of GDP, 2012 and 2007



Notes: Data for Australia, Colombia, Costa Rica, Iceland, Mexico, New Zealand and South Africa refer to 2011; data for India refer to 2007. Data for Switzerland refer to 2008 and 2012. Data for Malaysia refer to 2008 and 2011.The EU28 is an OECD estimate.

Source: OECD, *MSTI Database*, June 2014, *www.oecd.org/sti/msti*. Data retrieved from IPP.Stat on 8 July 2014, *http://stats.oecd.org//Index.aspx?QueryId=57863*.

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During difficult economic times, firms become more risk-adverse and may respond to weaker market prospects by concentrating innovative efforts on activities offering short-term benefits. BERD data by type of research are inconclusive in this respect and do not point to a substantial shift in the orientation of business R&D during the downturn. For the countries with more substantial changes, firms seem to have refocused their efforts on earlier stages in the research process, i.e. applied research.

Israel has experienced a notable fall in business spending on R&D since 2007 but is the world's second most BERD-intensive country, with BERD at 3.32% of GDP in 2012 (Figure 1.21). Korea (3.40%) has made significant progress since 2007 and overtook Israel, Japan, Finland and Sweden in terms of BERD intensity to reach first place. OECD performance has been essentially flat during the period; OECD BERD stood at 1.63% in 2012. The EU28 BERD intensity (1.24%) weighs on overall OECD performance. The figure for Japan is a high 2.57% and that of the United States (1.95%) is above average.

Outside the OECD, China and Chinese Taipei have increased their BERD intensity since 2009. China (1.51%) is now on par with Belgium (1.52%) and France (1.48%), while Chinese Taipei (2.27%) is on par with leading OECD industrial R&D performers.

Of course, countries' industrial structure strongly influences the amount of their R&D, as some industries are inherently more R&D-intensive than others (OECD, 2010b). 2011 estimates of BERD adjusted for industrial structure show that Germany and Korea would be below the OECD average and Belgium, France and the Netherlands would be above average if they had the same industrial structure (OECD, 2013i).

The pattern of R&D intensity across countries follows some predictable trends (OECD, 2010b). The more developed economies tend to be more R&D-intensive, as they are closer to the technological frontier and their industries are under pressure to innovate to survive. Catching-up economies can reap substantial gains from adopting and adapting technologies and may therefore feel less pressure to emphasise R&D. As such, there is a generally higher concentration of emerging economies at the lower end of the R&D intensity spectrum. The upward progression of some emerging economies in this ranking reveals the fast development of industrial R&D capacities in these regions and points to growing global competition around R&D assets.

Policy trends

Most business-performed R&D is financed by industry, with 86% of OECD-area BERD funded by industry in 2011 (OECD, 2014g). However, public funding of business R&D has increased significantly over the past decade, driven by increasingly generous R&D tax arrangements as legal restrictions (e.g. WTO, EU) capped the volume of direct state aid.

The focus is either on direct (e.g. grants, subsidies, loans, procurement, etc.) or indirect (e.g. tax incentives, etc.) funding. In many cases, firms, especially the largest ones, are able to combine direct and indirect support. Direct and indirect funding combined accounts for 10-20% of business R&D expenditure in most countries (Figure 1.22). France, Canada and Hungary have the most attractive combined arrangement, with over a quarter of business expenditure potentially subsidised or refunded. Denmark, Japan and Italy are less generous (less than 10%). The total volume of R&D support provided to firms has increased in most countries since 2006, with the most notable increases in Belgium, France and Canada (Figure 1.22).

Although not all countries provide tax relief on R&D expenditure, 27 OECD countries have offered tax incentives to support business R&D since 2011, more than twice the number in 1995 (OECD, 2013t). By 2011 over a third of total public support to business R&D took the form of tax incentives, and more than half when the United States' direct procurement of defence R&D is excluded. Indirect tax support is considered the major funding instrument for business R&D in Australia, Belgium (federal government), France, South Africa and the United States. The Netherlands has made tax relief the main instrument for industrial policy, which focuses on the "top sectors".

R&D tax incentives have been simplified (e.g. by abandoning incremental design) and made more generous (e.g. by increasing the tax relief rate) and more accessible to a larger number (e.g. by raising or removing the ceiling on eligible expenditures or tax concession). R&D tax incentives that were originally non-discretionary have also been gradually redesigned to address particular market or systemic failures, or target specific populations (e.g. SMEs) or specific types of R&D (e.g. subcontracted R&D) (see the policy profile on "Tax incentives for R&D and innovation").

R&D tax incentives have become a way to increase the attractiveness of the national research ecosystem and to engage in tax competition to attract foreign R&D centres. In 2013 the United Kingdom introduced an expenditure credit scheme to make R&D tax relief more attractive to large firms and to leverage domestic R&D activity.

Direct funding through grants, debt financing and public procurement, however, remains the main channel of public support to business R&D in many countries (see the policy profile on "Government financing of business R&D and innovation"). Competitive grants are important in a majority of countries and not only in those that have no fiscal incentives for R&D (e.g. Finland, Germany and Sweden). China, where equity funding is the main instrument, is an exception.

Recent developments in direct funding of business R&D and innovation apply more market-friendly approaches, encourage competition-based selection and streamline public support schemes.

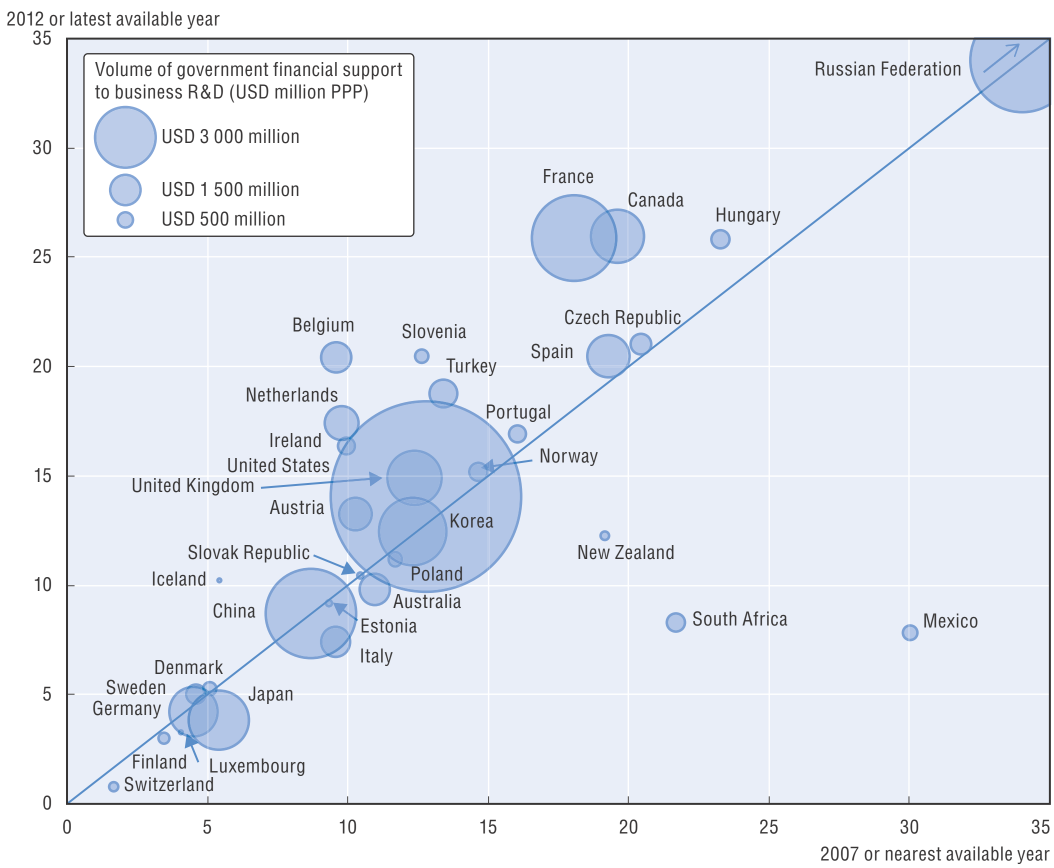
Countries also increasingly emphasise debt and equity financing in the policy mix for business innovation (see the policy profile on "Government financing of business R&D and innovation"). The United Kingdom is currently setting up a new national development bank, the British Business Bank, to increase the supply and diversity of finance available to UK SMEs. In 2012 France created the Public Investment Bank (BPI) to support business innovation and technology transfer and provide seed capital and loan guarantees. In 2013 Denmark introduced new subordinated loans for SMEs and Danish entrepreneurs.

In 2013 Canada announced its Venture Capital Action Plan. This is a comprehensive strategy for deploying USD 320 million PPP (CAD 400 million) in new capital over the next seven to ten years in order to attract close to USD 800 million PPP (CAD 1 billion) in private investments in funds of funds. In 2013 Germany implemented the Investment Grant for Business Angels to generate additional funds for innovative start-ups from private venture capital investors. Turkey launched a venture capital fund of funds, the TÜB TAK 1514 Programme, to stimulate the entrepreneurship ecosystem. The United Kingdom launched the Venture Capital Catalyst Fund to invest in commercially viable venture capital funds that might otherwise suffer because of a reduction in institutional investment.

As R&D tax incentives have increasingly replaced direct subsidies, their relative cost-efficiency must be addressed. In spite of the large amounts of public money provided, few evaluations have assessed the additionality of R&D tax incentives (Köhler et al., 2012), and no internationally comparable data exist on the management costs incurred by tax authorities and claimants. More broadly, the increase in tax concessions (of all kinds) raises the issue of the erosion of the tax base and the sustainability of national budgets at a time when many governments must consolidate their public finances. It is noteworthy that, in recent years, some countries that traditionally offered among the most generous tax concessions for R&D have tightened their tax policy (Australia, France to a lesser extent) and have reinforced compliance and control mechanisms (Canada). The Australian government, while enhancing the benefits available, has tightened eligibility requirements and has proposed to change legislation to reduce concession rates and exclude very large companies from claiming tax offsets under the R&D tax incentive. The Canada Revenue Agency is receiving more resources to strengthen reviews of its R&D tax programme. In France, the R&D tax credit (*Crédit d'impôt recherche*) has been marginally revised by reducing the eligible expenditure base and by repealing enhanced deductibility for new claimant firms.

Figure 1.22. **Total public support for business R&D has increased markedly since 2006**

Sum of government-funded BERD and tax incentives for business R&D, as a percentage of total BERD, 2007 and 2012 or nearest available years



Note: The estimates of R&D tax incentives do not cover sub-national R&D tax incentives.
Estonia, Germany, Luxembourg, Sweden and Switzerland do not provide R&D tax incentives. Mexico and New Zealand repealed their R&D tax incentives in 2009 and 2009-10, respectively. Finland is setting up the conditions for introducing a R&D tax incentive scheme for companies.
In Austria, Poland and South Africa, R&D tax incentive support is already included in official estimates of direct government funding of business R&D (OECD, *Science, Technology and Industry Scoreboard 2013: Innovation for Growth*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/sti_scoreboard-2013-en*). Iceland, Israel and Greece provide R&D tax concessions but the cost estimate of R&D tax relief is not available and therefore not included in the total.
For Chile, China and the Russian Federation, R&D tax estimates are available only for 2010, 2009 and 2011, respectively. The same year is therefore represented on the above figure for 2007 and 2012. Data for Estonia, Finland, Germany, Poland, Slovenia, Switzerland, the United Kingdom and the United States refer to 2012; data for Australia, Belgium, Chile, Ireland, Spain and South Africa refer to 2010; data for China and Luxembourg refer to 2009. Otherwise data refer to 2011.
For more technical information on the coverage of R&D tax data, see the OECD Directorate for STI webpage on measuring R&D tax incentives at *www.oecd.org/sti/rd-tax-stats.htm*.
Source: OECD, *MSTI Database*, June 2014, *www.oecd.org/sti/msti;* OECD data collection on R&D tax incentives, 2013; and country responses to the OECD STI Outlook policy questionnaire 2014. Data retrieved from IPP.Stat on 8 July 2014, *http://stats.oecd.org//Index.aspx?QueryId=57863*.

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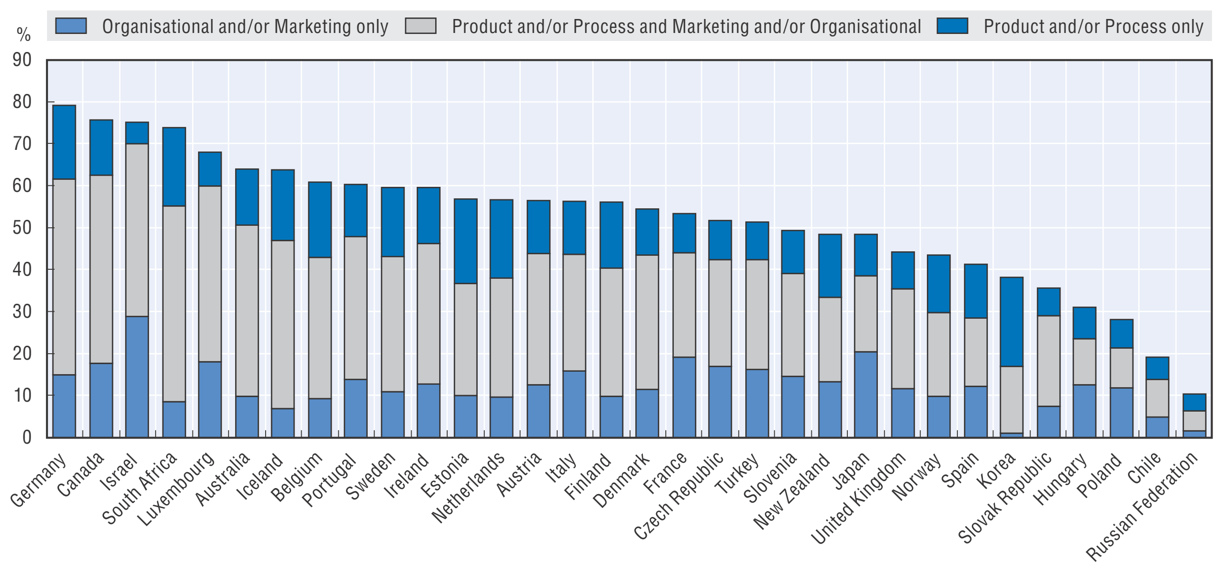
The frontiers between industry and services, technology and innovation are blurring

Innovation is more than science and technology. While R&D remains vitally important, many highly innovative firms do not engage in R&D at all (OECD, 2010a). Technological innovation also does not systemically require R&D. Innovation survey data show that most innovative firms have mixed innovation strategies that combine several modes of innovation (Figure 1.23). In addition, non-technological innovations, i.e. marketing[15] and organisational changes in business practices, workplace organisation or external relations, combined with technological innovations, account for a substantial share of firms' innovative activities. Non-technological innovation is of particular importance in services (OECD, 2013i).

Figure 1.23. **Most innovative firms combine several modes of innovation**

Innovative firms by mode of innovation, as a percentage of all firms (%), 2008-10



Note: Product- and/or process-innovating firms always include on-going and/or abandoned innovation activities. For more detailed information on data coverage by country, see the OECD Directorate for STI webpage on Innovation Statistics, *www.oecd.org/sti/inno/inno-stats.htm*.

Source: OECD, Innovation statistics 2014, based on Eurostat (CIS-2010) and national data sources, June 2013. Data retrieved from IPP.Stat on 8 July 2014, *http://stats.oecd.org//Index.aspx?QueryId=57863*.

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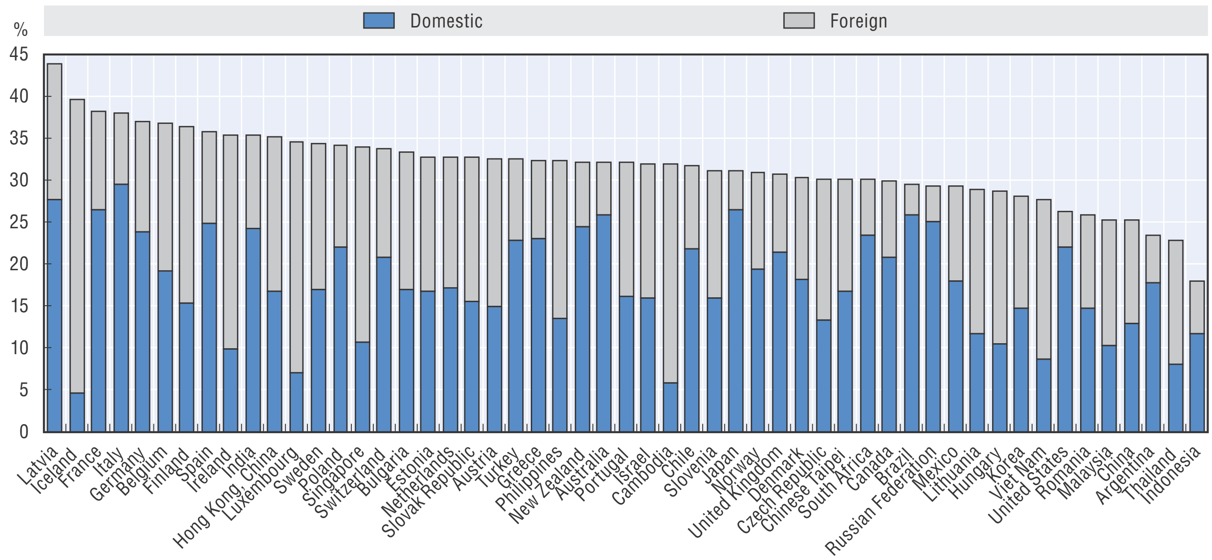
The growing importance of the services sector in OECD economies and its role in job creation and innovation activities have been widely documented. Services have been increasingly acknowledged as more knowledge-based, innovative and growth-enhancing than previously thought (OECD, 2005). At the same time, this structural shift has led, in some OECD economies, to a reallocation of resources towards a sector with lower average productivity.

Today, services are increasingly considered fundamental inputs and outputs of innovation processes in non-service sectors. Statistics on trade in value added show that in most OECD and non-OECD countries, over a third of manufacturing exports include value added from service industries, domestic or not (Figure 1.24). This indicates the importance of services for export competitiveness in manufacturing. Knowledge-intensive services,

Figure 1.24. **Services innovation has become a driver of competitiveness in GVCs**

Services value-added content of gross manufacturing exports, percentages, 2009



Source: OECD (2013), *Interconnected Economies: Benefiting from Global Value Chains*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/9789264189560-en.*

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including R&D services, are now part of wider business strategies and participate in the fragmentation of production along GVCs. In addition, the boundaries between sectors have blurred as manufacturing firms increasingly exploit new market opportunities by bundling experience, products and finance and expanding related services. Service innovation has become a driver of competitiveness along the entire value chain.

Policy trends

Existing innovation policy frameworks have been designed mainly from a technological or manufacturing perspective and tend to neglect the non-technological contribution of services and its potential. In addition, there is little information on service-specific market and system failures and the rationale for service-specific policies. The understanding of the role of services and the policies needed to foster their development is also limited. As a consequence, few countries have specifically paid attention to services in national innovation policies design.

Policies that can enhance innovation in the services sector (OECD, 2005) include skills development (given the reliance of services on highly skilled workers), entrepreneurship programmes (newly established firms tend to play a greater role in services than in manufacturing), IPR protection (software and business-method patents) and development of ICTs (a key enabler of service innovation). Standards can also promote innovation in services because they improve interoperability and compatibility, lower transaction costs, increase market transparency and consumer confidence, and enable deregulation.

The policy focus has evolved from a sectoral perspective towards embedding service innovation in the overall innovation policy mix (OECD, 2012a). An integrated view of manufacturing and services is needed and should take into account their complementary character (OECD, 2013h). Services are less likely to relocate abroad and it may be easier to turn innovation and knowledge into jobs in services than in manufacturing.

Innovative entrepreneurship is important

Creation of new firms and innovation in existing SMEs develop new products and services in all sectors and play an important role in innovation performance (OECD, 2013u). Non-technological innovation, which requires less knowledge capital and investments, changing technologies, more "niche market" demand, and the rise of GVCs have all reduced the structural disadvantages of SMEs.

New innovative firms and SMEs differ. New innovative firms are knowledge-intensive and high-risk, have high ambitions and can have a disproportionate effect on innovation and job creation. SMEs may have a more modest economic impact individually, but collectively[16] they make a substantial difference. Evidence for various countries suggests that 4-6% of high-growth firms may create half to three-quarters of all new jobs (OECD, 2013v).

There are significant constraints on SMEs' innovation performance and on the process of starting and growing businesses. SMEs encounter problems for accessing finance and finding qualified personnel (OECD, 2013u). In addition, young firms are more sensitive to entrepreneurship framework conditions than older firms (OECD, 2014i). Growing a business calls for instance for high-level management skills to cope with disruptive processes in organisation (OECD, 2013v).

Financial obstacles are particularly critical at the seed and early stages of development, as banks are reluctant to lend to small and young firms with little or no collateral. For their part, venture capitalists focus more on later stages where risks are lower (OECD, 2011e). Angel investors are therefore an increasingly important source of equity capital at the seed stage and play a key role in providing strategic and operational expertise and social capital (i.e. personal networks). Angel investment is growing and is becoming more formalised, with the creation of angel groups and networks (OECD, 2011e).

During 2007-10 credit conditions were stricter for SMEs than for large enterprises: higher interest rates, shortened maturities and more collateral (OECD, 2013u). After a slight improvement in 2010, credit conditions tightened again in most countries in 2011. Survey data on SMEs' access to finance also show a deterioration in SMEs' perception of banks' propensity to lend (ECB, 2014). Increased payment delays and bankruptcies over the period reflect SMEs' difficulties for maintaining their cash flows (OECD, 2013u). Equity financing was also severely affected, as the uncertain economic climate dragged down equity investment. In 2011 the level of equity investments was still well below pre-2007 levels in many countries (OECD, 2013u). In addition, although angel investors tend to be less sensitive to market cycles than venture capitalists, the financial crisis widened the investment gap at the seed and early stage (OECD, 2011e).

A significant degree of uncertainty continued to characterise the financial environment at the time of drafting. Concerns about the sustainability of public debt, structural weaknesses in the euro area banking sector, the sovereign debt issue in some countries, and Basel III reforms[17] could lead to further deleveraging by banks. This could further constrain lending activities and increase the risk of a credit crunch for small businesses (OECD, 2013u).

In view of these resource constraints, new sources of finance, such as peer-to-peer (P2P) lending, crowdfunding and IP-backed equity funds, are promising but remain marginal.[18] P2P lending, whereby individuals lend to each other via websites, has been growing in the United States, China, Germany and the United Kingdom. Many of these lending websites offer higher returns to investors, as the loans are sold in slices, and are now lending more to SMEs (Wehinger, 2012). Anecdotal evidence indicates explosive growth in the number of crowdfunding platforms and the amount of funds committed for a relatively short time over the past five years (Ham, 2013). This alternative funding mechanism has far-reaching potential, for instance to accelerate technology transfer from universities. There are initiatives related to the regulation and institutionalisation of crowdfunding around the world (Ham, 2013). However, crowdfunding raises issues of security in cyberspace and in monetary transactions, it raises the question of the true motivation of platform managers, and it suffers from a lack of mentoring and coaching of non-professional investors who may be unfamiliar with sophisticated risk-and-return analysis and decision-making tools.

Policy trends

Untapped private wealth is an abundant and growing source of funding for innovation. Tax policies could offer wealthy individuals or private wealth funds incentives to invest in innovative start-ups. Sovereign wealth funds in the Middle East are also investing in innovative ventures.

Much policy attention has focused in recent years on improving access to finance for entrepreneurs; skills barriers in SMEs have received less attention (OECD, 2013u). The most popular interventions have been credit loan guarantee programmes to promote new lending by banks to SMEs and venture capital programmes. Governments are also considering measures to promote the wider use of hybrid instruments that combine features of debt and equity, such as mezzanine finance,[19] to supply "growth capital" to SMEs and entrepreneurs (OECD, 2014j).

Governments are playing a more active role in fostering a transition towards greater non-bank intermediation (e.g. insurance companies, hedge funds). Insurance companies and pension funds, while major players, would not be able to fill the lending gap created by bank deleveraging; other non-bank entities are needed. The US *JOBS Act* recently legalised crowdfunding for start-ups, which can now raise up to USD 1 million a year through small investments on line and social media (Wehinger, 2012).

Policy makers need to identify firms with high growth potential and the main agents of business dynamism. Recent evidence has shown the key role played by students in university spin-offs, while much policy emphasis had previously been placed on researcher-entrepreneurs.

Collaboration on innovation and agglomeration are increasing

Increased openness is not specific to science. In today's complex and highly competitive global market, companies have to adopt new approaches to innovation and engage in new modes of collaboration. While firms traditionally seek to retain their core capabilities, open innovation may offer a faster and less risky route to diversification than internal development. The balance between internal and external sources of innovation is shifting, and innovative activities are increasingly organised across firm boundaries (OECD, 2008e). Moreover, corporate venturing has become a major channel for commercialising innovations that are not used internally (divesting, spinning out, spinning off).

For innovative SMEs, collaboration has become an important means of overcoming some of their size-related barriers, such as limited funding, lack of skills and inadequate time horizons for investing in a long-term strategy. New firms and SMEs collaborate with suppliers and customers but also with universities and research organisations (OECD, 2010e).

Policy trends

The policy debate on the legitimacy of industrial policy has recently resurfaced. Policy interest in a new generation of industrial policies arises from various trends mentioned throughout this chapter. These include the loss of productivity associated with the decline of manufacturing and the structural shift towards services in OECD countries; the growing fragmentation of production across GVCs and a recent erosion of OECD countries' positions in higher-value GVC segments; the potential erosion of downstream and upstream activities in the value chain, including activities related to innovation and design following the loss of core manufacturing activities; and the increased focus by large emerging economies on STI, often with substantial public endowment. The crisis has accelerated these trends, as it highlighted the need for countries to find new sources of growth (Warwick, 2013).

Governments are reconsidering the need to encourage the emergence or expansion of new industries that would become nodes in global innovation networks. As competition for talent and resources has increased and finance remains limited, governments have refocused policy action on areas with high potential for spillovers. The Australian government will support the transition to a new era of manufacturing and will assist in the shift from heavy industry manufacturing to higher value-added production. Canada sets high priority on strengthening the competitiveness of its manufacturing sector and has provided additional targeted support for aerospace, automotive, shipbuilding and forestry industries. USD 1.1 billion PPP (CAD 1.4 billion) in tax relief will be provided to manufacturing and processing sectors over 2014-15. In addition, USD 404 million PPP (CAD 500 million) over two years was provided to the Automotive Innovation Fund in the 2014 Budget. Denmark is preparing eight growth plans in areas of international competitiveness (e.g. creative industries, health and care, energy-water-environment, food, ICT and tourism) to raise its competitiveness in these areas. France adopted a new industrial policy based on 34 industrial plans that include energy, environment, and digital technologies. Germany's new High-Tech Strategy will be designed during the new legislative term to develop emerging technologies and solutions to address societal needs (e.g. clean energy, health care, sustainable mobility), in order to foster competitiveness and to promote Germany as an industrial location. The United Kingdom has adopted a whole-of-government approach to building strategic partnerships with industry to support key technologies and to implement its new Industrial Strategy. The most significant initiatives are in aerospace, automotive and agri-industry. The United States is establishing the foundations for its "industries of the future".

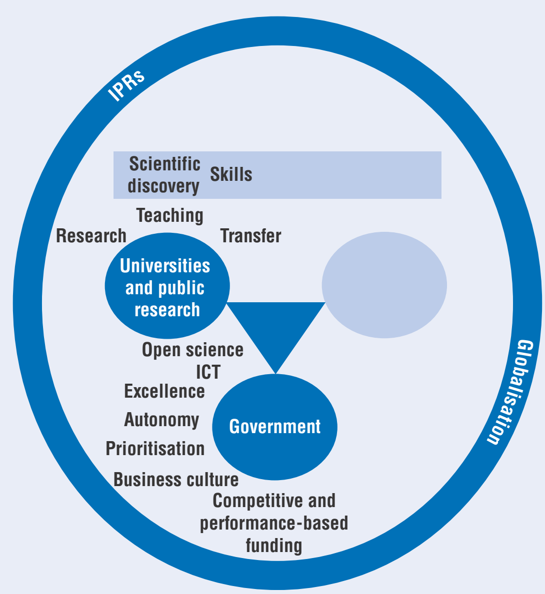
Infringement of intellectual property is seen as an important risk[20] to global innovation networks. Although it often offers strong IP protection, open innovation may also increase the risk of IP leakage and involuntary spillovers. This can reduce firms' ability to benefit fully from their innovative activities. Several governments have recently implemented reforms to improve national IP systems. Australia, Chile and Germany have made changes in their IP and patent legislation. In 2013 Canada launched Modernizing the IP Community to review how the Canadian Intellectual Property Office and other relevant IP agents collaborate to support the needs of Canadian businesses. The first Norwegian White Paper on intellectual property rights was also introduced in 2013. The United Kingdom reformed the Patents County Court of England and Wales to ensure access to justice at a fair cost for all rights holders and other businesses, and renamed it the Intellectual Property Enterprise Court to clarify its jurisdiction. Furthermore, the Intellectual Property Office of the United Kingdom launched an operationally independent Police Intellectual Property Crime Unit in 2013.

Belgium, China, the Netherlands and the United Kingdom have implemented tax relief on IP revenues to encourage the domestic commercialisation and exploitation of new technologies and better appropriate the full benefits of exploiting IPRs, including job creation and knowledge spillovers. As large multinationals develop global tax optimisation strategies and the production of knowledge is increasingly decoupled from its use, 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 its patent box, in addition to the USD 1.2 billion PPP foregone through its R&D relief for corporation tax. The patent box issue has also been introduced in policy discussions in Sweden (see the policy profile on "Tax incentives for R&D and innovation").

PUBLIC R&D IS TARGETING EXCELLENCE AND OPENNESS

This section focuses on universities and public research institutions, the other main actors in national innovation systems.

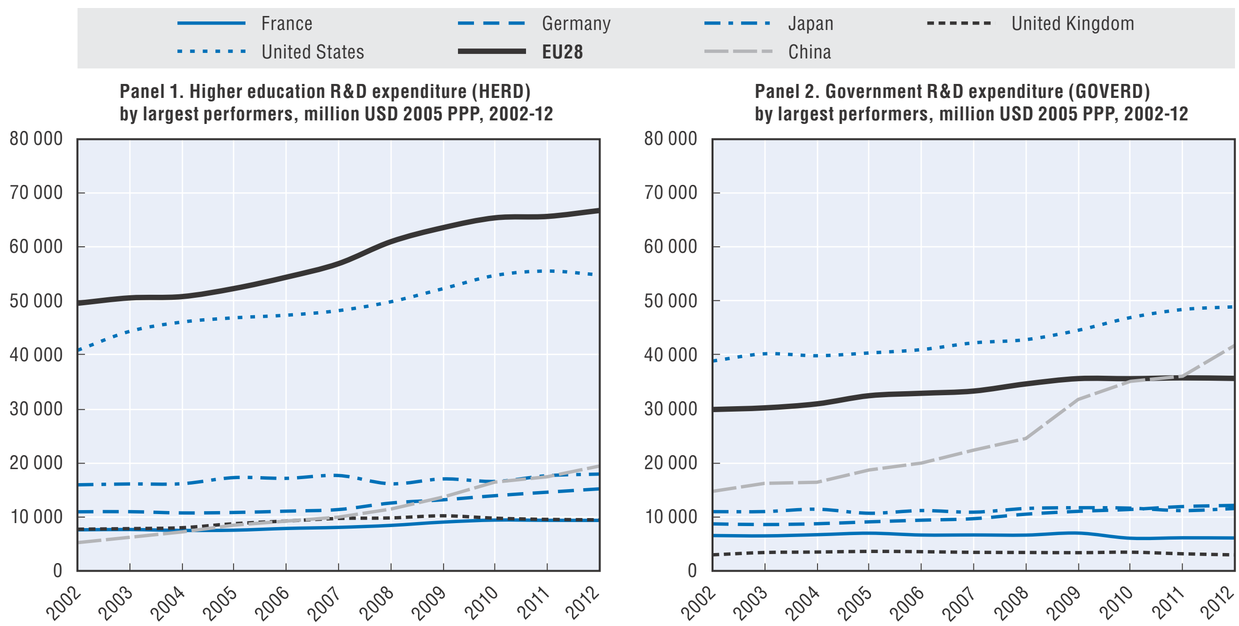
It describes recent trends and possible future developments in public R&D expenditure under the present fiscal and budgetary conditions. It considers the growing openness of science and the greater collaboration of universities with non-academic STI actors in globally connected nodes. It outlines recent policy developments in the governance, funding and steering of public research. It addresses the autonomy of universities, the reform of public research and academic careers, the prioritisation and concentration of public resources into areas or institutions of excellence, the introduction of more competitive and performance-based funding mechanisms, the new research excellence initiatives, the new approach to doing and sharing research through open science and the professionalisation of technology transfer.



The science base is increasingly concentrated in universities

The government and higher education sectors account for less than a third of the R&D performed in OECD countries (30% of the OECD total in 2012) (OECD, 2014g). In 2012, universities and public research institutes spent USD 330 billion on R&D, with the United States accounting for 36%, Japan[21] for 10% and the EU28 for 38% of the OECD total. Universities were the main actors in OECD public research, spending USD 200 billion on R&D, while PRIs spent USD 129 billion. China's universities and PRIs spent USD 70 billion in 2012, of which USD 48 billion by PRIs.

Figure 1.25. **Universities have expanded the science base**



Note: EU28 is an OECD estimate.

Source: OECD, *MSTI Database*, June 2014, *www.oecd.org/sti/msti*. Data retrieved from IPP.Stat on 8 July 2014, *http://stats.oecd.org//Index.aspx?QueryId=57863*.

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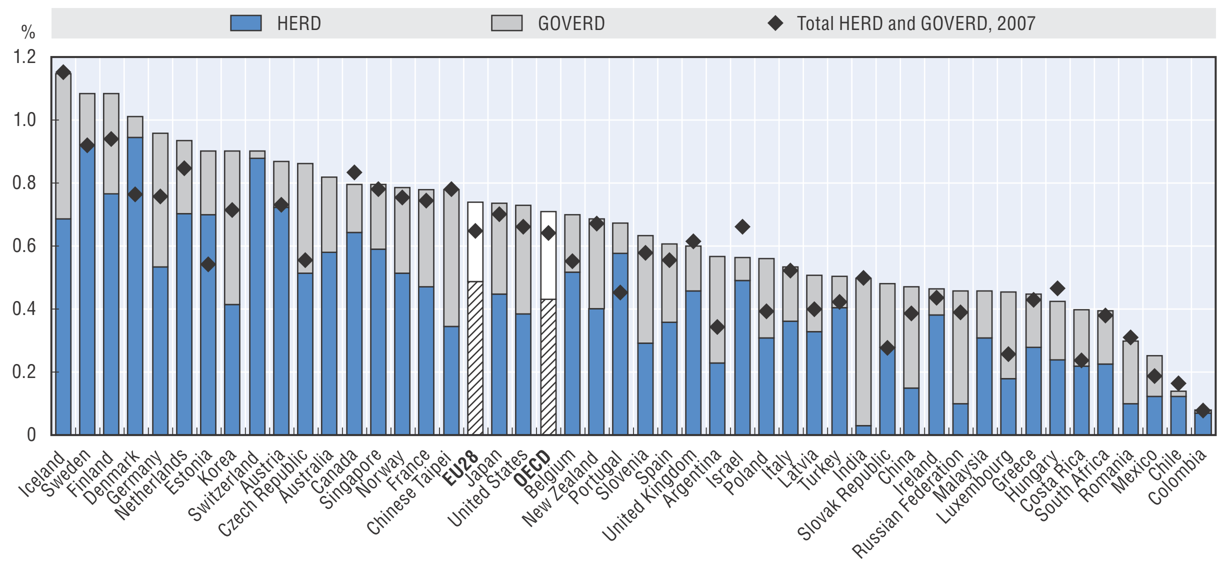
In the decade since 2002, the growth of the science base in the United States and the EU has been driven by universities, which have seen a robust increase in their expenditures. Over time there has also been a shift towards university-based research across the OECD (OECD, 2013w). In China, the growth of scientific activity has been driven by PRIs, in particular by large investments by the Chinese Academy of Sciences. There are notable structural differences in countries' public research systems (Figure 1.26). In China and Korea the public research system is built on public labs, while in Denmark, Israel and Switzerland it is based in universities (OECD, 2010b). The Russian Federation is currently restructuring its system to move closer to a university-based system.

With the exception of Canada, Hungary, Iceland, Israel and the United Kingdom, both higher education expenditure on R&D (HERD) and government expenditure on R&D (GOVERD) have consistently increased as a percentage of GDP in spite of the crisis, a sign of resilience and public commitment to R&D (Figure 1.26). The largest increases in the OECD area have been in the Czech Republic, Estonia and Luxembourg.

Figure 1.26. **Public R&D expenditure by type of research system**

HERD and GOVERD, as a percentage of GDP, 2012, and total HERD and GOVERD in 2007



Note: "Countries differ in terms of the extent to which their innovation systems are public-research centred or firm-centred, measured by the share of business in total R&D expenditure. […] The extent to which countries' public research system is public lab-centred or university-centred plays a role. […] Actions taken […] to enhance the contribution of public research are influenced by the country's position in this respect." (OECD, *OECD Science,Technology and Industry Outlook 2010*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/sti_outlook-2010-en*)

HERD data for Argentina, Colombia, Costa Rica, Iceland, Japan, Korea, Latvia, Luxembourg, Malaysia, Mexico and Turkey refer to 2011; data for Australia, Chile and South Africa refer to 2010; data for Indonesia refer to 2009; data for India refer to 2007. HERD data for Australia, Malaysia and Switzerland refer to 2006 instead of 2007.

GOVERD data for Colombia, Costa Rica, the Czech Republic, Iceland, Japan, Korea, Latvia, Luxembourg, Malaysia, Mexico, New Zealand, Singapore and Turkey refer to 2011; data for South Africa and Chile refer to 2010; data for India refer to 2007 and data for Indonesia refer to 2006 instead of 2012. GOVERD data for Australia, Indonesia Malaysia and Switzerland refer to 2006 instead of 2007.

Source: OECD, *MSTI Database*, June 2014, *www.oecd.org/sti/msti*. Data retrieved from IPP.Stat on 8 July 2014, *http://stats.oecd.org//Index.aspx?QueryId=57863*.

StatLink http://dx.doi.org/10.1787/888933151601

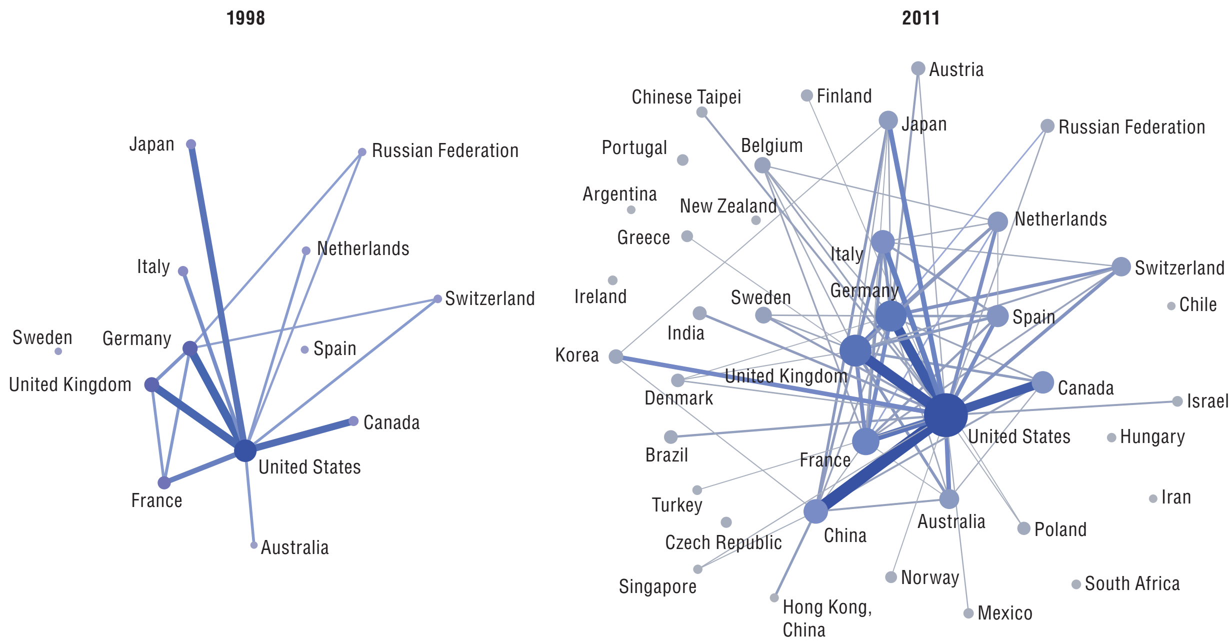
Open science calls for new approaches to research and new governance arrangements

Modern science is increasingly data-driven and requires new forms of collaboration and broader sharing of knowledge and resources. Universities and PRIs have strengthened knowledge and co-operation linkages with counterparts worldwide to achieve economies of scale and increase the visibility of domestic research. Publication data show that international collaboration among research institutions has intensified over the past decade and that China, among other economies, is increasingly integrated in the global science system (Figure 1.27).

The shift towards greater openness in science relies on the assumption that publicly funded research is a public good. Although the issue of how its diffusion and publication should be funded has not been resolved, the shift has received the support of governments and scientific communities in search of greater efficiency (including less duplication) and faster knowledge spillovers to industry and the economy (OECD, 2013x). Open science also creates opportunities for emerging countries, as it can facilitate faster integration into world scientific networks (OECD, 2013y) and co-operation to address global challenges.

Figure 1.27. **International collaboration networks in science**

Internationally co-authored documents, 2011 and 1998 (whole counts)



Note: The position of selected economies (nodes) exceeding a minimum collaboration threshold of 10 000 documents is determined by the number of co-authored scientific documents published in 2011. A visualisation algorithm has been applied to the full international collaboration network to represent the linkages in a two-dimensional chart on which distances approximate the combined strength of collaboration forces. Bubble sizes are proportional to the number of scientific collaborations in a given year. The thickness of the lines (edges) between countries represents the intensity of collaboration (number of co-authored documents between each pair). The positions derived for 2011 collaboration data have been applied to 1998 values. New nodes and edges appear in 2011 as they exceed the minimum thresholds.

Source: OECD (2013), *OECD Science, Technology and Industry Scoreboard 2013: Innovation for Growth*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/sti_scoreboard-2013-en*; Based on Elsevier (2012), *Scopus Custom Data*, version 5.2012, June 2013.

Governments play a key role in encouraging open science and new ways of doing research. Although ICTs have been a significant support of openness in science, far more is at stake than access to IT infrastructures or the skills to use them. Open science requires new approaches to public research funding; the research process; the exploitation of research output, including access to, protection of, and IPRs of research results; and the interaction between science and society (OECD, 2013x) (see the policy profile on "Open science").

Research excellence requires new forms of funding

As competition for ideas, talent and funds increases, governments often turn to more competitive forms of funding to promote efficiency and innovation. Public research funding has gradually shifted from institutional core funding (so-called "block grants") to project funding, often on a competitive basis. Experimental data reveal that there is significant variation in the share of project funding in total domestic funding, ranging from 25% in Switzerland to 76% in Chile[22] (OECD, 2013z). Current public budgetary situations call for greater selectivity and efficiency in funding; the issue of an optimal level of competition in public resources allocation is often raised. Research requires a proportion of stable funding, and national systems strive for a balance between competition and stability (OECD, 2012a). In this context research excellence initiatives have emerged in over two-thirds of OECD countries, mostly within the past decade, to encourage outstanding research with stable funding (OECD, 2014k). In some cases countries have also supported prioritisation of public research by channelling public outlays towards strategic research areas.

Research excellence initiatives are new funding instruments that combine elements of institutional and project funding. They provide large-scale, long-term funding to support complex, high-risk research agendas, in particular in interdisciplinary fields. The funds serve to reinforce overall research capacity by improving or extending physical infrastructure, recruiting outstanding researchers from abroad, and enhancing doctoral and post-doctoral programmes. Research excellence initiatives also allow for greater flexibility, notably to manage resources or to fast-track recruitment processes. While research excellence initiatives can raise the international visibility of host institutions, create positive externalities and lead to a virtuous funding circle that attracts third-party funding, they also involve considerable administrative and overhead costs and require a transparent selection process and systematic impact assessment.

In Switzerland, eight new National Centres of Competence in Research (NCCR) will be established in 2014 to support and strengthen outstanding research in strategic fields. The German Initiative for Excellence will be refinanced for the 2012-17 period, based on the positive results from promoting cutting-edge research at universities. Canada has also recently announced the creation of the Canada First Research Excellence Fund, the aim of which is to raise the research capabilities of its institutions to world standards. France, as part of its Investments for the Future, sponsored a number of "initiatives of excellence" in 2011 to foster the emergence of world-class research over a ten-year period. The expenditure amounts to USD 12 billion PPP (EUR 10 billion), most of it as capital endowment. Governments have also developed legal, tax or financial frameworks to help public research access new channels of funding, e.g. from private sources, and recover the full cost of research.

Transfer of public research results requires further professionalisation and a stronger business culture in commercialisation activities

The coverage of public research policies has been extended from knowledge production to technology transfer. The way in which universities and PRIs engage with business to take science from the laboratory to the market through commercialisation is evolving rapidly. Policy initiatives designed to foster industry-science co-operation on R&D, academic consulting, or student and faculty mobility, as well as public-private partnerships, have been widely used and have helped to introduce a market perspective in science. Governments have also increasingly developed support schemes to encourage universities and PRIs to protect and commercialise publicly funded research results.

In this respect, lacklustre academic patenting, licensing and spin-offs have prompted OECD countries to develop policies and instruments to exploit, transfer and commercialise public research. First, governments and institutions have revised their approach to IP protection and sharing, e.g. by providing licences free of charge, proposing preferential access to "sleeping" patents, requiring publication in digital format, and providing open research data repositories. Overall, IP, although its importance is still recognised, is no longer seen as the main vehicle for commercialisation. Second, they have facilitated the involvement of students and researchers in the commercialisation process, e.g. by allowing faculty members to suspend their tenure for commercialisation activities; by taking into account their commercial experience; by better linking teaching, research and commercialisation; or by mentoring student start-ups. Third, they have restructured and regrouped technology transfer offices, e.g. into regional centres, and fostered the adoption of more effective business models. The aim is to increase staff skills and strengthen staff incentives. Finally, financing has focused on universities and PRIs; these have, in some cases, established their own gap funding schemes to address financing issues. Overall, governments seek to strengthen a business culture in activities that have often been dominated by administrative approaches: the issue is not only to file patents, but to commercialise them, not only to create spin-offs but to grow them.

Notes

1. Several studies have documented the correlation between unemployment and mental disorders, including depression, which may result in additional costs to society (OECD, 2008a).
2. Israel is an exception. In 2011 Israel had the highest rate (37.7%) of "not in education, employment or training" (NEETs), twice the OECD average (18.5%) (OECD, 2013d).
3. *China Statistical Yearbook 2012*, accessed 14 January 2014, *www.stats.gov.cn/tjsj/ndsj/2012/indexeh.htm*. China does not participate in the OECD Indicators of Education Systems (INES) programme. Education data for China may not be fully comparable with data for OECD countries.
4. Australia, Canada, the Czech Republic, France, Italy, Korea, Mexico, the Netherlands, Norway and Sweden.
5. These are initiatives that lead to the development of new products and services that serve lower-income groups. A number of cases are provided in OECD (2013r).
6. As official OECD data on R&D investment are based on retrospective surveys of performing units, the discussion of cross-country R&D spending patterns currently only extends to the end of 2012.
7. Israel's R&D expenditure is underestimated because it does not include defence-related R&D budgets.
8. In interpreting these figures, it must be remembered that the GERD-to-GDP ratio reflects changes in countries' nominal spending on R&D as well in their GDP growth rate.
9. For Estonia, a significant investment in new technology in the oil industry explains part of the increase.
10. Triadic patent families are defined by patents for an invention filed at the European Patent Office (EPO) and the Japan Patent Office (JPO) and granted at the US Patent and Trademark Office (USPTO) to protect the same invention. Triadic patents are typically of higher value and eliminate biases from home advantage and the influence of geographical location.
11. New technology-based firms can also make substantial contributions to radical innovation and technological breakthroughs.
12. Big data and energy-efficient computing; satellites and the commercial applications of space, robotics and autonomous systems; life sciences; genomics and synthetic biology; regenerative medicine; agri-science; advanced materials and nanotechnology; and energy and its storage.
13. The *EU Industrial R&D Scoreboard* collects information for assessing the R&D and economic performance of companies. The main indicators are R&D investment, net sales, capital expenditures, operating profits and number of employees. The data for the Scoreboard are taken from companies' publicly available audited accounts.
14. According to the *EU Industrial R&D Scoreboard 2013*, these companies account for more than 90% of global business R&D.
15. The marketing mix focuses on the so-called 4Ps: Product (design or packaging), Placement, Promotion and Pricing.
16. In all countries most business are micro-enterprises, i.e. firms that employ fewer than ten persons (OECD, 2014i). Micro-enterprises account for 70% to 95% of all firms and SMEs, defined as firms with fewer than 250 employees, for 99%.

17. Basel capital accords are capital adequacy standards that are formulated by the Basel Committee on Bank Supervision (BCBS). National regulators usually implement the standards to regulate bank capital and to ensure a healthy banking system. The objectives are to strengthen the soundness and stability of the international banking system and to diminish sources of competitive inequality among international banks. To date three accords have been published, each improving upon the previous one: Basel I, Basel II, Basel III. See OECD glossary of statistical terms, *http://stats.oecd.org/glossary/detail.asp?ID=6194*, retrieved 26 January 2014.
18. Total funds leveraged by crowdfunding were estimated at roughly USD 1.5 billion in 2011 (Ham, 2013).
19. A typical mezzanine facility combines several financing instruments of varying degrees of risk and return, such as subordinated debt, profit participation certificates and equity warrants (OECD, 2014j). It is cheaper than equity finance, results in lower financing costs, and diminishes the dilution of control for founding entrepreneurs.
20. Other potential drawbacks are transaction costs and dependency.
21. Data for Japan are for 2011 instead of 2012.
22. From a sample of 19 countries and the European Commission (Seventh Framework Programme) that participated in the second OECD data collection on modes of public funding of R&D based on government budget appropriations or outlays on R&D (GBAORD) for 2009-11, launched in November 2012.

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PART II

Main trends in STI policy

OECD Science, Technology and Industry Outlook 2014

PART II

Chapter 2

STI policy profiles: Governance

NATIONAL STRATEGIES FOR SCIENCE, TECHNOLOGY AND INNOVATION

Rationale and objectives

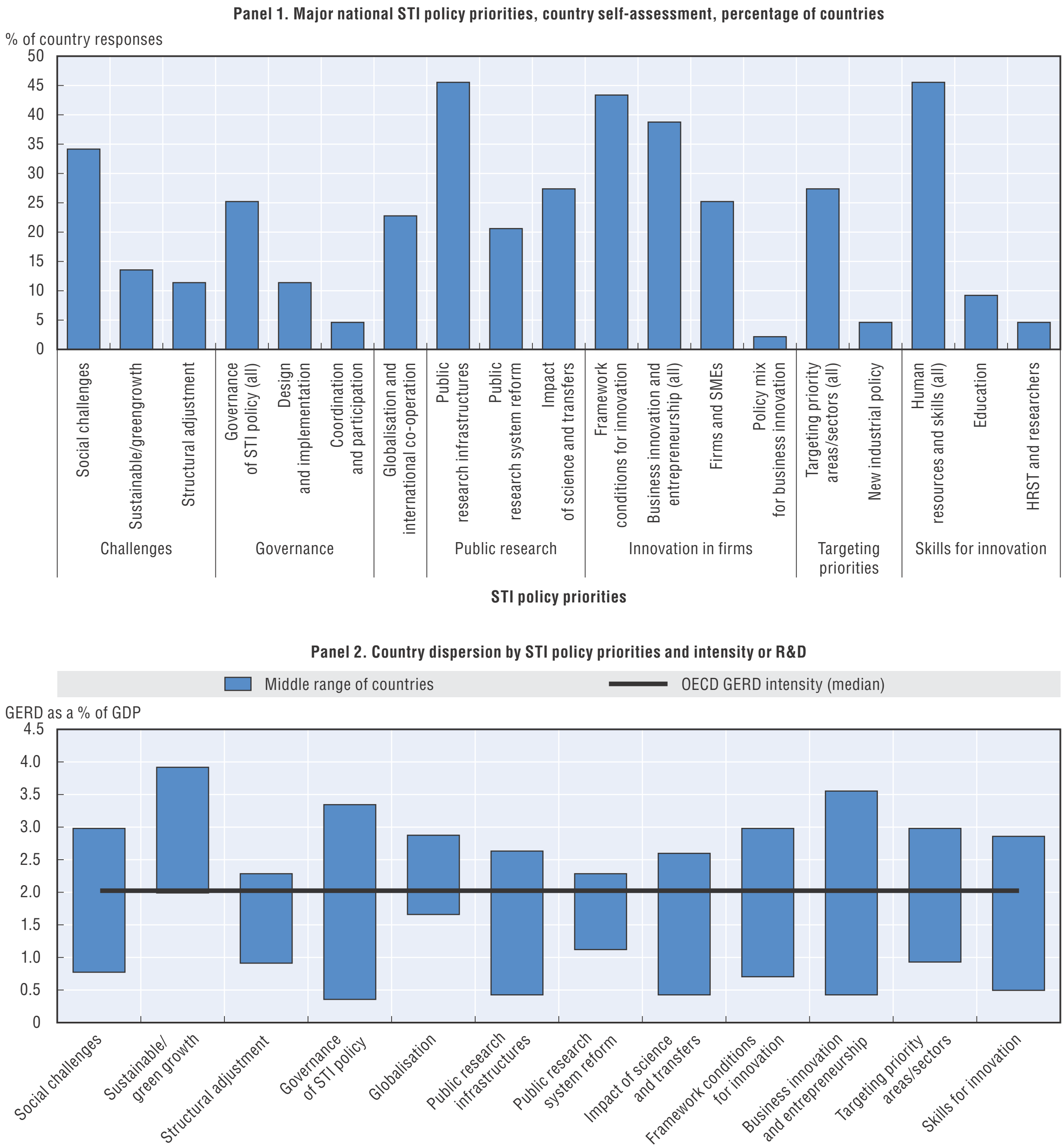
National strategies for science, technology and innovation (STI) serve several functions in government policy making. First, they articulate the government's vision regarding the contribution of STI to their country's social and economic development. Second, they set priorities for public investment in STI and identify the focus of government reforms (e.g. funding of university research, evaluation systems). They also mobilise STI actors around specific goals, such as energy, environmental issues or health, and may help steer investments of private actors and increasingly autonomous universities and public research institutes towards priority areas or technologies. Third, the elaboration of these strategies can engage stakeholders (the research community, funding agencies, business, civil society, regional and local governments) in broad consultations that will help building a common vision of the future and facilitate co-ordination within the innovation system.

Major aspects

Country responses to the OECD STI Outlook policy questionnaire 2014 have revealed both similarities and differences in goals and policy priorities across countries and also point to some international features in national STI strategies (Figure 2.1 Panel 1) as well as some broad cross-country policy patterns (Figure 2.1 Panel 2). A first similarity is that almost all countries have given high priority to business innovation and innovative entrepreneurship, whatever the approach and modalities of public action. Second, most countries aim at consolidating the innovation ecosystem by strengthening public R&D capacity and infrastructures, improving overall human resources, skills and capacity building, and improving framework conditions for innovation (including competitiveness). Third, countries at different stages of socio-economic development share some STI policy priorities, while other priorities are specific to certain countries. This is reflected in the relative concentration of countries in strategic STI policy fields according to the intensity of their gross domestic expenditure on R&D (GERD) (Figure 2.1 Panel 2).

Typically, for countries that already rank high in terms of business R&D and innovation, there is a focus on investing in the science base, both public research and human resources, to strengthen the basis for future innovation (OECD, 2010). These high-performing countries are also prioritising their research and innovation support to gain competitive advantage for future growth areas such as green technologies and health and to help address global challenges. Countries that identified the contribution of innovation to sustainable and green growth as a major STI policy priority in 2014 tend to be more R&D-intensive (Figure 2.1 Panel 2). Focusing on the three countries that spend the most (more than 3.5% of GDP) on R&D, Korea earmarked USD 2.4 billion PPP for green technology in its 2nd S&T Basic Plan and confirmed its ambition to become a hub for global green growth in its recently adopted 3rd S&T Basic Plan. Israel has shown a growing interest in the development of cleantech sectors and has allocated new resources to water and oil-substitute technologies since 2012. Following the launch in 2012 of a strategic Green Growth programme to identify potential new growth areas based on lower energy consumption and sustainable use of natural resources, Finland established its Bioeconomy Strategy in 2014 in order to address grand societal challenges raised by the food-energy-water nexus.

Figure 2.1. **Major national STI policy priorities and patterns by level of R&D intensity, 2014**



Note: STI policy priorities are defined by country self-assessment answers to the question: "What are the major STI policy priorities in your country? Please select three (maximum five) STI policy priorities in the drop-down lists below and describe briefly "in your words" (one sentence) these major policy priorities". Responses are provided by Delegates to the OECD Committee for Scientific and Technological Policy.

Panel 2 illustrates the extent to which national STI priorities can be linked to the degree of advancement of R&D system. It shows the countries that reported each STI policy priority as a major issue according to their GERD intensity. The middle range of countries includes all OECD countries and non-OECD economies to the exclusion of the two most R&D-intensive and two least R&D-intensive countries. For the policy priorities related to sustainable/green growth and structural adjustment, however, the middle range of countries includes the top two and bottom two to compensate for the small number of countries in these two policy categories. The intensity of GERD is expressed as a percentage of GDP.

Sources: Country responses to the OECD STI Outlook policy questionnaire 2014; OECD, *Main Science and Technology Indicators (MSTI) Database*, June 2014, *www.oecd.org/sti/msti*; Eurostat and UNESCO Institute for Statistics (UIS), June 2014. Data retrieved from IPP.Stat on 8 July 2014, *http://stats.oecd.org//Index.aspx?QueryId=57863*.

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For OECD countries in which innovation performance lags, there is a particular focus on building the institutional capacity to steer or "govern" STI policies, to strengthen the links between public research and industry, and to improve the quality of higher education and research (OECD, 2010).

Small open OECD countries with high exposure to trade and foreign direct investment (FDI) are also more likely to consider challenges raised by STI globalisation and increasing international co-operation as major policy priorities. The three Belgian authorities (Brussels Capital, Flanders and Wallonia) put particular emphasis on European integration and cross-border scientific co-operation in their respective strategic documents. One of the goals of the Irish Strategy for Science, Technology and Innovation (2006-13) is to maintain the country's attractiveness for FDI. In its new Education, Research and Innovation Plan (ERI-DISPATCH) (2013-16), Switzerland established three main policy guidelines, one of which is to strengthen further the country's internationally competitive position in research and innovation.

For their part, catching-up and emerging economies are seeking to include STI strategies in their longer-term economic development strategies. Emerging and middle-income economies (e.g. Argentina, Colombia, Costa Rica, Malaysia, Vietnam) are developing strategies to diversify their economies and mobilise innovation to improve their competitiveness, move up global value chains and escape the "middle-income trap" (see Chapter 1). Less R&D-intensive countries tend to set a priority on the contribution of innovation to structural adjustment and a new approach to growth, on improving the returns to and impact of science, and on increasing the skills base. The People's Republic of China's Medium- and Long-Term Plan for S&T Development (2006-20) aims to use innovation as a tool for restructuring Chinese industry and shift from investment-driven to innovation-driven growth.

However, OECD countries and emerging economies share certain concerns and priorities as regards the governance of their innovation system and policy, support to innovation in firms, entrepreneurship and small and medium-sized enterprises (SMEs), and the contribution of innovation to meeting social challenges (including inclusiveness).

National strategies for STI vary also in their duration, which rarely exceeds five to ten years. In some rare cases, the strategy timeframe is open (e.g. Colombia: National Innovation Strategy; United Kingdom: Innovation and Research Strategy for Growth). Few countries have projected strategic developments beyond 2020; most European countries have defined their national strategies in the framework of the EU's Horizon 2020.

Most countries have adopted quantitative targets to benchmark their performance and progress, especially through targets for R&D spending (Figure 2.4). The volume of GERD to be achieved is often expressed as a percentage of gross domestic product (GDP) and, in some cases, the relative contribution of the business or the public sector is specified as well. China and the Russian Federation target S&T output in terms of patents, citations and publications. New Zealand takes into account economic performance as reflected in the increase in exports, while Korea looks at S&T-related job creation. Denmark and Switzerland monitor educational outcomes and the share of a youth cohort completing upper secondary or higher education programmes.

National strategies for STI follow a vision and are designed on the basis of data-driven evidence, opportunity tools such as scenarios and strengths-weaknesses-opportunities-threats (SWOT) analyses. The process of making an innovation strategy is perhaps more important than the document, as it helps reveal problems, barriers and hidden opportunities and promotes a learning process.

Operational aspects of national strategies are often left to the innovation actors, e.g. ministries, or to the implementation and funding agencies that have enjoyed increasing autonomy in recent years. National strategies can also be relayed to the operational level through regional strategies (e.g. China, France), implementation or action plans (e.g. Flanders in Belgium, Finland), interim roadmaps (e.g. Germany) or contracts (e.g. university performance agreements). In Greece and the Russian Federation, national strategies are framed by legislation.

In some cases, national strategies articulate STI policy priorities in terms of the mix of policy instruments. Given the breadth of innovation policy, the instrument toolbox is large and goes well beyond a narrow focus on research (IPP, 2014). As examples, Australia, Belgium (federal government) and Finland have introduced tax incentive schemes for R&D in their national strategies.

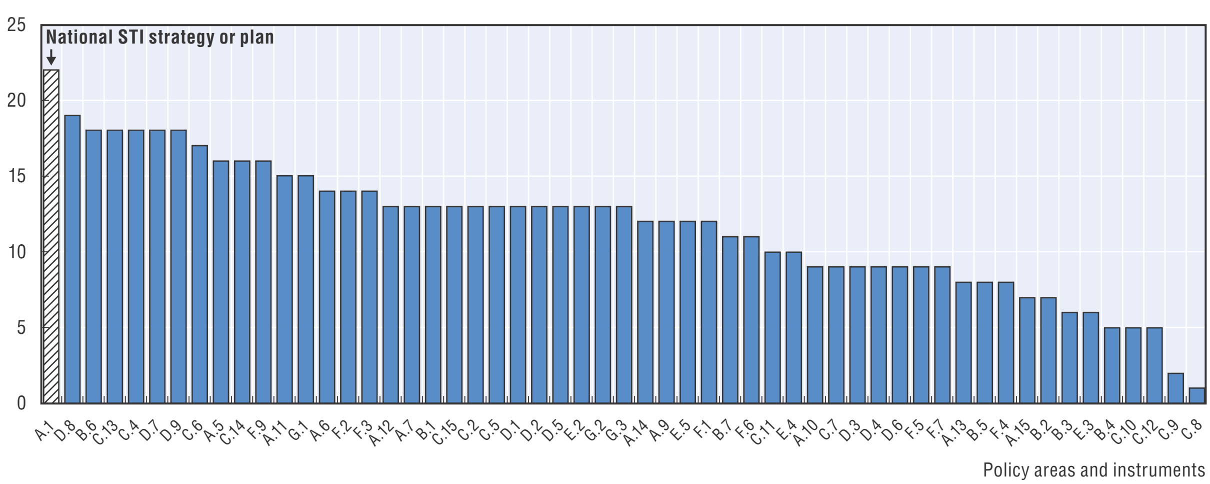
Many countries have included in their strategy a number of evaluation rules and tools. Evaluation concerns not only discrete policy interventions or instruments but also entire research portfolios or the overall research and innovation system (see policy profile on "Impact assessment in STI policies").

Recent policy trends

The changing context of innovation and policy intervention (see Chapter 1) has called for changes in national strategies. A majority of countries covered in the 2014 edition of the *OECD STI Outlook* have substantially changed their national strategy for STI since the 2012 edition. Strategic policy setting is by far the STI policy area that has changed the most (Figure 2.2).

Figure 2.2. **National STI strategy and plans among other areas of STI policy change, 2012-14**

Countries reporting a substantial change in the policy area, compared with other STI policy areas



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 2014 questionnaire). The y-axis shows the number of countries reporting that the situation has substantially changed in each policy area. Simple counts do not account for the magnitude and impact of policy changes. Responses are provided by Delegates to the OECD Committee for Scientific and Technological Policy.

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

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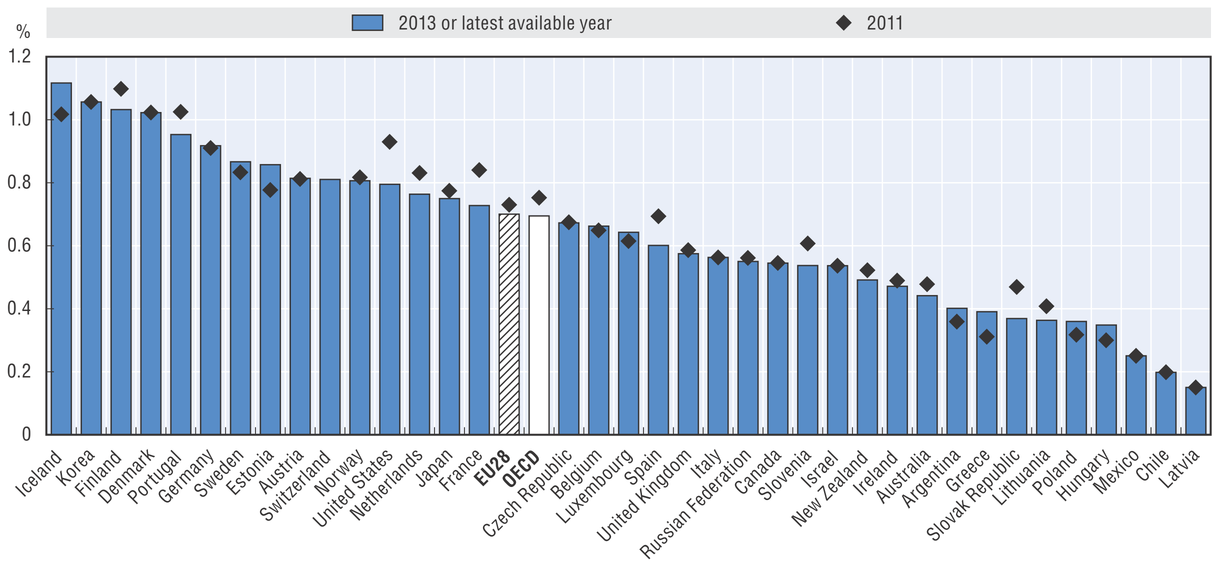
Broader-based innovation policy. Many governments have looked at policies for innovation as an important tool both to strengthen growth and to address a range of global and social challenges, including climate change and health.

- **Social cohesion.** Income disparities increased in several OECD and non-OECD economies during the global financial crisis. National STI strategies are increasingly used to enhance social cohesion while boosting economic growth. Argentina's Innovadora 2020, Mexico's National Development Plan (2013-18) or Hungary's National Reform Programme (2013-20) renew governments' commitment to social development. The Swiss Education, Research and Innovation Plan (2013-16) establishes policy guidelines to strengthen social cohesion through knowledge and to promote equal opportunities in education. Korea includes gender issues in the orientations of its 3rd S&T Basic Plan (2013-17).
- **Social challenges.** European countries are aligning their national strategies with Horizon 2020 to tackle major societal challenges, including health, food, mobility, security and freedom. Korea's 3rd S&T Basic Plan (2013-17) integrates social and ageing-related issues as well (see policy profile on "Innovation for social challenges").
- **Wider toolkit.** There has been a strong push to accelerate the transfer, exploitation and commercialisation of public research (see policy profile on the "Commercialisation of public research"), and more attention is paid to demand-side instruments (see policy profile on "Stimulating demand for innovation").
- **Participative innovation policy.** Several countries have taken a participative approach to the design and implementation of their national strategies. Denmark carried out a national dialogue with non-state stakeholders to prepare its Innovation Strategy and develop a catalogue of challenges. A recent review of the Chilean innovation system concluded that there was a need for modernisation of STI governance institutions and for greater participation of the private sector in the management of implementing agencies.

STI budgets under pressure. Public R&D budgets have helped to partially offset the decline in business R&D investments during the global economic downturn (see Chapter 1). However, government budget appropriations or outlays for R&D (GBAORD) have stagnated, relative to GDP, in most OECD and partner economies since 2011, owing to the fading impact of stimulus packages and the simultaneous recovery in GDP (Figure 2.3). The OECD-wide public R&D budget remains below its pre-crisis level (0.69% of GDP in 2013 compared to 0.76% in 2008). The current economic and fiscal situation is changing the conditions under which governments may intervene. Finland, the Netherlands and the Russian Federation foresee cuts in public R&D budgets in the coming years. Greece, Hungary, Ireland, Italy, New Zealand and the United States anticipate a budgetary *status quo*, and China and Korea expect public R&D spending to slow. Consequently, many governments' capacity to drive further increases in domestic R&D expenditure is limited. In addition, given the current world economic outlook, the gap between overall strategic R&D spending targets and current R&D expenditure remains too large to be closed by target dates in many countries (Figure 2.4). Greece and the Russian Federation have revised their targets downward to 1.50% and 1.77% of GDP by 2020 and 2015 respectively; Hungary (1.80%) and Poland (1.70%) have postponed their target date to 2020 instead of 2013 and 2015, respectively. Efforts have also been made to streamline and consolidate business innovation programmes (see policy profiles on "Government financing of business R&D and innovation" and "Tax incentives for R&D and innovation").

Figure 2.3. **Government budget appropriations and outlays for R&D, 2011 and 2013**

As a % of GDP



Note: Data for Belgium, Hungary, Ireland, Israel, Italy, Latvia, Lithuania, Spain, Sweden, the United Kingdom and the European Union refer to 2012 instead of 2013; data for Argentina, Canada, Chile, Korea and Mexico refer to 2011 instead of 2013; data for Poland refer to 2012 and 2009 instead of 2013 and 2011; data for Switzerland refer to 2010 and 2008 instead of 2013 and 2011.

Source: OECD, *Research and Development Statistics (RDS) Database*, March 2014, *www.oecd.org/sti/rds*; Eurostat and UNESCO UIS, June 2014. Data retrieved from IPP.Stat on 8 July 2014, *http://stats.oecd.org//Index.aspx?QueryId=57863*.

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New industrial policy and targeting of strategic technologies/sectors. Besides their support for general purpose technologies such as nanotechnology, biotechnology and information and communication technologies (ICTs), many OECD countries are emphasising support for innovation in strategic technologies or sectors, including traditional ones (e.g. agriculture) and services. A number of STI strategies include industrial policy in their innovation policies (see policy profile on "New industrial policies").

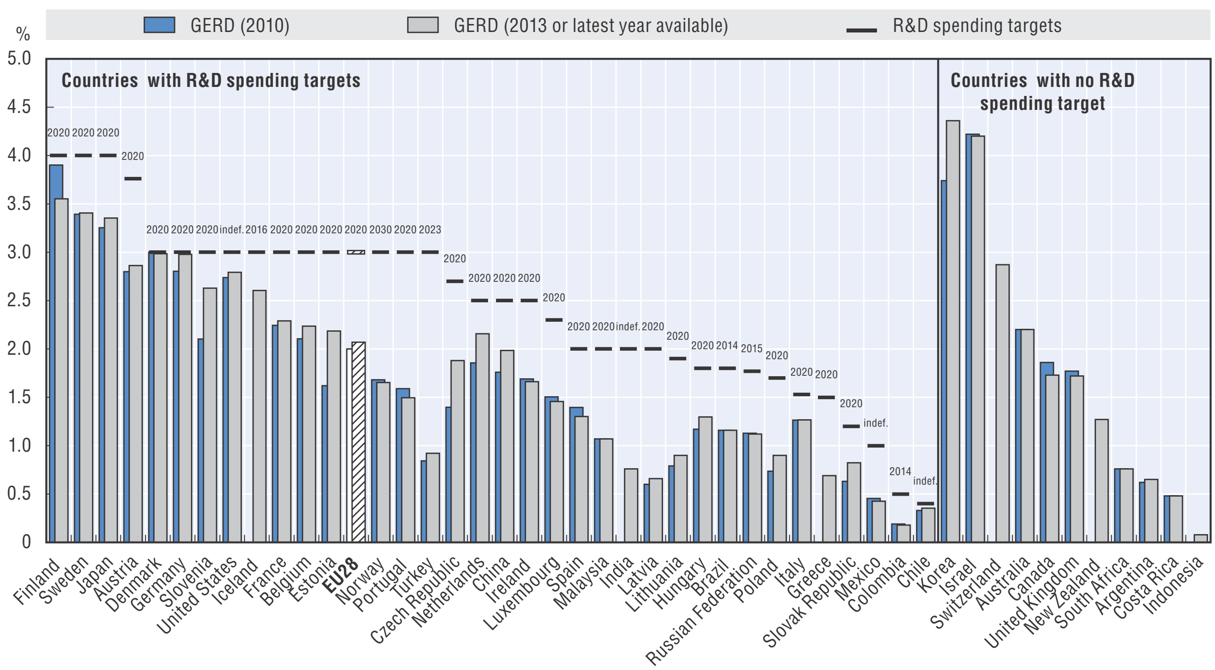
Building a culture for innovation. Several countries have emphasised building a broad science and innovation culture to encourage broader appropriation of S&T and the spirit of entrepreneurship (see policy profile on "Building a science and innovation culture").

Evaluation and monitoring as part of the overall strategy. Measuring the impact of policies has become a key aspect of STI policy governance. Attention has been paid to developing an evidence base for policy making and to strengthening the role of evaluation. Belgium (Brussels Capital) integrated strategic monitoring, evaluation and the strengthening of the Scientific Policy Board in the main actions of its Regional Innovation Plan (2013-20). Slovenia's Research Infrastructure Roadmap (2012-20) serves to monitor the implementation of public policy and goals in the area. Israel has set high priority on developing an information system in innovation.

Looking further ahead. A few countries have started looking beyond 2020. In 2012 Belgium (Flanders) performed a foresight study to 2025 and set up a transition model to address grand societal challenges. "Surfing Towards the Future: Chile on the 2025 Horizon" considers strategic orientations for the future, rather than specific guidelines for action. South Africa released its "National Development Plan: A vision for 2030", which identifies

Figure 2.4. **National R&D spending targets and gap with current levels of GERD intensity, 2014**

As a % of GDP



Note: Countries are ranked by descending order of national R&D spending targets and by descending order of GERD intensity in 2013 (or latest available year). For countries that adopted a range of target values, the minimum threshold is used in the chart. For Chile, the national R&D spending target is 0.4-0.8% of GDP, for Luxembourg 2.3-2.6% of GDP by 2020. For Ireland, the national R&D spending target is 2.5% of gross national product (GNP) by 2013. Argentina, Australia, Austria, Canada, Costa Rica, Korea, Indonesia, Israel, Malaysia, New Zealand, South Africa, Switzerland and the United Kingdom have not defined R&D spending targets.

Source: Country responses to the OECD STI Outlook policy questionnaires 2012 and 2014; OECD, *MSTI Database*, June 2014, *www.oecd.org/sti/msti*; Eurostat and UNESCO UIS, June 2014; International Monetary Fund (2014), *World Economic Outlook*, January, *www.imf.org/external/pubs/ft/weo/2014/update/01/index.htm*. Data retrieved from IPP.Stat on 8 July 2014, *http://stats.oecd.org//Index.aspx?QueryId=57863*.

StatLink http://dx.doi.org/10.1787/888933151649

areas of competitive advantage to be developed (e.g. water, power, marine, space and software engineering). The French Innovation 2030 Commission was tasked to propose several means of meeting the needs of tomorrow's society through major innovations. Japan adopted a comprehensive Strategy on Science and Innovation as a long-term vision to 2030, with a roadmap and intermediate targets, to achieve an ideal economic society. Malaysia will undertake foresight studies and monitoring of international developments to address uncertain and complex issues.

Innovation Policy Platform. The OECD and the World Bank are developing the Innovation Policy Platform (IPP) (*www.innovationpolicyplatform.org*) as a tool for diagnostics, strategy design and implementation. The IPP will collect reputable materials on innovation policy, including reports and statistics, and provide a forum for exchange of ideas and experiences among policy makers and analysts looking for facts and evidence to solve problems.

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SYSTEM INNOVATION

Rationale and objectives

Interest in system innovation is motivated by the realisation that system-wide change is necessary to make economies socially, economically and environmentally sustainable. Although many national governments have put sustainability and green growth objectives at the centre of their economic development strategies, achieving this goal will require wide-ranging changes in their underlying economic, technological and social systems, from transport, water and energy systems to modes of consumption and waste management. Ensuring that socio-technical systems move towards greater sustainability is a major challenge for governments but also for civil society. At the core of the transition is a shift in governance structures that not only allows change to occur but also directs and orchestrates some of the changes. The "smart city" initiatives that mobilise technological and social innovations to make the production and consumption of a city's goods and services more sustainable illustrate this point.

A key leitmotiv is that socio-technical systems, whether local, national or sectoral, are not responding swiftly enough to global challenges in areas such as climate, energy, food, transport and health to avoid bleak scenarios. The economic rationale for policies in a system innovation context is the market and system failures that are familiar to STI policy makers, including the need to internalise externalities that dampen the incentive to invest in innovation and to foster co-ordination within the system to improve synergies. These imply changes in framework conditions to shift incentives in the desired direction (laws, regulations) and changes in the price structure. System innovation also raises issues of vertical and horizontal co-ordination and requires governments to challenge existing governance structures or to build new ones.

Major aspects

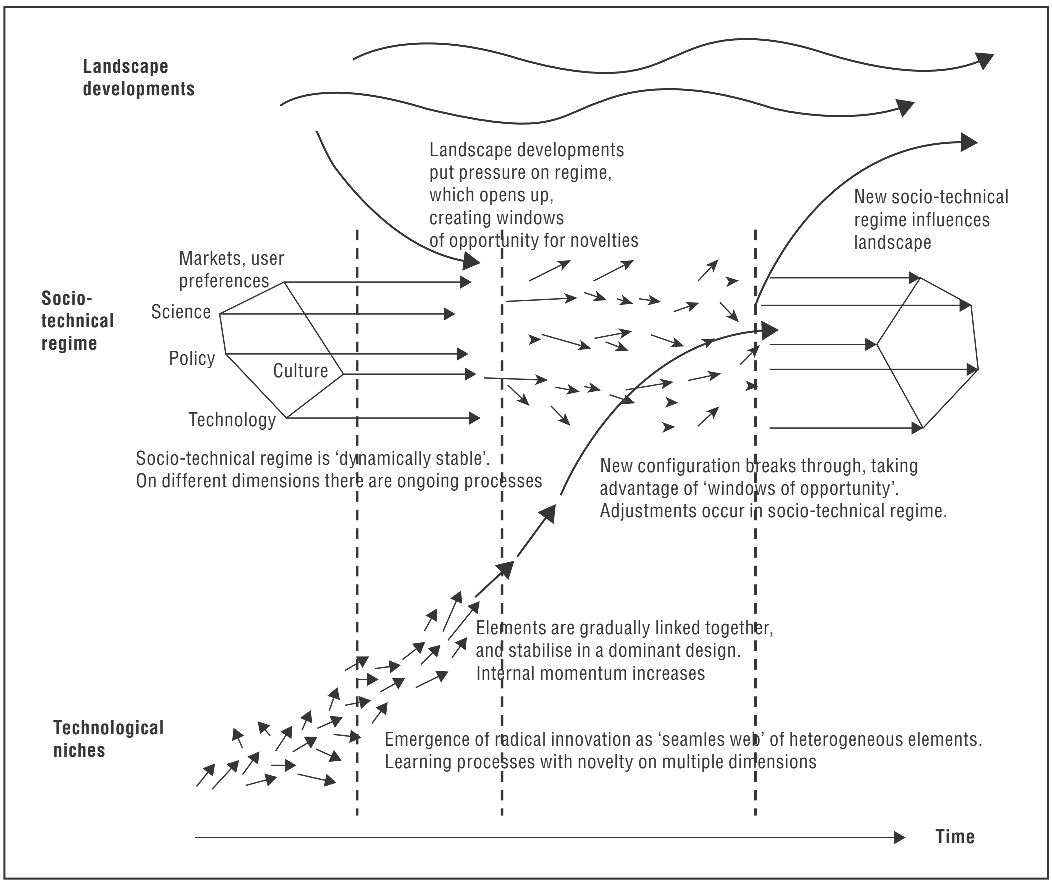
System innovation can be defined as a radical innovation in socio-technical systems that fulfil societal functions, which entails changes in both their components and architecture.

Some of the defining characteristics of system innovation are:

- A fundamentally **different knowledge base** and **technical capabilities** that either *disrupt* or *complement* existing competencies and technologies, resulting in new combinations. For example, synthetic biology has a strong potential to revolutionise industrial and biological processes. However, innovation based on the technology is limited by a range of systemic factors such as regulatory barriers or a lack of coherence between research funding policies and product and safety regulations and technical and market risks (e.g. scale, financing).
- Changes in **consumer practices** and **markets**. The digitisation of commerce is an example of a change brought about by technology and changing consumer behaviour that results in companies' potential loss of control over consumers, increased competition, and the need to engage digitally with suppliers, partners and employees and consumers/citizens.
- Changes in **infrastructure** and other elements, including policy and culture. An example is modern mobility systems (i.e. e-mobility) that are evolving as a result of underlying changes in technology, ownership structure, consumer preferences and related changes in energy systems and their linkages to other systems.

Figure 2.5 presents a stylised pattern of transitions in socio-technological systems. Technological innovations arise first in niches then gather momentum and a dominant design emerges; the emergent dominant design interacts with the prevalent socio-technical regime and eventually breaks through. Pressures exerted by developments in the landscape (i.e. the general socio-economic context) may present opportunities to upset the status quo sooner; the absence of such pressures may thwart the transition. Breakthroughs are not guaranteed and, in practice, there are a variety of possible outcomes, as the impulses interact with existing technologies and actors in the system (e.g. fuel-cell-powered vehicle technology versus hybrid vehicles).

Figure 2.5. **A dynamic multi-level perspective on system innovations**



Source: OECD (2013), adapted from Geels (2002), p. 1263.

Recent policy trends

As many transitions have an explicit sectoral dimension, national policies may manage more than one transition at a time. To provide an overview of the kinds of policies mobilised, this section outlines recent policy trends aimed at moving to more environmentally sustainable economies (or "green growth"). It draws on national responses to the STI Outlook policy questionnaire 2014 and a series of case studies made as part of a larger OECD study on system innovation.

In facilitating the transition to the green economy, policy faces various challenges and sets objectives accordingly. In Denmark, the adaptation of existing production and consumption practices is an important objective of the Market Development Fund and the Fund for Green Business. In Finland, a key issue is the achievement of critical mass in research and innovation relevant to green growth. In Sweden, challenges are identified at the city level, with "Sustainable smart cities" featuring prominently among projects funded by the Challenge Driven Innovation (CDI) programme. Belgium's Smart City Mobility scheme has a similar outlook. Italy issued a USD 870 million PPP (EUR 655 million) call to boost collaborative research on Smart Cities in 2012. China's chief environmental objective (under its 12th Five-Year Plan 2011-15) is gradually to establish a carbon market, which represents a shift in policy attention to reducing dependency on fossil fuel and promoting higher-value added and more sustainable industries. Korea's green growth strategy takes a systemic approach to meeting sustainability goals combined with a new growth strategy.

Many other OECD countries have strategies to support this transition through a dedicated green economy agenda or as part of energy and industrial regeneration strategies. Finland is currently formulating a Bioeconomy Strategy to be published in 2014. Extensive inter-ministerial co-operation and consultation with key research actors sought to ensure that the strategy's systemic reach is comprehensive. In Austria, the Energy Strategy foresees actions to meet the EU's renewable energy goals by 2020, including the development of a support system (technology, education, internationalisation) for electro-mobility. Among the challenges for e-mobility are the need for international technology standards and the need to take account of consumer preferences. It is generally recognised that the transition to e-mobility will not simply be the replacement of one technology by another. Switzerland's Cleantech Masterplan 2011-14 aims to address the challenges of climate change and the growing scarcity of natural resources and to enhance Switzerland's innovative strengths by providing a framework for joint actions by the partners involved (federal offices, cantonal authorities, the economy, science and research, non-governmental institutions) to enhance public awareness and to monitor progress. There are similar strategies in Australia (CLEAN21), Belgium (PACT 2020, Flanders in Action, Marshall Plan 2 Green in Wallonia), Germany (Green Economy Agenda Process, Progress), Japan (Japan is Back, Low Carbon Technology Plan) and South Africa [Industrial Policy Action Plan 2 (IPAP2)].

A number of countries have dedicated R&D and innovation programmes or themes within existing programmes. In the United States the 2014 budget proposes USD 2.8 billion for the Department of Energy's Energy Efficiency and Renewable Energy Office (with a focus on improving clean-vehicle technologies to move closer to one million advanced vehicles on the road) and USD 2.7 billion for the US Global Change Research Program (USGCRP) to understand, predict, mitigate and adapt to global change. In France, re-industrialisation subsidies and export subsidies are available for companies developing environmentally friendly products. Dedicated research funding for environmental projects is also in place in Austria, Belgium and France.

Legislative and regulatory initiatives also facilitate the transition, such as the Federal Electricity Supply Act in Switzerland and the foreseen changes in national procurement legislation in Finland. Japan has a strong focus on public procurement. Its Green Public Procurement initiative is continuing, building on experience gained since the programme's launch in 2002. Korea has made green growth part of its national development strategy. On-going initiatives include energy plans, green towns and a smart grid roadmap. Low energy prices, the hidden costs of transition programmes, lack of market opportunities and weak consensus building with local communities create difficulties for the transition to sustainability. The modernisation of the energy sector is a key element of Italy's Sustainable Growth Agenda. The National Energy Strategy includes a series of measures to 2020 to ensure that the energy sector copes with the country's structural disadvantages and improves environmental, security and safety standards.

The emergence of cities as actors in the transition to sustainability has given rise to a range of smart cities initiatives such as Finland's National Innovative Cities (INKA) programme; the Tekes Witty City programme and Germany's National Platform for Future Cities, whose overall goal is to make cities CO_2-neutral, energy-efficient and climate-adapted. Major stakeholders in this process are city administrations, research institutes, companies and the central government. Improving urban housing renewal and waste management systems is the focus of smart city initiatives in Sweden and Belgium. Sweden's Malmö Innovation Platform uses the renovation plans of the Swedish Million Programme as a model for a more general shift towards a sustainable city.

Improved governance mechanisms and better means of engaging a range of stakeholders are needed to facilitate system innovation. Finland and the Netherlands have public-private partnerships to foster co-ordination and alignment [Strategic Centres for Science, Technology and Innovation (SHOKs) in Finland and the Top Sectors approach in the Netherlands]. To improve the impact of government interventions on environmental challenges and to facilitate the transition to a low carbon economy, the UK Low Carbon Innovation Co-ordination Group co-ordinates the efforts of organisations with public-sector backing. Collectively the group's members are expected to spend over USD 1.45 billion PPP (GBP 1 billion) on related innovation activities. In Germany, initiatives such as the Energiewende Research Forum, the Koordinierungskreis Forschung and the Science Academies' "Energy Systems of the Future" Project foster dialogue and co-ordination of research, government, society and industry stakeholders for the common goal of transforming the energy system. In 2014 Italy will host the third European Bioeconomy Stakeholders' Conference. The conference will work to increase understanding of the bioeconomy as an interconnected system and to inspire actors to take further concrete actions to build the bioeconomy in Europe.

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Strategic public/private partnerships

Rationale and objectives

For governments, public-private partnerships (PPPs) in science, technology and innovation can help make research and innovation policy more responsive to the changing nature of innovation and to social and global challenges. For business, partnering with public research can help solve problems, develop new markets or generate value through co-operation and co-production. Traditionally used for physical infrastructure, PPPs are increasingly popular in R&D and innovation policy because they are better adapted to some innovation goals or challenges than policy instruments such as subsidies or tax credits.

Partnerships can take many forms, from a partnership between a single company and a single university on a research project with specific short-term goals to the creation of physical research centres with a specific mission (e.g. development of vaccines) and long-term mandates, to large infrastructure projects with a longer-term horizon and broad networks. For practical purposes, the OECD defines PPPs in STI as "any formal relationship or arrangement over fixed-term/indefinite period of time, between public and private actors, where both sides interact in the decision-making process, and co-invest scarce resources such as money, personnel, facility, and information in order to achieve specific objectives in the area of science, technology, and innovation" (OECD, 2005). PPPs may combine both hard and soft elements (e.g. creation of a joint research centre and provision of training). They can have specific targets or goals (e.g. vaccines for certain diseases, development of renewable energies).

The fundamental rationale of most PPPs in research and innovation is to harvest broader economic and social benefits from investments in public research by: *i)* improving the leverage of public support to business R&D by sharing costs and risks; *ii)* securing higher-quality contributions from the private sector to government mission-oriented R&D and increasing opportunities for commercial spillovers from public research; *iii)* fostering the commercialisation of results from public research; and *iv)* upgrading knowledge infrastructures. PPPs are perceived as a more adaptive tool than traditional subsidies for achieving such objectives in an environment in which the nature of R&D and innovation processes is changing (e.g. increased user-centred content, higher dependency on external sources of knowledge and know-how, as illustrated by open innovation approaches), and business R&D strategies and social needs are rapidly evolving (e.g. ageing population, the environment, sustainable cities). The need to connect science to innovation to meet global challenges has become particularly pressing. Finally, PPPs are a useful policy tool in demand-side innovation policy such as public procurement of innovation or in efforts to foster smart specialisation strategies in regions.

Major aspects

PPPs have been used for many years in various research areas or industrial sectors. In Finland, Tekes partnership programmes have carried out R&D involving businesses and research groups since 1983. At the EU level, joint technology initiatives (JTIs) were set up for certain focus areas of the 7th Framework Programme, with the European Commission and industry jointly funding strategic research and innovation agendas (EC, 2013). As far back as 1980, Japan established the New Energy Industrial Technology Development Organisation to promote the development and introduction of new energy technologies through the combined efforts of industry, academia and government. In most countries, these collaborative research or innovation efforts are carried out under a joint governance board with representatives from all partners and are co-financed by private partners in order to share risks and gain prior commitment. Over the same period, the Dutch government has supported PPPs in structures such as innovation-oriented research programmes, leading technological institutes and interdisciplinary multi-actor programmes funded from national gas revenues (the so-called BSIK and FES investment impulses). The PPPs may or may not be institutionalised in a designated entity such as a research centre. Organisationally, PPPs may be small-scale (temporary) projects or large-scale, longer-term joint ventures with multiple (public and private) members and stakeholders. These characteristics distinguish PPPs from pure contract research.

One particularity of PPPs in the area of STI, as compared with other fields, is that many of the public assets involved are intellectual assets such as intellectual property, databases, human capital or software with particular characteristics. They therefore require financing and governance rules for sharing and developing this "soft infrastructure" that differ from those for physical infrastructure (e.g. buildings and laboratories or large computer infrastructures). The process of innovation and technology development is also extremely complex, involving standards setting, management of IPRs and consumer acceptance. Many PPPs in the STI area tend to involve a broad range of stakeholders. For example, the Magnet consortium in Israel consists of a number of firms together with research personnel from at least one academic or research institution, and all partners sign an agreement which ensures them the rights to the intellectual property created by the consortium.

Recent policy trends

The rise in PPPs in STI is being driven by factors such as budgetary constraints, the new public management ethos, and the fact that research and innovation are increasingly co-operative and network-based. Business R&D strategists are pursuing open innovation and collaborating with universities and government labs. Policy makers increasingly rely on PPPs as an instrument of innovation policy as well as a means of attracting private funding. For example, RETOS-COLABORACION Call in Spain is an instrument for public-private collaboration to increase the participation of private funding in innovative activities, facilitate company access to public research and foster the development of technology-based companies and young innovative companies. Indeed, PPPs have become a mainstream instrument in many areas of STI policy, from the funding of thematic research programmes to the promotion of downstream business innovation activities, and have continued to expand in OECD and non-member countries. The United Kingdom has a Biomedical Catalyst programme to support innovative ideas in the biomedical sciences and to bridge the financing gap. Malaysia's mission-oriented innovation policy and its R&D programmes use PPPs in the life sciences, ICTs, agriculture sciences or engineering, environmental sciences and advanced materials science. Costa Rica supports collaborative R&D via a non-refundable fund to promote business innovation.

Most countries have seen a rise in PPPs in the STI area that are strategic, long-term, large-scale, high-risk and multidisciplinary and involve diverse stakeholders (government, business, universities, non-governmental organisations). For example, the Czech Republic has a Centres of Competence programme to create conditions for the development of long-term public and private collaboration on R&D and innovation. In the Dutch top sectors approach, each sector is governed by a team consisting of firm representatives, an SME, an academic and a high-ranking government official. This is an important principle of a new governance approach and implies strong involvement of the private and academic sector. These PPPs concern broad, emerging scientific and technological fields such as nanotechnology additive manufacturing (e.g. 3D printing) or seek to address global challenges. They are initiated by government and usually aligned with national and ministerial innovation strategies (e.g. re-industrialisation, green growth, competitiveness). They typically involve a broad network of actors, large investments over a long period and a high level of uncertainty regarding economic return. This uncertainty is especially pronounced in knowledge- and R&D-intensive sectors, and is intensified by technological convergence, the declining costs of acquiring external R&D and knowledge inputs, and reduced product cycle times. The United Kingdom's Strategy for Agricultural Technologies exemplifies the industrial competitiveness, value chain orientation and challenge-driven approach to partnering with industry. It is to be "led by industry, working in partnership with the public and third sectors, to unlock long-term investment by businesses, private investors, foundations and trusts, and Government, as well as seeking long-term, sustained growth in inward investment in the sector".

A common concern for policy makers is to ensure "value for money" from the use of PPPs. Yet in the STI area, value for money may not always be the main purpose of PPPs; partnering for research breakthroughs and more radical innovation in high-risk areas may be the main goal. For example, Switzerland has implemented bilateral collaborations with Germany, the Netherlands, Sweden and Turkey that aim to promote networking and joint R&D projects. Norway has a funding initiative for regional R&D and innovation to strengthen regions' innovative capacity and promote new forms of co-operation between public and private research; it offers professional and financial support to long-term, research-based development processes in the regions. Japan has a programme focused on interdisciplinary R&D projects with a ten-year horizon. Its governing board consists of leaders from academia and industry. Germany's Industrial Collective Research Scheme (IGF Research Scheme) and the Carnot institutes in France target SMEs. Denmark has tried to address the lack of a comprehensive framework for PPPs by developing national guidelines for innovation consortia.

There is also an international dimension to PPP policy development. Research and innovation are increasingly international but differences in legislation, rules and procedures for PPPs in OECD and non-member countries may make the establishment of cross-border PPPs difficult. These differences make the management of PPPs in the STI area more complex than in other areas and deserve particular attention from policy makers. At the EU level, where the scale of investments required for certain large projects is beyond the means of individual member states, PPPs represent a promising approach to research and innovation policy. PPPs in fact feature prominently in the toolbox of Horizon 2020 programmes.

Table 2.1. **Major types of PPPs in STI and examples of programmes**

Issues	Key challenges	Selected country examples
	Time frame for PPPs	
Long-term/No limited period	End-user challenges, application-orientated basic research	Australia (CRC programme), Austria (CDG), Czech Republic (centres of competence), Germany (Forschungscampus), Italy (national technological platforms)
	Global challenge, societal challenge	France (Thematic programmes), Japan (COI programme), Norway (FME)
	Novel/emerging technologies	Chile (Technological Consortia 2.0), Japan (S-Innovation), United States (AMP), United Kingdom (A UK Strategy for Agricultural Technologies)
Short to medium term	Commercialise rapidly	Greece (Co-operation 2009)
	Scale/governance of PPPs	
Separate governance	Managing financial support and monitoring the structure separately from implementing R&D	Austria (COMET), France (Carnot Label), Ireland (Research Prioritisation Initiative), Japan (NEDO, JST)
Joint board	A board with representatives from all partners to define research agenda, develop project plans, etc., to meet stakeholders' needs	Austria (CDG), Ireland (research prioritisation initiative), Netherlands (top sectors), United States (AMP)
Regionally lead	To increase the visibility of the region, to create economic value in the region, to strengthen the region's innovative capacity	Belgium (Strategic Platforms), Colombia (UCSE), Ireland (Technology Gateway), Norway (VRI), Slovak Republic (RIS3 SK)
	Partners in the PPPs	
Firms	To reinforce SMEs' innovation capacity and bring their innovative ideas to market more quickly	Belgium (VIS), France (Laboratoires Communs), Germany (IGF Research Scheme), Switzerland (CTI projects)
Public research institutes/universities	To exploit commercial possibilities of the research	Czech Republic (GAMA Programme), Israel (MAGNET), Poland (Initech Project), South Africa (CoCs), Spain (CENIT, CIEN), Turkey (TUBİTAK 1505)
Civil society	Training of human resources, mobility of students and researchers, participation of end users	Australia (ITRP), Canada (NSERC Strategy for Partnership and Innovation – SPI), Ireland (Industrial Partnership Research Supplements Programme), Italy (Integrated Projects for Support to Industry), Japan (Programme for Promoting Self-sustained Management of Industry-Academia-Government Collaboration in Universities), Norway (Industrial PHD Training), South Africa (THRIP)
	Financing modes	
Competitive grant	To ensure transparency of the process	Australia (JRE), France (ANR programmes), Spain (Retos Colaboración), United Kingdom (Biomedical Catalyst)
Private contribution	To gain prior commitment by the business community	Most countries (50% of the total cost, less contribution in case of SMEs, in-kind, etc.)

Source: OECD STI Outlook policy questionnaire 2014 except United Kingdom (A UK Strategy for Agricultural Technologies) and United States (AMP).

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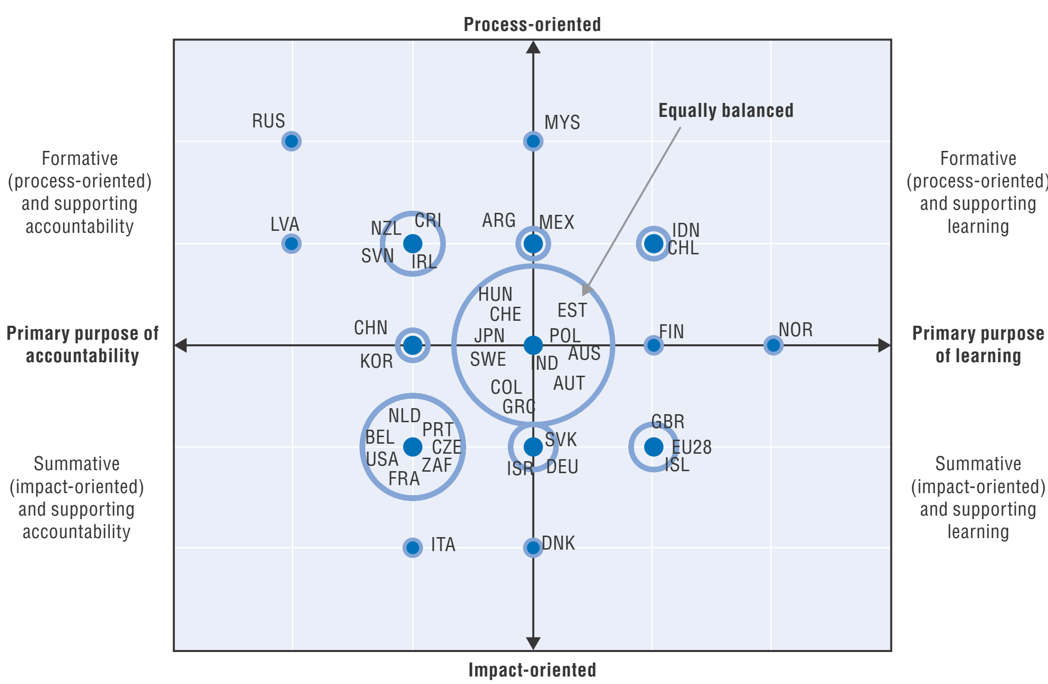
Impact assessment in STI policies

Rationale and objectives

Impact assessment (IA) is an important preoccupation of much evaluation in the STI policy field, as shown by country responses to the OECD STI Outlook policy questionnaire 2014 (Figure 2.6). Through IA exercises, policy makers aim to better understand, identify and often quantify the causal relationships that link inputs (e.g. investments in R&D) to different actors (e.g. ministries, R&D agencies, firms) and to their impact on output and outcome measures (e.g. economic growth, improvements in health, environmental and living standards or broader societal changes). The rationales for such assessments include: to fine-tune and improve existing policy interventions; to inform spending priorities and focus future policy interventions on areas with the greatest expected impact; and to hold actors accountable for their performance and spending.

Figure 2.6. **Primary purposes and orientation of STI policy evaluation, 2014 (based on own country ranking)**



Note: A summative evaluation measures the impact a policy programme may have upon the problems it addressed. A formative evaluation monitors the way in which a programme is being administered or managed so as to improve the implementation process.

The primary purpose and orientation of STI policy evaluation are defined by country self-assessment answers to the question: "What are the major trends (over the past 5 years) of STI policy evaluation and impact assessment (IA) in your country? Have the purposes of evaluation (learning versus accountability) changed in the last five years? Have the orientation of evaluation (summative versus formative) changed in the last five years?" Responses are provided by Delegates to the OECD Committee for Scientific and Technological Policy.

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

StatLink http://dx.doi.org/10.1787/888933151654

Important to the success of IA is the use of the results in policy making. In this regard, it is important to understand use in a broad sense, recognising that while the results of IA may be used by policy makers and programme managers in decision making, they may also influence policy in less direct ways, for example, by diffusing key concepts and ideas that "enlighten" policy actors. Still, while many countries report using evaluation results when shaping policy, under-utilisation is not uncommon, particularly where evaluation practices and routines are still emerging.

Major aspects

A key concept in IA is "additionality", which refers to the changes that can be attributed to the policy intervention. Among these is "behavioural additionality", which concerns itself with sustained changes in the behaviour of target groups that are induced by contact with the policy intervention (OECD, 2006). Accurately attributing observed outcomes to the public intervention being assessed is always a challenge. Two countervailing tendencies are common: first, the so-called "project fallacy", whereby outcomes that are in reality cumulative and dependent upon the interaction of several factors are wholly (or mostly) attributed to the intervention assessed; and second, a tendency to under-estimate the effects of an intervention because the focus of the IA is too narrow or because of the timing of the assessment, as the full effects might not yet be felt. Awareness of these tendencies is important, even if the problems they create cannot be fully solved.

As a concept, "impact" can mean different things to different audiences (Gluckman, 2014) and different types of impacts can be assessed for a variety of specific policy needs. Economic impacts, for instance, are measured in terms of changes in a wide array of financial, productivity or budgetary metrics (e.g. revenues, profits, prices, labour productivity, business start-ups, export volumes, employment levels, aggregate GDP, etc.) at very different levels of aggregation (e.g. from the household to the firm up to the national and macro aggregate level). Environmental impacts are usually assessed in terms of the overall management of the environment, the reduction of pollution and the efficient use of natural resources. Health impacts measure, among others, the increase in life expectancy, the prevention of illness, or the overall sustainability of national healthcare systems. Social impacts measure the effects that the policy intervention has on welfare, well-being, habits or other social dimensions such as practices and activities of groups of people, consumption patterns, work-life balance, and so on.

Recent policy trends

Many countries have given greater attention to assessing the impact of public investments in research and innovation in recent years. This has coincided with increased political interest in the economic impacts of innovation policies and the growing need to use over-stretched public STI financing more efficiently and to allocate resources more effectively to meet the demand and needs of the economy and society.

IA can be prospective in order to identify the expected impacts of policy interventions. It is particularly useful for establishing clear and measurable objectives upfront when developing a policy, and for setting data collection requirements to ensure that outcomes can be measured effectively. In Australia, the Department of Industry's Evaluation Unit works with line areas to develop performance indicators and data collection methodologies. For example, it conducts programme logic workshops to help policy developers link programme drivers and activities with anticipated outcomes.

IA is more commonly thought of as a retrospective activity focused on identifying the impacts of a completed or ongoing policy intervention. As noted above, an important consideration in this case is when to conduct an assessment, given the time required for the impacts of many policy interventions to be perceived. One approach is to stagger IA over two or more points in time so as to capture both more immediate and longer-term impacts. Australia has a rolling programme of IA studies that subject every policy initiative to review every three to five years. The impact assessment of user-oriented programmes in Norway (Hervik, 1997; Hervik et al., 2012) is another example of on-going efforts to measure impacts over time in order to capture shorter and longer-term impacts.

Various quantitative and qualitative methods are used to measure impacts. Case studies, surveys and participatory methods usually complement the quantitative analysis provided by econometric models, regression analysis or bibliometric approaches to provide policy makers with a broader overview of impacts. In the Netherlands and the United Kingdom, greater attention is being given to the use of control groups and experimental design methods in evaluations of business-oriented instruments, with a view to improving the measurement of their impacts (Warwick and Nolan, 2014).

Since IA can be expensive, some countries are exploring approaches that draw on existing administrative data ("big data"). Australia (Jensen and Lane, 2013) has recently commissioned a feasibility study on the introduction of a systemic mechanism for capturing and integrating administrative data collected by government departments and programmes, publicly funded research agencies and universities. Similarly, New Zealand is shifting its focus away from expensive and potentially unreliable data collected through surveys and towards using public administrative data more intensively. These approaches follow the lead of the United States, which, since 2010, has been establishing a data infrastructure called STAR METRICS to link inputs to outputs and outcomes of S&T policy automatically, utilising existing datasets with minimal burden on research institutions and federal agencies.

Several countries indicate an interest in developing better quantitative indicators in support of IA. Such indicators have the advantage of supporting benchmarking (internationally, but also between national programmes) and assessments of changes over time. At the same time, some countries express concerns that this may go too far. The Czech Republic's desire to de-politicise and depersonalise R&D funding processes has led to strict reliance on quantitative indicators for evaluating R&D programmes and R&D organisations, but this has led to a narrow perspective that neglects the R&D system's contribution to satisfying societal needs. In Finland, there are calls for evaluation to pay more attention to the soft dimensions and processes of STI actions and programmes and to focus less directly on the money spent, objectives reached and outputs attained.

The capabilities to carry out IA (and evaluation more generally) are weakly developed in some countries. In Colombia, these capabilities, in terms of available information and specialised institutions, including universities and consultants, are still in their infancy. In Malaysia, regular evaluation of STI policies, programmes and institutions has not featured prominently, which has hampered the development of a more informed policy-making process. In Russia, evaluation routines are rather weak and evaluation practices are not widely embedded, and in South Africa, IA is not yet broadly implemented.

The feasibility and appropriateness of using IA depends not only on the competency to carry it out but also on the ability to utilise its processes and results to inform future policy interventions. The intended and actual use of IA results depends on its purpose, its scope, its timing, and the political-institutional context. Many IA studies are quite limited in scale and scope and targeted at the technical level of officials in ministries and funding agencies. In China, the majority of such studies are for internal use by S&T policy managers and are not published; they are used primarily to support the re-design of programme and policy instruments, and to inform the development of science and innovation priorities and strategies. In Denmark, France and New Zealand, IA results are aggregated and synthesised in summary reports for wider consumption by government ministers, parliamentarians and other stakeholders. In Denmark, for example, IA results have been used in this way to justify and legitimise, for politicians and the general public, the use of public research and innovation funds. Likewise, in Israel, IA results that show high returns on governmental investments in R&D have been used to convince the government to increase R&D budgets.

The utilisation of IA results may also be indirect. Results may contribute to the accumulation of knowledge through "trickle down" effects (Austria) and to a better level of knowledge among key stakeholders (Denmark). Knowledge accumulation can sometimes be tangible: in Australia, a database of evaluations is available to Department of Industry staff to review key findings and recommendations on areas previously reviewed.

Some countries are also looking to improve the utilisation of IA findings. Norway has placed greater emphasis on the follow-up and use of evaluation results, prioritising evaluations according to the need for knowledge and their perceived usefulness. In Japan, the recently revised National Guidelines for Evaluating Government Funded R&D require funding organisations to use evaluation results to review their R&D programmes. Moreover, they must demonstrate to the Japanese public how evaluation results have been used. For its part, Korea has sought to strengthen the impact of IA results by formally linking them to R&D budget allocations and the salaries of directors of PRIs.

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ANNEX 2.A

Comparative table of national STI strategies or plans, OECD countries and some major non-OECD economies, 2014

National STI plan(s) or strategy	Period covered	Main objectives
		Argentina
Innovadora 2020	Up to 2020	Extend the scope of the former Plan PNCTI (2012-15) in order to cover a decade.
National Plan for Science, Technology and Innovation (PNCTI)	2012-15	Promote the transition towards further knowledge-based societies and economies by enhancing national S&T capabilities: *i)* improve national economic competitiveness; *ii)* increase quality of life and foster social development; *iii)* support sustainable development mainly through the protection of natural resources.
Bases for an STI Strategic Plan	2005-15	*i)* Increase consistency and social equality; *ii)* promote sustainable development; *iii)* move towards a new productive specialisation profile, with further incorporation of knowledge; *iv)* foster access to a knowledge-based society and economy.
		Australia
AUD 100 million Growth Fund	2014-15	Support initiatives in regions facing pressure in their manufacturing sectors, including support for business and R&D, grants to aid the commercialisation of R&D in the automotive component manufacturing sector and lead to new products or processes.
Research Workforce Strategy	2011-20	A vision for 2020 of a strong and productive Australian research workforce with the skills required to support innovation. Maps out Australia's research needs and provides a comprehensive plan to match Australia's capabilities to its innovation goals.
National Industry Investment and Competitiveness Agenda	2014 onwards	Promote national competitiveness and productivity, including options to encourage innovation, support for R&D and the commercialisation of good ideas. A Ministerial Taskforce has been established to develop the National Industry Investment and Competitiveness Agenda.
		Austria
Becoming an Innovation Leader: Realising Potential, Increasing Dynamics, Creating the Future	2011-20	Be one of the EU's most innovative countries EU by 2020 and among the "Innovation Leaders": *i)* a well-equipped education system; *ii)* basic research as a fertile ground for the innovation system; *iii)* intensified R&D activities in companies ensured by knowledge transfer between scientists and businesses; *iv)* new framework conditions and funding governance structures, and distribution of responsibilities in a multi-level political system, from regional co-ordination to internationalisation; *vii)* efficiency and effectiveness of funding, as well as the principle of competition-based funding allocation. *Quantitative target:* ● Raise R&D expenditures to 3.76% of GDP by 2020.

		Belgium *(Federal government)*
Federal Government Agreement	Since 2008	Reduce costs of researcher employment (through tax allowance on R&D wages) and increase the commercialisation of research. *Quantitative targets:* ● Raise R&D expenditures to 3% of GDP by 2020.
		Belgium *(Brussels Capital)*
Regional Innovation Plan – Innovative Brussels	2013-20	A focus on regional R&D strategic platforms, development of clusters and identification of potential niches for specialisation through: *i)* financing of innovation and seed funding; *ii)* assistance and support for innovative companies; *iii)* increasing the availability of human capital by encouraging scientific, technological and entrepreneurial careers; *iv)* innovative public procurement; *v)* joint development of innovation (e.g. living labs); *vi)* promotion of the image of "innovative Brussels"; *vii)* increased European support to the Region; *viii)* strategic monitoring and analysis; *ix)* evaluation of RDI policy; *x)* strengthening of the Scientific Policy Board (CPS); *xi)* co-operation with other Belgian regions. *Quantitative targets:* ● Raise R&D expenditures to 3% of GDP by 2020.
Smart Specialisation Strategy	Forthcoming	Identify sectors in which the region will invest, reshape and adapt financial measures and instruments, and rethink a governance model. Priority sectors: ICT, life sciences, environment.
		Belgium *(Flanders)*
Flanders in Action (Vlaanderen in Actie – ViA)	2009-20	Seven breakthroughs. The Breakthrough on Innovation Centre Flanders states that Flemish policy should : *i)* boost investment in higher education institutions (up to 2% of GDP); *ii)* focus on key areas to boost creativity and innovative capacity; *iii)* give more attention to research outputs; *iv)* provide more opportunities for research; *v)* simplify the set of innovation policy instruments. *Quantitative targets:* ● Raise R&D expenditures to 3% of GDP.
Pact 2020	2009-20	Monitor progress towards ViA targets in 20 thematic chapters, including one on innovation. *Quantitative targets:* ● Raise R&D expenditures to 3% of GDP by 2020 ● Raise education investments to 2% of GDP by 2020.
Concept Note on Innovation – Innovation Centre Flanders	Since 2011	A framework for research, with six innovation hubs focused on societal challenges and their link with the fundamentals of the Flemish STI system. Priority areas: transformation (of the economy) by innovation, eco-innovation, energy-innovation, care-innovation, sustainable mobility and logistics, social innovation.
Foresight study	Up to 2025	Establish STI priorities to help address grand societal challenges through a model with transition areas and a strengths/weaknesses analysis of the current situation in Flanders. Priority transition areas: 1 horizontal transition area (Society 2.0), 6 vertical transition areas (e-society, food, health and well-being, smart resource management and manufacturing industries, urban planning, mobility dynamics and logistics, new energy demand and delivery).
		Belgium *(Wallonia)*
Marshall Plan 2. Vert (PM2)	2010-14	*i)* Competitiveness cluster policy; *ii)* strengthened R&D; *iii)* establishment of an appropriate framework for creating businesses and quality jobs; *iv)* strengthened human capital and vocational training; *v)* stronger focus on sustainable development and environmental issues. Six competitiveness clusters: BIOWIN (health), SKYWIN (aeronautics and spatial), WAGRALIM (agro-food), LOGISTICS IN WALLONIA (transport and logistics), MECATECH (Mechanical engineering), GREENWIN (Green technologies).
Strategy for an Integrated Research Policy	2011-15	Orientations of R&D support at the regional and community levels: *i)* improve the complementarity of available support tools; *ii)* strengthen investment in R&D to approach the goal of 3% of GDP; *iii)* encourage partnerships for research support and optimise tools for exploiting research results; *iv)* increase the presence of Wallonia on the international scene; *v)* strengthen human resources for research by raising awareness of S&T professions; *vi)* target funding to a limited number of strategic areas; *vii)* make systematic evaluations of results of R&D support programmes. Five research priorities: sustainable development, renewables, technology research, quality of life in the context of ageing societies, health. *Quantitative targets:* ● Raise R&D expenditures to 3% of GDP by 2020. ● Some targets in the PM2. Vert (number of people involved in awareness initiatives for S&T professions, number of programmes or mandates funded, number of companies active in European research programmes).
Creative Wallonia Action Plan	2010-15	Put creativity and innovation at the heart of economy and society. Three main axes: *i)* stimulating creative society; *ii)* encouraging innovative practices; *iii)* support for innovative production. Some 20 actions already implemented, including: university courses; co-working spaces; "smart work centres"; an observatory of trends; a support tool for the start-up of innovative processes (Boost-up/Creative Industries and Crossmedia); a plan for development of connectivity in Wallonia.

	Brazil	
National Strategy for Science, Technology and Innovation (ENCTI)	2012-15	Decrease the technological gap through science and innovation; increase international presence; promote a green economy; contribute to eradicating poverty and decreasing social and regional inequalities by: *i)* increasing resources for financing innovation; *ii)* expanding and strengthening infrastructure for S&T research; and *iii)* increasing support for human resources capacity building in strategic fields, especially engineering. Priority areas: renewable energy, subsea oil, health, biodiversity, climate change, defence, nuclear, space and social technologies. *Quantitative targets:* ● Raise R&D expenditures to 0.9% of GDP by 2014.
Great Brazil Plan – Plano Brasil Major (PBM)	2011-14	Negotiation forum; no financial resources committed.
	Canada	
Mobilizing Science and Technology to Canada's Advantage	Since 2007	*i)* Promote world-class excellence; *ii)* focus on priorities; *iii)* foster partnerships; *iv)* enhance accountability.
Science, Technology and Innovation Strategy	Forthcoming	Updated Science, Technology and Innovation Strategy.
	Chile	
Growth, Innovation and Productive Agenda	Since 2014	*i)* Facilitate and encourage diversification and productive development, *ii)* promote economic sectors with high growth potential, *iii)* increase firms' productivity, *iv)* boost exports. Include priority sectors for social and economic development.
"**Surfing towards the Future: Chile on the 2025 Horizon**"	2014-25	Consider future "strategic orientations" rather than specific guidelines for action with cultural issues one of the main challenges for Chile. Priority areas: energy, biology and education.
National Innovation Strategy for Competitiveness – Innovation Plan	2010-14	Improve productivity and competitiveness as key drivers of growth and economic and social development by *i)* creating a culture of innovation and entrepreneurship, *ii)* increasing critical mass in scientific and entrepreneurial capacity, *iii)* removing bottlenecks to business creation and competitiveness, *iv)* encouraging global connections, *v)* improving technology absorption and transfer; and *vi)* generating, attracting and retaining top talent to become an innovation hub in South America. *Quantitative targets:* ● Raise R&D expenditures to 0.4% of GDP (indefinite).
	People's Republic of China	
Medium and Long-term National Plan for Science and Technology Development	2006-20	*i)* Enhance China's S&T and innovation capabilities; *ii)* use innovation as a tool to restructure Chinese industry and shift growth from investment-driven to innovation-driven; *iii)* build a conservation-minded and environmentally friendly society; and *iv)* enhance independent innovation capabilities as a national priority. *Quantitative targets*: ● Raise R&D expenditures to 2.5% of GDP by 2020. ● Rank among the world's top five in patenting and international citations.
12th Five-year Plan for S&T Development	2011-15	*i)* Improve indigenous innovation capability, especially in firms; *ii)* strengthen S&T competitiveness and international influence with a focus on development of human resources, creativity and innovation culture; *iii)* make breakthroughs in core and critical technologies in key areas to support economic restructuring; *iv)* develop a functional, well-structured and efficient national innovation system through reform of the public research and S&T governance systems and better co-ordination and collaboration among stakeholders. *Quantitative targets:* ● Raise R&D expenditures to 2.2% of GDP. ● Raise investment of large and medium-sized industrial enterprises in R&D to an average of 1.5% of their revenue. ● Increase proprietary core technologies. Increase the role of large-scale enterprises in driving technological innovation. Foster world-leading innovative SMEs. ● Raise the number of researchers to 43 out of every 10 000 employees. ● Raise the share of citizens with basic scientific proficiency to over 5%.

	Colombia	
National Innovation Strategy	Since 2011	*i)* High-quality human capital; *ii)* relevant science and technology; *iii)* private-sector innovation and entrepreneurship (including social innovation). Two enabling platforms: ICT/connectivity and innovation culture. *Quantitative targets*: ● Raise R&D expenditures to 0.5% of GDP. ● Raise doctoral grants to 3 000 in 2014. ● Raise the share of technologically innovative companies to 25% of firms in 2014.
Sectoral Strategic Plan for Science, Technology and Innovation	2010-14	*i)* Consolidate the National System for Science, Technology and Innovation (NSSTI); *ii)* increase human capital for research and innovation; *iii)* promote knowledge and innovation for production and social transformation. *Quantitative targets:* ● Raise R&D expenditures to 0.5% of GDP by 2014.
National Policy on Science, Technology and Innovation – CONPES-3582	2009	Generate economic and social development based on knowledge.
	Costa Rica	
National Science, Technology and Innovation Plan (PNCTI)	2011-14	*i)* Strengthen national STI capacities and their role in productivity and socio-economic development by improving the allocation of investments; *ii)* reinforce high-level human resources in basic sciences and engineering; *iii)* promote social appropriation of science, S&T vocations and the spirit of entrepreneurship; and *iv)* strengthen the institutional framework of the STI sector.
	Czech Republic	
National Innovation Strategy	2012-20	Raise the importance of innovation and use top-of-the-range technologies as a source of competitiveness and increase their contribution to long-term economic growth, high-quality jobs creation and the development of quality of life in the Czech Republic through *i)* excellent research; *ii)* co-operation between research institutions and enterprises; *iii)* innovative entrepreneurship; *iv)* human resources as originators of new ideas and initiators of changes.
International Competitiveness Strategy	2012-20	Strengthen the competitiveness of the Czech economy in nine pillars: institutions, infrastructure, macroeconomics, health care, education, labour market, financial markets, business environment and innovation. Institutions, infrastructure and innovation ("3i") are considered the most important areas for future competitiveness. Create friendly conditions for creative business, innovation and growth.
National Research, Development and Innovation Policy (NRDIP)	2009-15	Improve conditions for innovation, knowledge transfer and diffusion of frontier technologies as key sources of economic growth over the long term through: *i)* supply of high-quality human resources; *ii)* improved framework for transfer and use of knowledge; *iii)* increased innovative capacity in the business sector; and *iv)* better strategic management of the system. Updated with an outlook to 2020. *Quantitative targets:* ● Raise R&D expenditures to 2.7% of GDP by 2020. ● Raise government spending on R&D to 1% of GDP by 2020.
Reform of the Research, Development and Innovation System	Since 2008	Increase the competitiveness of the Czech economy and improve the quality of life in the Czech Republic through institutional arrangements, legislative changes regarding public support of R&D and funding to: *i)* improve efficiency and simplify R&D support; *ii)* support excellence in R&D and facilitate application of R&D in innovation; *iii)* strengthen co-operation with users of R&D results based on co-financing from public and private resources; *iv)* improve organisational flexibility of public research institutes; *v)* ensure a supply of HRST; and *vi)* increase involvement in international co-operation.

	Denmark	
The Innovation Strategy – Denmark: A Nation of Solutions		Ensure that the substantial public investments in research, innovation and education translate into more growth and jobs and help find solutions to global societal challenges through: *i)* a more demand-driven innovation policy; *ii)* increased exchange of knowledge and greater focus on innovation competencies in education. Central initiatives are the reform of the Research and Innovation Council, the Societal Innovation Partnerships and the INNO+ catalogue, which identifies promising areas for strategic investments in innovation.
RESEARCH2020 (Forsk2020)	Since 2012	Find the most promising research areas for growth, employment and welfare using major societal challenges as a starting point and the basis for decision on strategic funding of research. RESEARCH2020 replaces RESEARCH2015. *Quantitative targets (by 2020):* ● Raise R&D expenditures to 3% of GDP. ● 95% of a youth cohort to complete an upper secondary education programme. ● 60% of a youth cohort to complete a higher education programme. ● 25% of a youth cohort to complete a long-cycle higher education programme.
	Estonia	
R&D and Innovation Strategy – Knowledge-Based Estonia (KBEIII)	2014-20	Create favourable conditions for increased productivity and standard of living, good education and culture, preservation and development of Estonia. *Quantitative targets (by 2020):* ● Raise R&D expenditures to 3% of GDP. ● Raise business expenditures on R&D to 2% of GDP (2/3 of GERD).
Entrepreneurship Growth Strategy	2014-20	Raise productivity and employment through a single strategic framework that ensures coherence of entrepreneurial and innovation policies. Focuses on areas (smart specialisation) and groups of enterprises with major potential.
R&D and Innovation Strategy Knowledge-Based Estonia (KBEII)	2007-13	Ensure high-quality R&D, increase business-sector innovation and value added and establish Estonia as an innovation-friendly country through: *i)* development of human capital; *ii)* more efficient organisation of public sector R&D&I; *iii)* increased innovation capacity of enterprises; *iv)* policy making aimed at long-term development of Estonia. *Quantitative targets (by 2020):* ● Raise R&D expenditures to 3% of GDP. ● Raise business expenditures on R&D to 1.6% of GDP (half total R&D expenditures).
Research Infrastructures Roadmap	Since 2010	Focus on 20 research infrastructures of national importance, either new or in need of upgrading and Estonian priorities in pan-European partnership projects.
	Finland	
Action Plan for Research and Innovation Policy (TINTO)	Since 2012	*i)* Encourage constant renewal and the transcending of boundaries and the courage to experiment and take risks; *ii)* Make faster, more efficient use of research outcomes and strengthen the social impact of STI policy by broadening the scope of innovation activities; *iii)* ensure long-term basic funding for universities and public research institutions; and *iv)* use competitive research funding more strategically to boost the exploitation and social impact of research outcomes.
Research and Innovation Policy Guidelines	2011-15	Enhance competitiveness and the knowledge base to create a world-class basis for expertise and business activities through: *i)* a change the public sector's operating culture to match the new role of government in R&D and innovation; *ii)* a broad-based innovation policy (e.g. tools for demand and user-driven innovation; public procurement; regulatory framework issues, lead market initiatives); *iii)* a new R&D tax incentive scheme for companies and tax incentives for private VC investors; *iv)* support for new growth-oriented young companies; *v)* continued structural development of PRIs and establishment of a national infrastructure policy. *Quantitative targets:* ● Maintain R&D intensity at 4% of GDP to 2020 (public R&D funding at 1.2%).
Internationalisation of Education, Research and Innovation (ERI)	2010-15	*i)* Secure financing and human resources; *ii)* create and maintain infrastructures; *iii)* speed up the internationalisation of PRIs and enterprises; *iv)* promote networking and risk-taking.

	France	
National Research Strategy (SNR)	2013-18	Identify ten societal challenges, and define a research strategy for each challenge, a strategy for large equipment, a limited number of major scientific and technological priorities and some steering rules. The ten challenges: sustainable resource management and adaptation to climate change; safe, effective and clean energy; stimulate industrial revival; health and wellness; food security and demographic challenge; sustainable mobility and urban systems; information society and communication; innovative, integrative and adaptive societies; spatial ambition for Europe; freedom and security for Europe, its citizens and its residents. *Quantitative targets:* ● Raise R&D expenditures to 3% of GDP by 2020.
Plans for Industrial Recovery	Since 2013	34 plans to define innovation-focused strategies for industrial sectors, to support existing industries and prepare tomorrow's industry. Development of sectoral contracts in partnership with entrepreneurs and guidelines for funding bodies.
Innovation 2030	2013	Major innovations to meet the needs of tomorrow's society: innovation competition, public procurement, equity participation but also standardisation activities, specific regulatory simplifications, appropriate training, experiments, etc.
National Strategy for Higher Education (SNES)	2014-18	Develop five major objectives regarding future challenges: *i)* raise the general level of knowledge and skills; *ii)* promote equality of opportunities; *iii)* include training in the European area of higher education; *iv)* make better use of training for employability, *v)* renew the governance of higher education.
"A New Deal for Innovation" (report)	2013-14	Strengthen the capacity for growth through innovation in France by: *i)* organising and evaluating public policies for innovation (e.g. establishment of a commission for the evaluation of innovation policies); *ii)* developing a culture of entrepreneurship and innovation (e.g. New Argonauts programme, a EUR 10 million "Young Entrepreneurs Award" for selected start-ups); *iii)* increasing the economic impact of public research through transfer (e.g. Partnership for Open Innovation); *iv)* supporting business growth through innovation (e.g. Nova plan for innovative SMEs, French Tech project for digital technology, large venture fund by BPI, sovereign fund for industrial property).
	Germany	
Expansion of the High-Tech Strategy	Under development	Expansion of the High-Tech Strategy into a more comprehensive and application-oriented interdepartmental innovation strategy. Will cover both technological and societal innovations with the aim to transform research results better and faster into practice.
High-Tech Strategy	2006-13	Gear research and innovation policy towards a number of central missions and adopt an integrative approach by *i)* identifying key technologies that support the emergence of lead markets; *ii)* linking up topics in various fields of innovation policy across federal ministries; *iii)* addressing aspects of funding in connection with efforts to improve general conditions; and *iv)* defining specific missions, so-called "forward-looking projects" (*Zukunftsprojekte*). Related innovation strategies form the basis of roadmaps for achieving interim milestones. Priority areas: health, nutrition, energy, climate change, mobility, communication and security. *Quantitative targets:* ● Raise R&D expenditures to 3% of GDP by 2020.
	Greece	
Strategic Plan for Research, Technology and Innovation	Forthcoming	New legal framework for research and technological development (including a National Strategic Framework for Research, Technological Development and Innovation and a National Action Plan for its implementation) to replace the existing legal framework in order to address emerging STI policy issues and long-term challenges in Greece.
Action Plan for Research and Technology	Forthcoming	Establish more favourable conditions for R&D&I and the exploitation of new knowledge; establish a variety of incentives to promote investments by the private sector; simplify financing procedures and facilitate the activities of research organisations.
National Strategic Plan for Research and Development	2007-13	Increase and improve investments in knowledge and excellence with a view to sustainable development and innovation: *i)* support scientific/research personnel and research infrastructure; *ii)* link research with industry; *iii)* strengthen international R&D orientation; and *iv)* increase dissemination of research results on all issues related to science in society to generate economic and social value. *Quantitative targets:* ● Raise R&D expenditures to 1.5% of GDP by 2020.

		Hungary
National Research and Development and Innovation Strategy – Investment in the Future	2013-20	Focus on utilisation-oriented R&D and innovation activities of companies through: *i)* internationally competitive knowledge bases that underpin economic and social progress; *ii)* promoting co-operation on knowledge and technology transfer that is efficient at national and international levels, and *iii)* innovative enterprises and the public sector intensively utilising the results of modern science and technology. Priority areas: ICT, biotechnology, nanotechnology, renewable energy and natural resources, environmental technologies. *Quantitative targets (by 2020):* • Raise R&D expenditures to 1.8% of GDP. • Raise business expenditures on R&D to 1.2% of GDP.
S&T Innovation Policy Strategy	2007-13	*i)* Commercialisation (transfer to knowledge-based industries); *ii)* regional innovation systems. Priority areas: ICT, biotechnology, nanotechnology, renewable energy and natural resources, environmental technologies. *Quantitative targets*: • Raise R&D expenditures to 1.8% of GDP by 2013 with half of the R&D performed by the business sector.
New Szechenyi Plan	2011-14	Make the economy more dynamic and ensure economic growth through innovation and the use of measures such as: *i)* strengthening knowledge infrastructures (research institutes, universities), *ii)* supporting innovative companies with high growth potential operating in the processing and service sectors; *iii)* increasing the innovation and absorption capacity of SMEs; *iv)* developing innovative clusters; and *v)* joining national and international knowledge sources and markets necessary for innovation. *Quantitative targets:* • Raise R&D expenditure to 1.5% of GDP by the mid-decade. • Reach the EU average of the summary innovation index (SII) and enter the top third of EU countries during the next cycle. • Create 1 million new jobs in ten years.
		Iceland
New Policy for S&T	2013-16	*i)* Human resources and recruitment (e.g. a focused and comprehensive education system, with emphasis on the natural sciences and technology, increase in PhD graduates and funding support for young researchers); *ii)* co-operation and efficiency (e.g. a revised STI structure, increased support and incentives for co-operation, long-term projects and secured funding); *iii)* growth and value creation (e.g. more competitive and performance-based funding of R&D, support through tax incentives and strengthened venture capital market, support for internationalisation and participation in global co-operation); and *iv)* impact and follow-up (e.g. comprehensive system for monitoring results in science and innovation, improved industry statistics). *Quantitative targets*: • Raise R&D expenditures to 3% of GDP by 2016.
		India (1)
Decade of Innovations	2010-20	*i)* Design and develop a national innovation system based on national priorities; *ii)* implement policy instruments to encourage business R&D and innovation on public and social goods including clean energy; *iii)* improve international S&T co-operation. *Quantitative targets*: • Raise R&D expenditures to 2% of GDP (indefinite).
		Indonesia
Vision and Mission of Indonesian S&T Statement	2005-25	Improve the global competitiveness of the national economy and foster the transition toward a knowledge-based economy by: *i)* building an ethical foundation for the development and implementation of S&T; *ii)* supporting the diffusion of S&T; *iii)* strengthening national capabilities (human resources, infrastructure and institutional actors for S&T). *Quantitative targets:* • Raise R&D expenditures to 1% of GDP by 2014.
Second National Medium-Term Development Plan (RPJMN)	2010-14	Refine development priorities set in the Vision and Mission of Indonesian S&T Statement: *i)* quality of human resources; *ii)* development of S&T through improved R&D capabilities (institutions, resources and domestic and international networks); and *iii)* economic competitiveness. *Quantitative targets:* • Raise R&D expenditures to 1% of GDP by 2014.

Ireland		
Strategy for Science, Technology and Innovation (SSTI)	2006-13	*i)* Improve competitiveness, *ii)* remain attractive for FDI and maximise social cohesion; *iii)* promote R&D to become an innovation-driven economy. *Quantitative targets:* ● Raise R&D expenditures to 2.5% of GNP by 2013.
Israel		
Various national reports and STI-related policy documents		Increased investment and greater policy focus on biotechnology, nanotechnology and low-technology industries. Growing interest in cleantech sectors (renewable energies, water and oil substitutes). Establish and develop an information system on innovation (i.e. innovation survey and database).
Higher Education Plan	2011-15	Expanded budget for improving the quality of the higher education system and its competitiveness.
Programme For Investment In Oil-Substitute Technologies	2011-20	Promoting global reduction of oil consumption and increased development and uptake of oil substitutes through: *i)* co-operation with the industry sector to reduce bureaucracy in introducing and testing new technologies; *ii)* increasing venture capital investments through government participation; and *iii)* increasing the budget for applied academic study in the field.
Italy		
National Research Plan (2014-16)	Forthcoming	Strongly based on the so-called "Major Societal Challenges" in Horizon 2020, it has produced Horizon 2020 Italy to improve alignment with EU instruments.
National Research Plan	2011-13	*i)* Promote knowledge-driven research; *ii)* strengthen the involvement of the business sector and co-operation with the public sector; *iii)* support the internationalisation of research; *iv)* promote centres of excellence in the national/international context; *v)* concentrate efforts on large projects and research infrastructure. *Quantitative targets*: ● Raise R&D expenditures to 1.53% of GNP by 2020.
Industry 2015	2006-15	Enhance the competitiveness of the productive system through: *i)* industrial innovation projects; *ii)* public-private partnerships.
Strategy for the Internationalisation of Italian Research	2010-15	Renew the vision of Italian research in the context of implementing the EU 2020 strategy, adapt the national context to the present global situation to lead to a sustainable society.
Research Infrastructures of Excellence for Italy – The Italian Roadmap 2010	2010-12	Identify research infrastructures of excellence in all areas of demand in Italian scientific communities recognised by all stakeholders, taking into account the international and European context and expressed priorities for the next 5-10 years.
Destination Italy (Destinazione Italia)	Since 2013	Sketch a coherent national policy to attract foreign investment and improve the competitiveness of Italian firms (e.g. start-ups, SMEs) through 50 measures designed to reform a broad range of sectors, including research and higher education. Underpin the connection between basic research and the production system by focusing on university spin-offs.
Italy towards Europe: the Italian Technological Alliances	2011-14	Address the contribution of the business/private sector to Horizon 2020.
Reform of the National Doctoral Programme	Since 2013	*i)* Better respond to the needs of enterprises and academia; *ii)* improve their interaction within the framework of the European Research Area; and *iii)* better respond to the challenges sketched in Horizon 2020 EU research programme.
Japan		
Comprehensive Strategy on Science, Technology and Innovation	2013-30	Set a long-term vision of national STI policies (target year: 2030) to design Japan's ideal economic society from the viewpoint of STI and set detailed policies and intermediate targets towards its realisation, through a clear roadmap for implementation. Formulate a package of problem-solving STI policies in an inclusive approach, involving relevant stakeholders, and clarify the division of roles among different actors, ministries and other institutions.
4th S&T Basic Plan	2011-16	Comprehensive promotion of S&T and innovation and an issue-driven approach through: *i)* integrated development of STI policies to address societal challenges; *ii)* further focus on the roles of human resources and organisation; *iii)* realisation of a policy to be created and promoted with civil society ("Science in society, science for society"). Priority areas: environment; energy; health and medical/nursing care; social challenges. *Quantitative targets:* ● Raise R&D expenditures to 4% of GDP by 2020.

	Korea	
3rd S&T Basic Plan	2013-17	High Five Strategy: *i)* expand national R&D investment and improve its efficiency; *ii)* develop national strategic technologies; *iii)* strengthen mid- and long-term creative capability; *iv)* identify and support new industries; and *v)* create S&T-related jobs. Succeeds the 2nd S&T Basic Plan (a.k.a., 577 Initiative). *Quantitative targets*: ● Contribution rate of R&D to economic growth: 40%. ● S&T-related job creation: 640 000. ● STI capacity: World Top 7th.
	Latvia	
Guidelines for Science, Technology Development and Innovations	2014-20	*Quantitative targets:* ● Raise R&D expenditure to 2% of GDP by 2020.
Smart Specialisation Strategy	Forthcoming	
	Lithuania	
Innovation Development Programme	2014-20	Increase competitiveness and innovation performance, by *i)* achieving better commercialisation of R&D results, *ii)* increasing R&D investments. *Quantitative targets:* ● Raise R&D expenditure to 1.9% of GDP by 2020.
National Programme for the Development of Studies, Research and Experimental Development	2013-20	Encourage sustainable development and competitiveness and creates conditions for innovation by developing higher education and R&D. *i)* create an environment favourable for individuals to acquire high professional qualifications; *ii)* create new knowledge and conditions for the integration of science, businesses and culture in society; *iii)* ensure the functioning of an education and SR&ED system that is based on data, information, evidence, professionalism and trust.
Programme on the Implementation of the Priority Areas of Research and Socio-Cultural Development and Innovation	Since 2014	Increase the impact of high value-added, knowledge-intensive and highly-qualified-labour-intensive economic activities on the GDP and structural changes of the economy. *i)* Create innovative technologies, products, processes and/or methods and, using the outputs of these activities address global and long-term national challenges; *ii)* increase competitiveness and opportunities to access global markets through the commercialisation of R&D and innovation and greater collaboration of science and industry.
	Luxembourg	
No strategic document		
	Malaysia	
National Science, Technology and Innovation Policy	2013-20	*i)* Advance scientific and social R&D and commercialisation; *ii)* Develop, harness and intensify talent; *iii)* energise industries; *iv)* transform STI governance; *v)* promote and sensitise to STI; and *vi)* enhance strategic international alliances. *Quantitative targets:* ● Raise R&D expenditures to 2% of GDP by 2020.
	Mexico	
National Development Plan (PND)	2013-18	Make S&T development and innovation the pillars of sustainable economic and social growth. Design the new Special Programme for Science, Technology and Innovation 2014-18 (PECiTI). *Quantitative targets:* ● Raise R&D expenditure to 1% of GDP (indefinite).
Special Programme for Science, Technology and Innovation (PECiTI)	2014-18	Transform Mexico into a knowledge-based economy.

	Netherlands	
New White Paper on Science Policy	Forthcoming	
Enterprise Policy – "To The Top"	Since 2011	Strengthen Dutch competitiveness and make the Netherlands one of the top five knowledge economies in the world (by 2020) through: *i)* fewer subsidies in exchange for lower taxes; *ii)* fewer and less complicated rules; *iii)* broader access to corporate financing; *iv)* better utilisation of the knowledge infrastructure by the business sector; and *v)* better alignment of the tax system, education and diplomacy with the needs of the business sector. *Quantitative targets*: ● Raise R&D expenditures to 2.5% of GDP by 2020. ● Establish top consortia for Knowledge and Innovation to which public and private parties contribute more than EUR 500 million, at least 40% of which is financed by the business sector (by 2015).
Strategic Agenda for Higher Education, Research and Science	2011-15	*i)* Strengthen the quality of education; *ii)* focus on specific economic sectors (such as water, energy); and *iii)* strengthen curiosity-driven (fundamental) research through promotion of co-operation in the so-called "golden triangle": education, research and entrepreneurship.
	New Zealand	
Business Growth Agenda	Since 2012	To build a more productive and competitive economy based on export markets, innovation, infrastructure, skilled and safe workplaces, natural resources and capital markets by: *i)* encouraging business innovation; *ii)* boosting public investment in science; *iii)* strengthening research institutions; *iv)* increasing the innovation workforce; *v)* building international linkages; *vi)* improving IP settings; *vii)* developing innovation infrastructure; v*iii)* boosting public investment in science and research. *Quantitative targets:* ● Raise business R&D expenditures to more than 1% of GDP. ● Increase the ratio of exports to GDP from 30% to 40% by 2025.
	Norway	
White Paper on Research – "Long-Term Perspectives – Knowledge Provides Opportunity"	Since 2013	New approach to the formulation of national research policy, through the long-term National Plan for Research and Higher Education to be presented in 2014 and updated every four years. *Quantitative targets*: ● Raise R&D expenditures to 3% of GDP (indefinite).
Political Platform	Since 2013	Establish policy priorities for government with high priority for knowledge, innovation and technology. *Quantitative targets*: ● Raise R&D expenditures to 3% of GDP by 2030.
White Paper on Intellectual Property Rights (IPRs)	Since 2013	Overview of IPRs in Norway with a view to a stronger Norwegian patent office and education in IPRs at Norwegian universities.
White Paper on the Organisation of Innovation Norway and SIVA	Since 2012	*i)* Establishment of national seed capital funds; *ii)* increased support to internationalisation through Innovation Norway and better co-operation between Innovation Norway and SIVA; *iii)* simplification of the instruments of Innovation Norway; *iv)* strengthening of the Management by Objectives approach of Innovation Norway and SIVA; *v)* revision of the mandate of Investinor; *vi)* establishment of the Norwegian investment agency Invest in Norway, as a collaboration between Innovation Norway, the Research Council of Norway and SIVA.
White Paper on Innovation Policy – "An innovative and Sustainable Norway"	Since 2009	Improve the knowledge base and establish strategy councils in specific areas (SMEs, environmental technology, tourism and the maritime industry), and increase innovation by promoting: *i)* a creative society with a sound framework and a favourable climate for innovation; *ii)* creative people who develop their resources and competences, while grasping possibilities to apply them; and *iii)* creative undertakings that develop profitable innovations.
Strategy for Research Co-operation with Europe	Since 2014	Identify clear objectives and priorities for research co-operation through Horizon 2020 and the European Research Area.
Strategy for Environmental Technology	Since 2011	Marshal policies to develop competitive industries and businesses and help Norway reach its environmental targets. Priority areas are: *i)* commercialisation and testing (e.g. Innovation Norway grants for environmental technology pilot and demonstration); *ii)* research and competence development (e.g. National Programme for Environmental Technology); *iii)* networks and co-operation; *iv)* environmental regulations; *v)* public and private procurement; *vi)* a stronger knowledge base for policy making.

	Norway	
21-Strategies and 21-Forums	Since 2001	Sectoral research and innovation strategies (21-strategies and 21-forums), focused on: petroleum industry (Oil and Gas in the 21st Century –OG21), renewable energy, energy efficiency and CO_2 capture and storage (Energi21), climate research (Klima21), maritime industry (Maritim21), sustainable management of marine resources and the marine industry (Hav21), knowledge- based construction sector (Bygg21), health and care services (Health&Care21), forestry sector (Skog22).
Technological R&D strategies	Since 2009	National R&D strategies for the prioritised technology areas of ICT (2013), nanotechnology (2012), biotechnology (2011), as well as for environmental technology (2011) and marine bioprospecting (2009).
	Poland	
Strategy for an Innovative and Efficient Economy– "Dynamic Poland 2020"	2013-20	*i)* Adjust the regulatory and financial environment to the needs of innovation; *ii)* provide the economy with appropriate knowledge and human resources; *iii)* ensure sustainable use of resources; *iv)* increase the internationalisation of Polish economy. *Quantitative targets:* ● Raise R&D expenditures to 1.7% of GDP by 2020. ● Raise the Summary Innovation Index (SII) rank among EU countries to the innovation followers group by 2020. ● Raise the Global Competitiveness Report innovation index rank among EU countries to 15 by 2020. ● Raise resource productivity (GDP/DMC) to 0.5 by 2020.
Science Strategy in Poland	2009-15	*i)* Promote the drivers of a knowledge-based economy, such as biotechnology, nanotechnology, materials and information technologies; *ii)* select relevant priorities and research programmes.; *iii)* reform governance and restructure HEIs (e.g. creation of the Science and Innovation Council for the preparation of strategic development directions); *iii)* increase competitive funding *vis-à-vis* statutory funding and revise performance assessment criteria. *Quantitative targets*: ● Raise S&T expenditures to 1.7% of GDP by 2015. ● Raise allocation to science to 1% of GDP.
Strategy for Increasing the Innovativeness of the Economy	2007-13	Support clusters development and networking.
	Portugal	
Research and Innovation Strategy for Portugal	2014-20	Multi-level research and innovation strategy to inform the design of national programmes for 2014-20. *Quantitative targets:* ● Raise R&D expenditures to 3% of GDP by 2020.
	Russian Federation	
Series of Presidential Decrees of 7 May 2012	Since 2012	Set the major goals in Russian STI policy for the coming years. *Quantitative targets:* ● Raise R&D expenditures to 1.77% of GDP by 2015. ● Raise R&D expenditures of universities from 9% to 13.5% of GERD by 2018. ● Raise overall funding of public science foundations to RUB 25 billion by 2018. ● Raise average salaries of researchers to 200% of the regional average by 2018. ● Raise the share of Russian publications in total scientific journals indexed in Web of Science to 2.44% by 2015. ● Establish and modernise 25 million high-performance workplaces by 2020. ● Raise the share of goods produced by high-technology and knowledge-intensive industries in GDP by 1.3 times from the level in 2011 by 2018.

	Slovak Republic	
Research and Innovation Strategy for Smart Specialisation (RIS3) – Through Knowledge towards Prosperity	2014-20	Drive structural change to promote self-sustaining growth in income, employment and standard of living. Main strategic goals are to: *i)* integrate key industries through co-operation of local supply chains in embedded clusters; *ii)* increase the contribution of research to economic growth via global excellence and local relevance; *iii)* create a dynamic, open and inclusive innovative society as a precondition for the rise in the standard of living; *iv)* improve the quality of human resources. R&D priorities: material research and nanotechnology, ICTs, biomedicine and biotechnology; technological priorities: industrial technologies, sustainable energy, environment and agriculture; social priorities. *Quantitative targets:* ● Raise R&D expenditures to 1.2% of GDP by 2020.
	Slovenia	
Research and Innovation Strategy of Slovenia (RISS)	2011-20	Establish a modern research and innovation system that will allow for a higher quality of life for all, critical reflection in society, efficiency in addressing social challenges, increased value added per employee, and assurance of more and higher-quality workplaces. Main priorities are: *i)* a new R&D Activities Act; *ii)* smart specialisation; *iii)* science excellence; *iv)* co-operation between universities, research institutes and industry and technology transfer; *v)* implementation of the National Roadmap for Research Infrastructure 2011-20; *vi)* transnational R&D and international mobility; *vii)* more autonomous and responsible research organisations; v*iii)* more public funding of innovation-oriented R&D and a greater share of innovation-active enterprises; *ix)* public awareness of the impact of industrial R&D activities.
Research Infrastructure Roadmap	2012-20	Priority areas: food, biotechnology, biomedicine, environment and renewable energy, advanced materials, nanotechnology, construction, space, high-performing computing and grids, open data and digital sources, social sciences and humanities.
Slovenian Development Strategy (SDS)	2006-13	*i)* Better link science to business needs and capabilities; *ii)* increase R&D expenditures and promote business R&D investment; *iii)* raise business, especially SMEs, absorption capacity for R&D results in the business sector and encourage commercialisation of research results; *iv)* reform the organisational structure of public R&D; *v)* increase the number of researchers and their mobility between sectors; *vi)* shift public research towards applied and targeted research; *vii)* encourage international co-operation; v*iii)* stimulate patenting and high-technology exports. *Quantitative targets:* ● Raise R&D expenditures to 3% of GDP by 2010, partly by designing special measures to promote business R&D investment.
Resolution on the National Higher Education Programme	2011-20	*i)* Employability and mobility of graduates within Europe and worldwide; *ii)* diversity and equitable accessibility through internationalisation, diversification, study structures and funding of higher education.
Framework Programme for Promoting Entrepreneurship and Competitiveness	2007-13	*i)* Promote entrepreneurship and an entrepreneur-friendly environment; *ii)* provide business with knowledge and encourage R&D and innovation in companies; *iii)* promote SMEs with equity and debt instruments.
	South Africa	
National R&D Strategy	Since 2002	*i)* Increase private R&D investment; *ii)* achieve technological change in economy and society; *iii)* increase investment in science base (human capital and transformation); *iv)* create an effective government S&T system (alignment and delivery).
National Development Plan (NDP): A Vision for 2030	2011-30	Give South Africa a diversified economic base by extracting more local value from mineral resources, ensuring access to good quality water and alternative sources of energy, identifying new and innovative ways to address poverty, inequality and the burden of disease. Priorities areas: water, power, marine, space and software engineering.
Ten-Year Innovation Plan (TYIP)	2008-18	The country's transformation to a knowledge economy through: *i)* human capital development (HCD), *ii)* knowledge generation and exploitation (R&D), *iii)* knowledge infrastructure development, and *iv)* policy and institutional enablers to address the gap between research results and socio-economic outcomes. Priority areas: biotechnology, pharmaceuticals, space, energy, climate change, understanding of social dynamics.
Department of Science and Technology (DST) Strategic Plan	2011-16	Develop the innovation capacity of the national innovation system and contribute to socio-economic development by: *i)* enhancing knowledge-generation capacity to produce world-class research outputs and turn them into innovation products and processes; *ii)* developing appropriate STI human capital; *iii)* building world-class STI infrastructure, training the next generation of researchers and enabling technology development and transfer as well as knowledge interchange; *iv)* making South Africa a strategic international R&D and innovation partner.

	Spain	
Spanish Strategy for Science, Technology and Innovation (EECTI)	2013-20	Set out long-term STI policy and approaches to maximize economic and social benefits. Outline "service to society" as the driving force behind S&T advancement and the need to accelerate the flow of research and knowledge into the economy.
State Plan for Scientific and Technical Research and Innovation (PEICTI)	2013-16	Overarching mechanism under the 2011 STI Act that includes all programmes and initiatives in the area of STI and define the key implementation mechanisms. *Quantitative targets:* ● Raise R&D expenditures to 2% of GDP by 2020.
Science, Technology and Innovation Act	2011	New strategic framework based on the Spanish Strategy for Science and Technology (EEI) for research funding and governance with: *i)* a state research agency, comprehensive reform of PRIs and new excellence programmes; *ii)* greater incentives for technology transfer and researcher mobility (e.g. technological centres and S&T parks); *iii)* a new model of governance that ensures co-ordination between the autonomous communities and the central government and better links with the European Research Area; *iii)* more attractive and stable career paths for research and technical staff and better gender balance.
	Sweden	
National Innovation Strategy	Since 2012	*i)* innovative people; *ii)* high-quality research and higher education for Innovation; *iii)* framework conditions and infrastructures for innovation; *iv)* innovative firms and organisations; *v)* innovative public organisations; *vi)* innovative regions and environments.
Research and Innovation Bill 2012	2013-16	Increase investment in research and innovation by about 15% over 2012-16, with a focus on universities and excellence, life sciences, research infrastructure and targeted initiatives, collaboration with universities, strategic innovation areas, sustainable community development, innovation offices, test and demonstration facilities, industrial research institutes.
Swedish Innovation Strategy	Since 2010	Increase service innovation as a first step. *Quantitative targets*: ● Raise R&D expenditures to 4% of GDP by 2020.
	Switzerland	
Promotion of Education, Research and Innovation (ERI-Dispatch)	2013-16	*i)* Education: ensure a wide range of diverse and permeable education and vocational training programmes, consolidate international reputation, encourage international mobility, reform the funding and co-ordination of higher education; *ii)* research and innovation: consolidate competition-based grant funding while leaving room for unconventional research approaches, invest in strategic research infrastructures, maintain international co-operation and networking with European and non-European countries, improve co-operation between research institutes and the private sector; *iii)* principles of equal opportunity, sustainability and competitiveness: strengthen social cohesion, increase funding to train the next generation of researchers and qualified workers, promote equal opportunities, foster sustainable development. *Quantitative targets:* ● Raise educational attainment to at least 95% of youth at upper-secondary level education.
	Turkey	
Tenth Five-Year Development Plan	2014-18	National roadmap of development policies. *Quantitative targets:* ● Raise R&D expenditures to 3% of GDP by 2023. ● Reach an average 5.5% of GDP growth. ● Raise GDP to USD 1.3 million. ● Raise GDP to USD 16 000 per capita. ● Raise export volume to USD 277 billion. ● Create 4 million new jobs. ● Reduce unemployment rate to 7.2%.
Industrial Strategy Document – Towards EU Membership	2011-14	To become the Eurasia production base in medium- and high-technology products by increasing the competitiveness and efficiency of Turkish industry and expediting the transformation of the industry structure (higher share in world exports, production of mainly high-technology products with high value added, qualified labour, sensitivity to environment and society).
Machinery Sector Strategy Document	2011-14	Assist the machinery industry by developing the capacity for high-technology manufacturing.
Automotive Sector Strategy Document	2011-14	Increase the automotive industry's sustainable global competitiveness by transforming it into a high value-added manufacturing structure through advanced technology.
Iron-Steel and Non-Iron Metals Sector Strategy Document and Action Plan	Since 2012	
Electric Electronic Sector Strategy Document and Action Plan	Since 2012	

	United Kingdom	
UK Industrial Strategy	Since 2012	Identify areas of competitive advantage to build on in the next 20 years based on the government's commitment to a long-term partnership with business through: *i)* access to finance (e.g. the new national British Business Bank to provide SMEs lending and guarantee solutions); *ii)* skills (giving businesses more say over how funding for skills is spent, e.g. through the Employer Ownership Pilot and the Employer Ownership Fund); *iii)* procurement (e.g. Small Business Research Initiative to support pre-commercial procurement, simpler and more transparent public procurement and strengthening of private-sector supply chains); *iv)* eleven key sectors: aerospace, agri-tech, automotive, construction, information economy, international education, life sciences, nuclear, offshore wind oil and gas, and professional and business services; *v)* catapult centres and eight great technologies: big data, space, robotics and autonomous systems, synthetic biology, regenerative medicines, agri-science, advanced materials, energy.
UK Innovation and Research Strategy for Growth	2011	Strengthen UK ability to accelerate the commercialisation of emerging technologies and to capture related value chains linked and succeed in the global innovation economy through: *i)* blue skies research and discoveries and inventions; *ii)* better interface between higher education institutions and business; and *iii)* a better environment for commercialising research.
	United States	
Strategy for American Innovation	Since 2009 (updated in 2011)	*i)* Invest in the building blocks of American innovation, including R&D and human, physical and technological capital; *ii)* promote competitive markets that spur productive entrepreneurship; and *iii)* catalyse breakthroughs for national priorities such as developing alternative energy sources and improving health outcomes. Priority areas: ICT (wireless broadband), energy (clean energy technologies), biotechnology, health and health care, nanotechnology, advanced manufacturing, space, educational technologies. *Quantitative targets:* • Raise R&D expenditures to 3% of GDP (indefinite).
	EU28	
Innovation Union Flagship Initiative		Ensure Europe's global competitiveness by creating an innovation-friendly environment that will drive smart, sustainable and inclusive growth and jobs creation by: *i)* making Europe a world-class science performer; *ii)* removing obstacles to innovation (e.g. expensive patenting, market fragmentation, slow standard-setting, skills shortages); and *iii)* revolutionising the way public and private sectors work together (e.g. innovation partnerships). Also: strategic use of public procurement for innovation, an Innovation Scoreboard based on 25 indicators, a European knowledge market for patents and licensing, and measures to reinforce successful initiatives (e.g. the Risk Sharing Finance Facility).
EU Framework Programme for Research and Innovation – Horizon 2020	2014-20	Financial instrument to achieve the Innovation Union through: *i)* excellent science: reinforce the science base and make the European Research Area more competitive at global scale; *ii)* industrial leadership: speed up the development of technologies and innovations for tomorrow's businesses and help innovative SMEs become world-leading companies; *iii)* meeting societal challenges: address concerns of citizens in Europe and elsewhere (health and well-being, food security, sustainable agriculture, bioeconomy, secure and clean energy, smart and integrated transport, environment, resource efficiency, inclusive, innovative and secure societies). *Quantitative targets:* • Raise R&D expenditures to 3% of GDP by 2020.
European Research Area (ERA) Communication	2012	*i)* More effective national research systems, including increased competition within national borders and stable or increased investment in research; *ii)* excellent transnational co-operation and competition (e.g. common research agendas on grand challenges, key research infrastructures on a pan-European basis); *iii)* an open labour market for researchers; *iv)* gender equality and gender mainstreaming in research; *v)* optimal circulation, access to and transfer of scientific knowledge including via digital ERA.

Note: This table does not include national reform programmes, national cohesion strategies and operational programmes in line with the EU directives that are not country-specific but common to all EU member countries.

1. The responses for India express the collective opinion of a group of researchers from the National Institute of Science, Technology and Development Studies (NISTADS, *www.nistads.res.in*) Their views do not necessarily represent the institute or the Government of India.

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

PART II

Chapter 3

STI policy profiles: Globalisation of innovation policies

Attracting international science and technology investments by firms

Rationale and objectives

International investments have grown rapidly in recent decades owing to the rapid rise of global value chains. Production processes have become increasingly fragmented, with goods and services produced in stages in different countries. Firms seek to optimise their production processes by locating their various production stages in different sites and countries on the basis of optimal location factors. While distribution, sales and production activities led the way, also science and technology (S&T) activities and R&D have increasingly been located and/or relocated abroad.

A first reason to invest in S&T abroad is to customise technologies developed in the home country to fit local conditions. In this case innovation and R&D are largely adaptive in nature. Motivations to decentralise this type of innovation are primarily demand-oriented and related to market proximity and the need to be close to "lead users" and to adapt products and processes to local conditions.

A second and more recent type of S&T investment abroad seeks to obtain access to foreign knowledge and technology. Innovation strategies increasingly rely on global sourcing to tap into new S&T trends worldwide and to develop new ideas that can be implemented around the world. This also explains the trend towards open innovation, whereby firms seek partners for collaboration on R&D and innovation. Location factors for these investments are more supply-driven and are affected by factors such as the host country's technological infrastructure, the presence of firms and institutions with benefits that investing firms can absorb, access to trained personnel, established links with universities or government institutions, and the existence of appropriate infrastructure for specific kinds of research.

Through their growing investments abroad, multinational enterprises (MNEs) play a major role in the internationalisation of R&D and innovation. While the majority of their investments in R&D are still concentrated close to MNE headquarters, foreign affiliates play an important role when they organise their R&D and innovation activities on a worldwide scale. MNEs have become central actors in the global innovation process, and, as a result, "national" innovation activities in host countries are significantly affected by MNEs' international location decisions.

Attracting international investments in innovation is a policy priority not only in OECD countries, but also increasingly in emerging economies who consider these activities as leverage for their economic development. During the past decade, the latter have increasingly attracted international investments, including in S&T. Changes in the investment behaviour of MNEs largely reflect the changing landscape of innovation and the increasingly global supply of S&T resources and capabilities (see Chapter 1). China and India, for example, with their growing capacity for research and innovation, are now important players.

The increasing competition from emerging economies for international investments – in both labour-intensive and innovative activities – has raised concerns in some advanced economies about their longer-term economic future. They question whether the relocation of major production and distribution investments by MNEs (including their own) may result in a loss of higher value-added activities, such as R&D and innovation-related activities, to emerging economies.

There is increasing policy competition between countries to attract international investment by offering individual investors direct incentive packages (e.g. subsidies and tax breaks, including R&D tax credits). There is evidence suggesting that such incentives may divert investments from one country to another within a geographic region. While there is not yet conclusive evidence that competition to attract international investment has systemic negative effects, policy makers should remain vigilant about potential adverse consequences. Furthermore, spillovers from MNEs do not occur automatically and complementary measures are therefore necessary to increase the absorptive capacity of domestic firms for the advanced technology of MNEs.

Major aspects

Innovation has become a key source of growth and competitiveness in OECD countries, and attractiveness for investment in innovation is high on the policy agenda in many countries. A country's attractiveness for international investment is directly determined by favourable location factors. Governments typically use a mix of policies to attract international S&T investments. These can be broadly categorised under traditional investment promotion policies (Table 3.1) on the one hand and innovation policies on the other. In general terms, the goal of investment promotion is to create a positive image of the country as an international investment location and that of innovation policy is to foster the innovation performance and outcomes of host countries. A successful innovation strategy encompasses several policy domains, with specific measures to attract international investments in innovation.

Table 3.1. **Investment promotion policies**

Function		Objective	Activities
Image building		Create a positive image of the country as an attractive site for international investment	• Advertising • Public relations events • Mass media campaigns abroad • Investor forums • Maintaining relationships with journalists and business partners • Developing the investment promotion agency (IPA) website
Investment targeting/generation		Create investment leads that target investment projects in specific sectors, development areas or companies	• Identification of potential investors • Matchmaking • Direct mailing, telephone campaigns • Seminars for targeted investors
Provision of investment services	Pre-investment services	Facilitate the international investor's arrival in the country; assist in analysing investment decisions	• Information provision • One-stop shop registration/approval service • Sectoral analyses • Assistance in obtaining sites, suppliers, etc.
	Post-investment/ after-care services	Assist the international investor in maintaining his business, facilitate re-investment decisions in the future	• Legal or advisory support to on-going foreign investment projects • Dealing with bureaucracy
Policy advocacy		Improve investment climate by establishing effective feedback between the international investor and the government	• Surveys of the business sector • Participation in task forces • Policy and legal proposals to authorities • Lobbying

Source: Piontkivska and Segura (2003) in OECD (2011).

To be effective, the more traditional inward investment promotion has to be complemented by specific innovation policies. Because of the broad and pervasive character of innovation, countries draw on a broad range of policies. International investors carefully study the strengths and weaknesses of the underlying determinants of the locations under consideration and typically look for a package of attractive location factors and sound economic fundamentals. The design and implementation of a country's innovation policy depends on the (innovation) characteristics of the country. There is no "one size fits all" optimal set of policies for all countries/regions.

Recent policy trends

Almost all governments have sought to attract international investments in high-technology industries in one form or another, as these investments are generally believed to bring greater benefits to host countries, due to their large spillover effects. While differences exist across countries, industries commonly targeted are electronics and telecommunications equipment, pharmaceuticals, aerospace, automotive (manufacturing) and business services and telecommunications (services). In recent years, in addition to this industry-based approach, countries increasingly consider the growing international fragmentation of firms' value chains, and are taking a more functional approach by prioritising innovation, S&T, R&D laboratories, headquarters and other decision centres.

Many countries and regions try to position themselves as attractive locations for S&T investments, often with strong marketing and publicity campaigns. Recent examples are: Research in Germany, Team Finland-Strategy for promoting foreign investment, and Essential Costa Rica. Japan's Invest seeks to attract both R&D facilities and Asian regional headquarters of global companies. National investment and export promotion agencies play a key role in these strategies by disseminating information, identifying and targeting prospective investors, and providing tailor-made investment services. A number of these programmes are developed in close co-operation with the business sector, such as the United Kingdom's Catalyst UK and UK Advisory Network initiatives.

Chile and Sweden have established centres of excellence, while South Africa has preferred to enter into Memoranda of Understanding with MNEs that invest in domestic R&D facilities. Many countries (Australia, Belgium, the Czech Republic, Germany, Slovenia, etc.) offer new incentives, or have modified existing incentives, to invest in R&D and innovation, including tax incentives (see the policy profile on "Tax incentives for R&D and innovation"). A major challenge for governments is to design policy instruments that are open to MNEs, but at the same time optimise the benefits to the domestic economy.

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INTERNATIONALISATION OF PUBLIC RESEARCH

Rationale and objectives

Internationalisation is an increasingly important dimension of public research in OECD and partner countries. In line with economic globalisation, research co-operation and academic mobility have internationalised sharply in recent decades. With new technologies, collaborators in different countries can communicate easily and cheaply, and it is easier than ever before to obtain information about research communities in other countries. Financing from abroad – through initiatives such as the EU Framework Programme – has become a more important part of the research funding of many institutions. While internationalisation has increased opportunities for co-operation, it has also increased the competitive pressures on research and higher education, as universities are now being ranked on a worldwide basis.

Internationalisation can benefit public research in various ways. First, it can improve the flow of information and exposure to new ideas and thus boost a country's science and innovation system. Second, it offers countries opportunities to attract and retain high-quality human capital for their research system and for the economy. It allows domestic researchers to gain experience and skills abroad, and this mobility helps boost knowledge flows. Finally, it can generate revenue for the economy and higher education sector, e.g. through international students' tuition fees, and help in sharing the costs of expensive research infrastructures.

Government policies to encourage internationalisation of public research seek to capture these benefits. They aim to facilitate co-operation with partners around the world but also to ensure that their countries are able to compete in a global research environment.

Major aspects

Countries have long used international agreements to encourage the internationalisation of public research, and institutions often establish their own cross-border research agreements and projects. Country-level multilateral or bilateral research agreements typically promote co-operation on science, technology and innovation and knowledge sharing, often through co-financing, joint research projects or researcher exchange programmes. These agreements are often motivated by historical ties or by the strategic importance of partner countries. For instance, OECD countries have been actively undertaking co-operation on science and innovation with emerging economies such as the People's Republic of China, India and Brazil. The outcomes of such agreements are hard to discern and their scale and ambition vary considerably. The most concrete partnerships may be those undertaken between specific institutions or research centres with clear research aims; Canada and Japan, for example, signed a two-year collaborative research agreement in 2013 to perform aeronautic damage assessment. In another example, seed funds were used to foster joint research between Chilean universities and four leading US universities between 2011 and 2013.

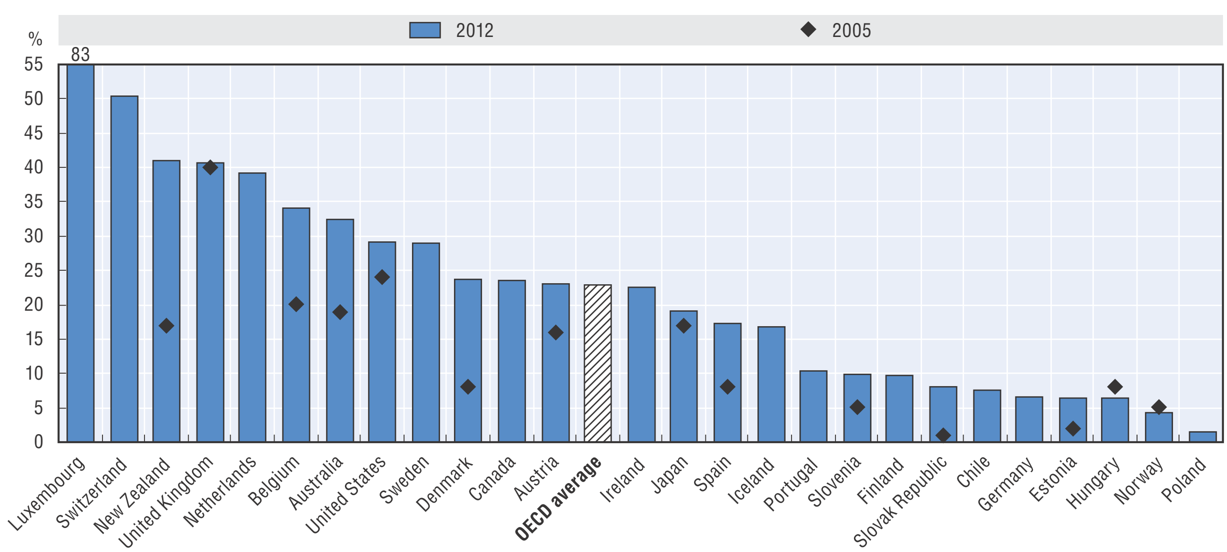
International research centres also encourage the internationalisation of public research through formal or informal joint research partnerships. Denmark and China have collaborated to create the Centre for Education and Research, which brings together researchers in the higher education and government sectors in five major research areas. Partnership arrangements can also be forged around large research infrastructures, which provide a highly visible example of international co-operation in science. The

Korea-United States Collaboration Center for Accelerator Science (KUCC), based at Fermilab in the United States, for example, was opened in 2012 to serve as a base for Korea to collaborate with experts on particle acceleration and to promote exchanges of technology and personnel between the two countries. Finally, foreign institutions can locate in a country to collaborate and help build capacity. As a result of a Portuguese initiative several leading US universities offer master's and doctorate programmes in partnership with Portuguese institutions to reinforce the quality of training and research, notably in engineering. A similar partnership has been established with the Fraunhofer-Gesellschaft, the German research centre company.

Researcher and student mobility is closely linked to the growing international co-operation in higher education and is another important aspect of the internationalisation of public research. Attracting scientific talent from abroad can boost domestic research efforts, while researchers who travel abroad develop new knowledge, perspectives and professional contacts. Recognising these benefits, most OECD and partner countries promote researcher and student mobility. Figure 3.1 shows that for the majority of countries with available data, the proportion of foreign nationals in advanced research (doctoral) programmes increased between 2005 and 2012. Even though the proportion of international students in doctoral programmes varies considerably across countries, partly owing to geographical location or language, it is significant everywhere and, on average, it is twice the proportion of international undergraduate students in an OECD country.

Figure 3.1. **International students in advanced research programmes, 2005 and 2012**

As a percentage of all students (international plus domestic) in advanced research programmes



Note: International students are based on residency status. Countries who define international students based on citizenship are excluded.
Data for Canada refer to 2011.
For the Netherlands, the denominator in the percentage of international students includes all students in independent private tertiary programmes. The country of previous education or residence of these students is unknown, which means that it is not possible to determine if these students are international mobile or not.
For Norway, the number of international students by foreign residency is underestimated as some international students are granted residency during their studies

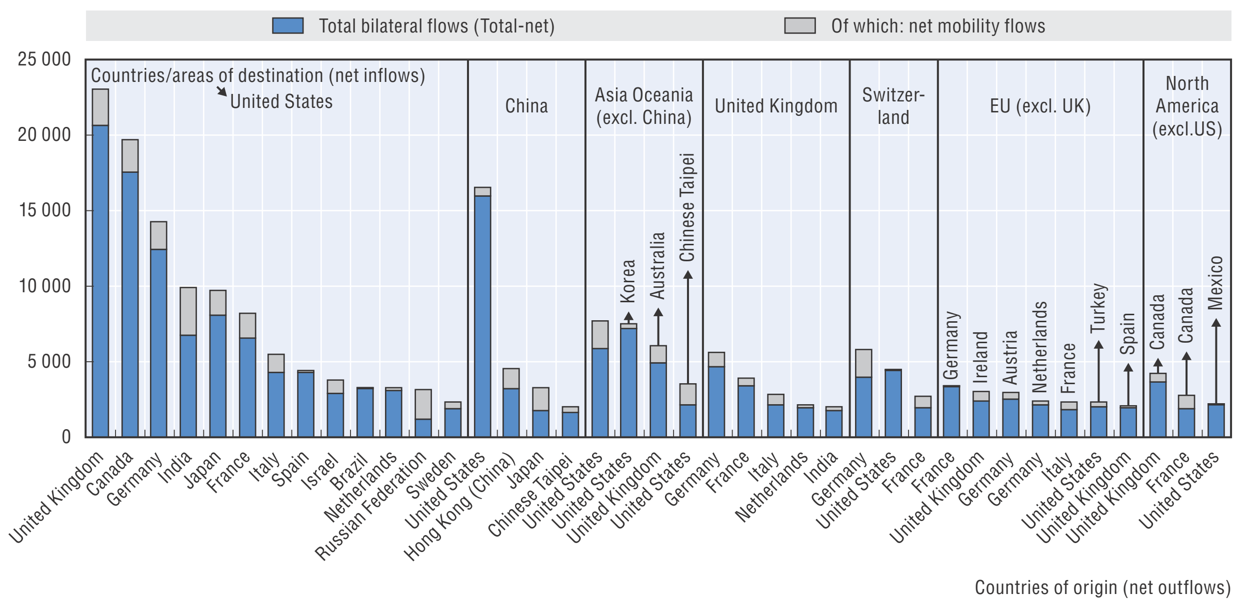
Source: OECD (2014), *Education at a Glance 2014: OECD Indicators*, OECD Publishing, Paris. *http://dx.doi.org/10.1787/eag-2014-en*; Eurostat, *Education and Training Databases*, June 2014; UNESCO Institute for Statistics (UIS), *Education Databases*, June 2014. Data retrieved from IPP.Stat on 8 July 2014, *http://stats.oecd.org//Index.aspx?QueryId=57863*.

StatLink http://dx.doi.org/10.1787/888933151662

Bibliometric indicators provide a complementary picture of researcher mobility at a global level (Figure 3.2). The top nine international bilateral flows, whatever the final affiliation of scientific authors, involve exchanges with the United States, while the United Kingdom is the second most connected economy. The US connections with the United Kingdom, Canada and China are particularly strong but unlike the two first countries, China has a net inflows of researchers from the United States, meaning that more scientists who started by publishing in the United States moved to affiliations in China over the period. Korea and the Chinese Taipei are the economies with the largest net migration of scientific authors from the United States.

Figure 3.2. **International flows of scientific authors, 1996-2011**

Largest bilateral flows by country of origin and country of destination and net mobility flows



Note: This is a new experimental indicator that tracks changes in the institutional affiliation of scientists who publish in scholarly journals. The first block of bars represents the largest migration flows with the United States for which the United States has a net inflow of scientific authors (e.g. from the United Kingdom). The second block of bars represents the largest migration flows with China in which China has a net inflow of scientific authors (e.g. from the United States). The first bar should read: 23 062 scientific authors changed institutional affiliation between the United Kingdom and the United States between 1996 and 2011, with a net inflow of 2 416 authors to the United States.

Scientific authors are listed in the Scopus database of peer-reviewed scientific publications and identified by a unique author ID. International mobility is inferred from authors with at least two publications over the reference period based on changes in the location of their institutional affiliation. Publications are filtered for citation-based scientific impact. Minimum thresholds of 2 000 bilateral flows and 25 000 "stayer" scientific authors –i.e. scientific authors that maintain the same country of affiliation over their entire record- per economy are applied. This experimental indicator requires careful interpretation. Mobility records are less accurate for less prolific authors and for those who move from and into roles for which disclosure in scholarly journals is not the norm. In addition institutional affiliations and the assignment of author IDs present some limitations that may distort mobility estimates.

For further details on measurement and definitions, see OECD (2013), "Researchers on the move" in *OECD Science, Technology and Industry Scoreboard 2013: Innovation for Growth*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/sti_scoreboard-2013-23-en*.

Source: Adapted from the OECD (2013), *OECD Science, Technology and Industry Scoreboard 2013: Innovation for Growth*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/sti_scoreboard-2013-23-en*. Original OECD calculations based on Elsevier, *Scopus Custom data*, version 5.2012, May 2013.

StatLink http://dx.doi.org/10.1787/888933151679

Recent policy trends

In recent years internationalisation has commonly been fostered through research funding (see the policy profile on "Financing public research"). Performance-based funding for institutions or grant funding for research projects can include criteria that favour or stimulate international co-operation. Norway's performance-based institutional funding for higher education institutions (HEIs) and public research institutes (PRIs), for example, includes incentives for international collaboration. Countries can also promote collaborative research directly through policy levers such as joint calls for research, while research excellence initiatives often have a strong international component (OECD, 2014). To promote more international collaboration, research funding arrangements must be flexible enough to allow for proposals that include international partners. Australia's National Health and Medical Research Council, for example, allows research grants to be used overseas if an equivalent outcome could not be achieved domestically, while some Austrian funding schemes facilitate the portability of grants if a researcher wishes to pursue part of a project abroad.

Many countries' internationalisation efforts include promotion and information campaigns to increase opportunities for research co-operation as well as to improve awareness of a country's R&D capabilities abroad and increase foreign direct investment. Belgium (Wallonia) has established a network of regional STI representatives charged with promoting and implementing collaborative projects with a number of countries. Germany hosts an Internet portal that lists opportunities for international collaboration with German researchers. Japan, Sweden and Switzerland operate overseas liaison offices to promote their R&D activity.

Promoting mobility is part of a number of new OECD country strategies for the internationalisation of higher education and public research. Canada launched the International Education Strategy in early 2014 to attract more international researchers and students and to deepen research links between Canadian and foreign educational institutions. In 2013, Denmark initiated the first phase of an action plan for the internationalisation of higher education programmes. The initiative aims to increase the number of students studying abroad (including in non-English speaking and high-growth countries) and to increase co-operation on joint degrees with international institutions. France's research and innovation strategy, France Europe 2020, was launched in 2013; it envisions the opening of joint research centres abroad and aims to increase inward and outward researcher mobility. In Germany, the new internationalisation of higher education strategy, released in 2013, contains measures to increase research co-operation and transnational courses.

In addition to national policies, many countries promote international mobility through various regional programmes. In Europe, the Bologna Process promotes international co-operation and academic exchange among signatory countries. The European Commission's mobility initiatives, such as EURAXESS, include measures to share information on funding opportunities and job vacancies for researchers in Europe, while the ERASMUS programme focuses on university students. In the Nordic and Baltic countries, the Nordplus Higher Education Programme includes grants for student and teacher mobility.

The policy options most commonly adopted in OECD and partner countries to increase inward mobility of researchers and students are shown in Table 3.2. The most frequently used instruments include funding and financial incentives. In view of the competitive global market for researchers, some of these initiatives specifically target high-performing scientists. Invitation Fellowships for Research in Japan specifically seeks to attract world-renowned researchers such as Nobel laureates to Japan. The Czech Republic, Germany and Norway offer grant programmes for students from developing countries; this helps to internationalise domestic higher education and simultaneously helps build

Table 3.2. **Major policy options to attract inward international mobility of students and researchers**

Policy area	Types of instrument	Examples
Funding, financial incentives and working conditions	Fellowships and scholarships for foreign students and researchers; Lead researcher positions.	Finland (Distinguished Professor Programme)
		Germany (Graduate School Scholarship Programme)
		Ireland (International Scholarships)
		Japan (Fellowship Programs for Overseas Researchers)
		Mexico (cooperation agreement with Organization on American States)
Degree recognition	Mutual agreements and implicit rules for the recognition of foreign degrees (or credits acquired abroad)	Europe (Bologna process)
Social and cultural support	Relocation assistance and information; Grants for spouses and family	Austria (Dual Career Grant)
		Belgium (mobility centres)
Visa and immigration policies	Simplified visa process for highly skilled and students	Belgium; Canada (Temporary Resident Program); Netherlands; France
	Post-study work rights for postgraduate students	Australia
	Recognition of overseas qualifications	Germany (Recognition of Qualifications Act 2012); Switzerland
Creating an international environment	Structure of the academic calendar; Rules concerning sabbaticals	Germany
	Increased use of teaching in English or a foreign language	Slovenia (National Programme for Higher Education, 2011-20)

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

research capacity in developing countries. The Graduate School Scholarship Programme was designed to help young researchers from emerging and developing countries gain admission to structured PhD programmes in Germany. A noteworthy trend in terms of student mobility is the growing recognition of foreign degrees and the creation of double degrees. Immigration policies can sometimes be a barrier, but various institutional and whole-of-government means can be employed to encourage inward international mobility. In 2012, the Russian Federation addressed this issue by streamlining the process for the recognition of foreign qualifications for graduates of 210 leading world universities.

Many countries recognise the potential benefits from outflows of students and researchers as well as those from student inflows. Outward mobility can allow researchers to develop new skills and acquire new knowledge, although evaluation programmes need to ensure that policies are designed to maximise these benefits. A number of countries support outward mobility through funding: in Austria, the DOC-team Programme supports trans-disciplinary research teams and requires team members to spend at least six months at an overseas institution. The Brazil Scientific Mobility Programme provides 100 000 scholarships to undergraduate and graduate students in science, technology, engineering and mathematics to study in the United States and return to Brazil after an academic year to complete their degrees. France provides international mobility scholarships. Japan's Postdoctoral Fellowship for Research Abroad allows young researchers to spend time at an overseas university or research institution. National Research Foundation scholarships in South Africa fund foreign doctoral students and post-doctorates to visit overseas institutions. Switzerland has promoted the international recognition of its university courses (thereby facilitating the outward mobility of Swiss nationals). Moreover, even without any specific policy or financial support, researchers commonly go abroad during sabbaticals where these exist. In the United Kingdom, the higher education system is developing a publicly funded strategy in 2014 to help promote outward student mobility.

To benefit from researcher mobility while avoiding the possible negative effects of brain drain, many countries encourage researchers based abroad to return to their home country. In Argentina, the Scientists and Researchers Overseas Network (RAICES) establishes links with Argentine researchers located abroad and encourages their return to Argentina through job opportunities. China's Thousand Talents Programme offers relocation stipends to world-renowned Chinese researchers working abroad. Belgium, Finland, France, Germany, Slovenia, Sweden and Switzerland provide funding or assistance for expatriate researchers to return to their home country. The Momentum Programme in Hungary provides funds and domestic career opportunities to reduce emigration of young researchers. Israel aims to compensate for a recent brain drain by recruiting Israeli researchers working abroad for 30 new centres of excellence (ICORE) in universities. The structure of international mobility programmes may also encourage repatriation. Australia's early career fellowships in science and medicine fund researchers to travel abroad for two years but they must then return home for two years. The Researchers' Mobility Portal was replaced by the Connecting Australian and European Science and Innovation Excellence, and provides information to Australians who have pursued international careers in research but want to explore opportunities in their home country. In South Africa, the Research Chairs Initiative aims to attract highly skilled South Africans who may be in industry or abroad back into academia.

While not primarily targeted to research, the OECD and UNESCO have developed *Guidelines for quality provision in cross-border higher education*, highlighting a number of good practices to make higher education systems more transparent and secure for all stakeholders in a globalised world. The implementation of these guidelines should allow countries to continue to reap the benefits of internationalisation, including in research.

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Cross-border science, technology and innovation governance arrangements

Rationale and objectives

Cross-border governance of science, technology and innovation (STI) involves the partial or total delegation of policy making from the national to the international level. It implies, among other things, international co-ordination of national policy initiatives, removal of obstacles to the movement of resources, setting of international standards and regulations, and transfer of authority to intergovernmental organisations and supranational authorities. It is part of a wider dual delegation process that gives a greater say in STI matters to the international, but also to the sub-national, level of governance. There are good economic arguments for extending the scope of STI governance beyond national borders (OECD, 2012):

- The generation, diffusion and application of knowledge have significant international externalities: some of the benefits and costs of national STI efforts take place outside national borders. From a global perspective, national economies are likely to under-invest in R&D and innovation, as some of its benefits will occur abroad, and national policy is thus likely to give insufficient weight to the benefits of national efforts beyond a nation's borders.
- R&D and innovation are characterised by pronounced economies of scale and scope. In areas such as the increasingly transnational "grand challenges" (demographics, environment, energy), but also in some S&T disciplines (notably aerospace, some areas of physics), fixed costs exceed levels that could be covered by any one nation alone. Opening up national research systems to outsiders (e.g. through participation in joint R&D) may increase the variety of applications and have valuable learning and demonstration benefits (Mowery, 1998).
- International S&T policy can help resolve mismatches between national and functional systems when organisations, markets or networks extend beyond national borders. Its policy actions can lift barriers that inhibit flows and interactions within functional systems. Standards setting is a means commonly used to address such mismatches. It extends markets by homogenising demand and reducing uncertainty and allows for a division of labour to emerge in supply.

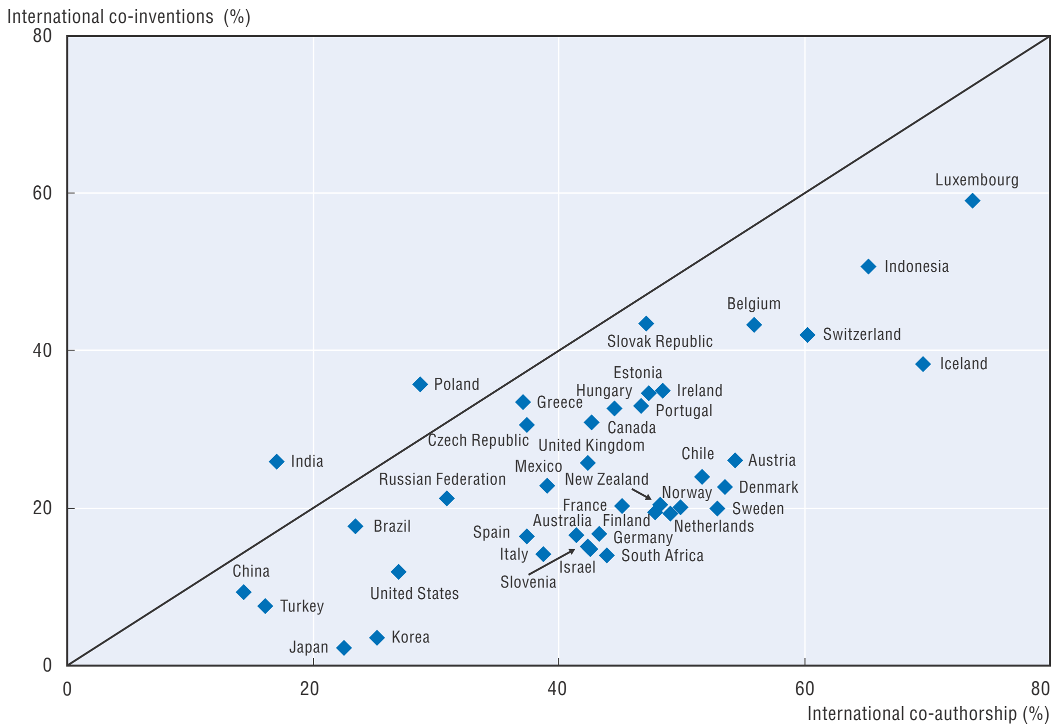
In terms of international STI policy goals, most countries seek efficiency and/or effectiveness gains from complementarities in orientation, planning, regulation and resource pooling. However, national governments focus on domestic challenges and can be reluctant to take a global or even a collective view. The economic and financial crisis has increased that reluctance, as has the emergence of STI as a focus of industrial policy. Countries also have concerns about the appropriation of the benefits of public investments in education, research and innovation, given the increasing international competition for scarce talent and investment. As a result, narrower objectives often determine the nature and extent of national involvement in cross-border STI initiatives. These range from foreign policy and economic diplomacy, to access to funding for the development of national STI capabilities and access to international scientific networks. Commitment to cross-border STI policy is therefore often shaped by contingency and tends to vary over time. Ultimately, the reluctance to internationalise aspects of STI governance reflects the limitations of existing arrangements to provide credible assurances about the distribution of the resulting costs and benefits.

Major aspects

Science is a global endeavour. National borders rarely circumscribe contemporary STI networks, which also include emerging economies (see Chapter 1). As globalisation has increased, technological development has become increasingly internationalised. However, evidence from patents and scientific publications suggests that international co-invention remains considerably less common than international co-authorship (Figure 3.2). This may reflect the relatively greater importance of proximity for technological innovation.

Figure 3.3. **International collaboration in science and innovation, 2007-11**

Co-authorship and co-invention as a percentage of scientific publications and PCT patent applications



Notes: International co-authorship of scientific publications is defined at institutional level. A scientific document is deemed to involve an international collaboration if there are institutions from different countries or economies in the list of affiliations reported by single or multiple authors. Estimates are based on whole counts from information contained in the Scopus® database (Elsevier B.V.). International co-inventions are measured as the share of patent applications filed under the Patent Co-operation Treaty (PCT) with at least one co-inventor located in a different country in total patents invented domestically. Patent counts are based on the priority date, the inventor's country of residence and whole counts.

Source: OECD (2013), *OECD Science, Technology and Industry Scoreboard 2013: Innovation for Growth*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/888932890371*.

StatLink http://dx.doi.org/10.1787/888933151689

Extensive international policy co-operation frameworks for R&D have developed (especially in Europe), but international frameworks in other STI areas are still in their infancy. For instance, much can still be achieved by establishing technological standards for the environment and improving international coordination on cyber-security.

Cross-border governance of STI can be achieved through arm's-length policies, such as bilateral or multilateral agreements of limited duration or co-ordination of national policies, without delegation to a supranational body. This seems to be the preferred approach to cross-border governance of STI outside of Europe. Even within Europe, international STI governance frameworks – by far the most developed of their kind globally – have historically been designed as complements, rather than substitutes, to national frameworks.

However, a number of STI policy areas can benefit from delegation of decision making and deeper integration. These are areas characterised not only by high fixed costs but also by high international transaction costs owing to the need for access on equal terms to highly specialised, single-purpose assets [examples of solutions include joint STI infrastructures such as the European Organization for Nuclear Research (CERN) and the International Thermonuclear Experimental Reactor (ITER)], high frequency of interaction (which, in addition to international STI infrastructures also applies to coordinating the EU Horizon 2020) and high uncertainty. A recent example of the latter is the high-risk, high-potential research funded by the European Research Council (ERC) which can maximise success by drawing from the largest possible pool of excellent scientists. Outside of Europe, the Consultative Group of International Agricultural Research (CGIAR) is an example of a long-term strategic arrangement with common R&D programming and performance functions (OECD, 2012).

Recent policy trends

There have been ambitious initiatives to promote cross-border governance of STI in several regions, including South East Asia and Latin America, e.g. the Association of Southeast Asian Nations (ASEAN) Committee on Science and Technology. However, contrary to Europe, they have a short history and limited continuity to date. The case of Europe is unique, in that its progress in cross-border governance of STI is part of wider economic integration.

The EU's European Research Area (ERA), launched in 2000, has sought to create a single space for research. In July 2012, the European Commission re-defined its priorities: to improve the effectiveness of national research systems; to achieve an optimal balance between transnational co-operation and competition; to open up the labour market for researchers; to promote gender equality; and to improve knowledge circulation (EC, 2012). European countries – EU members and partner countries such as Norway – see the ERA as the main framework for cross-border policy co-ordination in the region.

EU STI policy receives substantial financial support through Horizon 2020, the successor to the long-standing Framework Programme (FP), which aims to strengthen the competitiveness of European industry and through STI funding dispensed via the Structural Funds (SF), which supports regional development and intra-European cohesion. Together these account for as much as 20% of public research funding in the EU (Barré et al., 2013). Until 2013, the primary funding instrument for research and technological development was FP7, which financed collaborative research projects and frontier research (ERC) and technology (Joint Programming, Technology Platforms, European Institute of Innovation and Technology). Funding for Horizon2020 amounts to EUR 80 billion over 2014-20, an increase of over 20% with respect to its predecessor (EC, 2013). Moreover, compared to FP7, Horizon2020 is characterised by a move towards "near-to-market R&D" and a greater focus on social challenges. The recently concluded (2007-13) and current (2014-20) programming periods of the SF have also placed more emphasis on STI.

In response to the OECD STI Outlook 2014 policy questionnaire, many national authorities reaffirmed their commitment to cross-border governance of STI, specifying some of their reasons, but also listing important barriers and policy initiatives to lift them.

Mutual policy learning and the transfer of good practices appears to be an important motivation for engaging in international STI forums. This is seen as important not only by countries with emerging STI governance arrangements, but also by countries such as the United Kingdom and New Zealand. Global "grand challenges" such as climate change and threats to health and resource sufficiency are strong motivators for international co-operation. Other countries see unexploited scale economies as the major challenge. In Slovenia, an important obstacle to cross-border governance of STI is the lack of dedicated funding for large-scale and longer-term co-operation. Fragmentation of funding agencies – and of the rules and procedures for research funding – is considered an important obstacle in France. France therefore welcomes EU initiatives that seek to achieve greater coherence, such as the co-ordination of national research policies (ERA-NETs and ERA-NET+), joint programming and joint technology initiatives (public-private partnerships).

A number of countries mentioned barriers to cross-border governance of STI. Belgium, the Czech Republic, South Africa and Switzerland reported the absence of comprehensive national policies or mechanisms for domestic co-ordination of cross-border governance arrangements as an important constraint. Slovenia reported the lack of a nationally agreed thematic focus, while Norway noted a lack of knowledge about international funding opportunities.

Countries' mechanisms for promoting cross-border governance differ. Norway (a non-EU member) actively participates in ERA policy, such as the European Research Area and Innovation Committee (ERAC). Slovenia is drafting a strategy for internationalisation and bilateral agreements and for mobilising and financing joint R&D projects. South Africa is participating in regional and bilateral STI strategies and agreements. Australia, Finland and Korea seek to ensure greater consistency in international collaboration through a partnership between policy makers in STI, trade and foreign affairs. The United Kingdom emphasises standards and regulation (e.g. on intellectual property and metrology), given the potential for mutual gains from a larger global market.

In Europe, some regional authorities engage in cross-border innovation initiatives to capture the extent of functional systems, sometimes using EU Territorial Co-operation funding. Among the better-established and better-resourced initiatives are the Oresund cross-border area (Denmark and Sweden) and the Top Technology Region/ Eindhoven-Leuven-Aachen Triangle (TTR-ELAT) (the Netherlands, Belgium and Germany). Other examples include the Bothnian Arc, extending across the borders of Finland and Sweden and the Helsinki-Tallinn cross-border area (Finland and Estonia) (OECD, 2013b). On the whole, though, such initiatives are infrequent, small-scale and often lack a long-term orientation.

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PART II

Chapter 4

STI policy profiles: Facing new social and environmental challenges

Green innovation

Rationale and objectives

Concerns about the environmental unsustainability of past economic growth patterns and increased awareness of the impact of climate change have propelled green growth issues to the forefront of economic and innovation policies (see the policy profile on "National strategies for science, technology and innovation").

There are several rationales for policy action in the area of environmental innovation. One is the negative externalities associated with climate change and other environmental challenges. They have implications for both the creation and diffusion of technologies. Because greenhouse gas (GHG) emissions are not priced by the market, incentives to reduce them through technology development are limited. Similarly, there is less diffusion and adoption, once green technologies are available, if market signals regarding the environmental benefits of such technologies are weak, so that demand for green innovation will also be below the social optimum. In turn, there will be little incentive for companies to invest in innovation, because there will be little demand for any resulting products or processes (OECD, 2011).

These negative environmental externalities are the target of environmental and resource policies such as pricing policies, carbon taxes, tradable permits or other market instruments to internalise the price of externalities. Apart from the externalities associated with the environment, there are also important market failures specific to innovation, and particularly to green innovation. These include technological path dependencies, dominant designs in certain markets, such as energy and transport that favour incumbents, uncertainty about the prospects for success, the long timescales for infrastructure replacement and development, a lack of options for product differentiation, liquidity constraints of smaller challenger firms or barriers related to behaviour (e.g. consumer resistance to change). Other barriers to innovation are more generic such as lack of capabilities, etc. (OECD, 2012).

From the perspective of system-wide change – here defined as a drastic change in governance practice – other types of policy failure that are relevant for green technologies in the context of transition policy can be identified. These include the lack of a shared vision regarding the direction of change (directionality failure), inability of consumers and the public sector to articulate demand for new solutions (demand articulation failure) or the insufficient ability of the system to monitor, anticipate and involve actors in processes of self-governance (reflexivity failures) (see policy profile on "System innovation").

Major aspects

The scope of potential market and systemic failures suggests that policies for environmental and green innovation will only succeed if they enhance the performance of the economic system as a whole. "Getting prices right" is important but so is policy coherence. Policies that focus only on one element of the system, or are contradictory, are unlikely to be effective in improving overall performance. Indeed, recent experience suggests that carbon pricing contributes primarily to incremental innovation, which tends to increase efficiency but may result in growing consumption, as has been the case for personal transport. Other policies will therefore be needed to strengthen green innovation. As identified in the OECD Innovation and Green Growth Strategies (OECD, 2010, 2011b), this will involve a broad approach, comprising price-based instruments and incentives for firms to engage in green activities, as well as public procurement and the funding of basic research. It will be essential to remove barriers to trade in clean technologies as well as to the entry of new firms, and to improve conditions for entrepreneurship, especially in light of growing evidence that young firms represent an important source of more radical innovations. There is also the need for more effective and inclusive multilateral co-operation on science, technology and innovation.

One important policy action is public investment in basic and long-term research. Public research will need to cover many areas, including mitigation and adaptation to climate change, and should rely on multidisciplinary and interdisciplinary approaches. Recent data on government budget appropriations or outlays for R&D (GBAORD) show the public resources that economies invest in research on energy and the environment. In absolute terms, Japan, the United States and Germany are the largest funders, while Mexico, Canada and Japan are top investors in relative terms. With few exceptions, energy-related R&D accounts for the vast majority of GBAORD spent for the environment. Since 2002 most economies have increased the percentage of GBAORD going to energy and environment-related programmes (Figure 4.1).

A key challenge for moving to a lower carbon economy is alignment of the goals of ministries, research funding agencies, higher education institutions and social and market-based institutions so that they focus on green growth in all of its dimensions. The effectiveness of policy design for specific areas will depend on the innovation and knowledge capacity of a given country and its ability to develop an appropriate policy mix for green innovation that includes energy, trade, transport, agriculture and the links between them. Strategic policy intelligence, including via the exploitation of open government data and sharing of that data across ministries, can help deliver more effective policy mixes for greener growth.

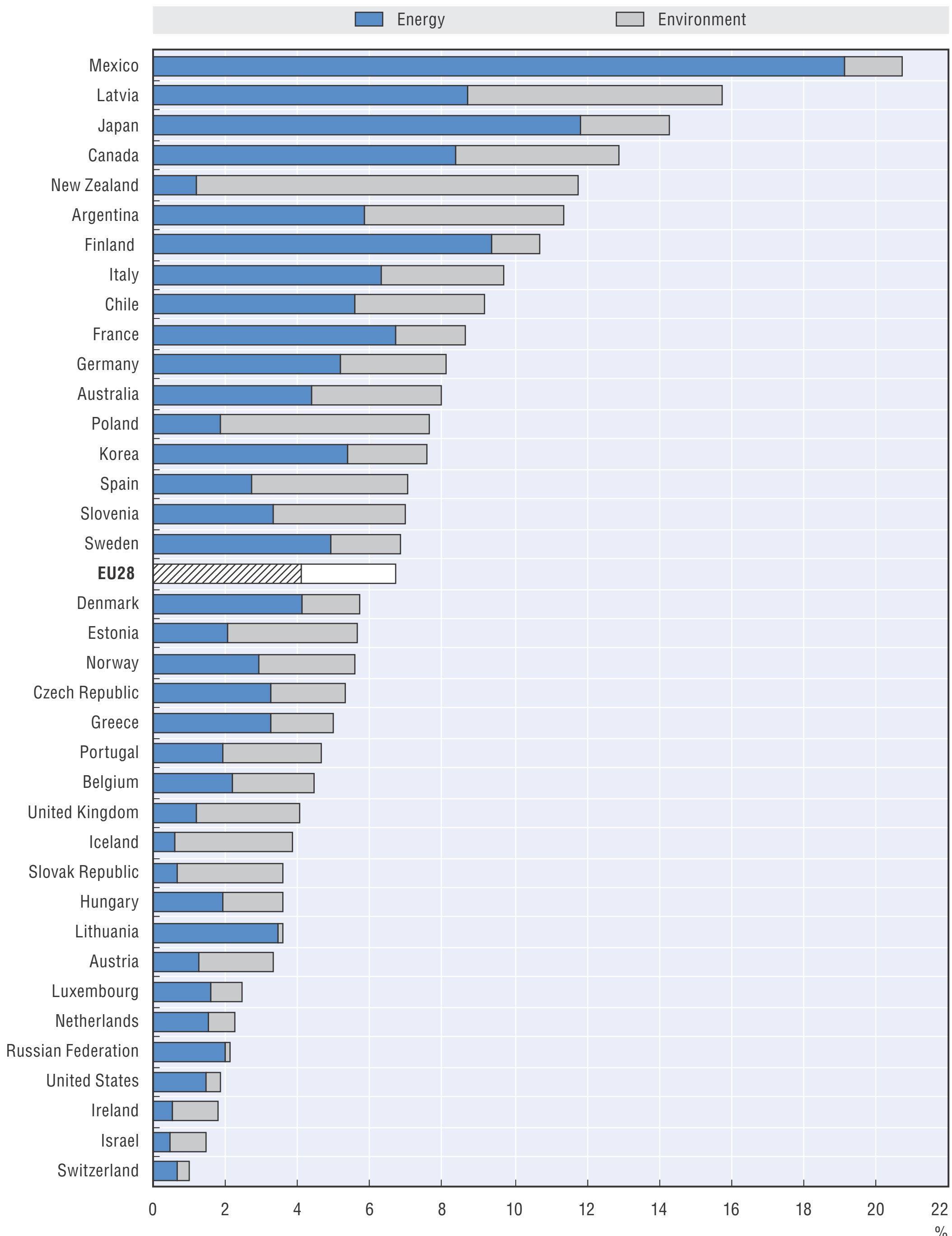
Recent policy trends

Many OECD and non-OECD countries have established green growth strategies or prioritised activities within their national S&T strategies to create critical mass and accelerate the transition to green innovation and technology. Indeed, most countries continue to place environmental issues, climate change and energy high on the list of priorities for innovation policy in general. However, specific policy priorities for green innovation and technology differ markedly, depending on countries' scientific and economic specialisation, competiveness goals and social objectives.

- The Italian Stability Law of 2013 introduces environmental measures to promote the green economy and restrain excessive use of natural resources. A package of rules aims to activate virtuous environmental policies, simplify and modernise the regulatory framework and create the conditions for investment in and growth of the green economy. The National Revolving Fund for Green Jobs was established in 2012 to facilitate private and public investments in the green economy. Youth employment is a requirement for receiving loans and SMEs represent 75% of the beneficiaries.
- In Korea, the Committee on Green Growth moved from the Office of the President to the Prime Minister's Office in March 2013. That same year Korea launched the Green Climate Fund (GCF) which, together with the Global Green Growth Institute (GGGI) and the Green Technology Centre (GTC), positions Korea as a global hub for green growth. In addition, various national ministries and agencies completed or are implementing programmes such as EACP (East Asia Climate Partnership), R&D Association for Green Tech and Green Growth Education for Youth.

Figure 4.1. **Government R&D budgets for energy and the environment, 2014 or latest available year**

As a percentage of total government R&D budgets



Note: Data for Iceland refer to 2014; data for Belgium, Estonia, Hungary, Ireland, Israel, Italy, Latvia, Lithuania, Poland, Spain, Sweden, the United Kingdom and the European Union refer to 2012; data for Argentina, Canada, Chile, Korea, Mexico refer to 2011; data for Switzerland refer to 2010; data for the Russian Federation refer to 2009; otherwise data refer to 2013.

Source: OECD, *Research and Development Statistics (RDS) Database*, March 2014, *www.oecd.org/sti/rds*; Eurostat, *STI Databases*, June 2014, *http://epp.eurostat.ec.europa.eu/portal/page/portal/science_technology_innovation/data/database*. Data retrieved from IPP.Stat on 08 July 2014, *http://stats.oecd.org//Index.aspx?QueryId=57863*.

StatLink http://dx.doi.org/10.1787/888933151691

- The Malaysian government's National Green Technology Policy, launched in 2009, aims to achieve the sustainable management of the environment, promote green research and technology development. This is achieved through a proactive public procurement policy. A Green Technology Financing (GTF) scheme has been launched that will, among others, issue credit guarantees of 60% for companies producing or using green technology.
- Mexico is planning to expand its National Climate Change Strategy (ENCC) by: increasing its energy efficiency target for the national oil company, PEMEX, by 5%; increasing the efficiency of flares on offshore platforms; increasing the efficiency of transmission and distribution lines by 2%; and increasing thermal efficiency of fuel oil-fired thermoelectric plants by 2%, among others. Beyond a reduction of GHG emissions, the ENCC aims to make Mexico more resilient by making more sustainable use of the ecosystem and shifting urban models towards more integrated waste management.

Carbon taxes have been applied in a number of countries and regions (e.g. Sweden and British Columbia), and Iceland and Ireland have recently introduced CO_2 taxes. Norway credits CO_2 taxes and carbon trading as having provided strong incentives to develop carbon capture and sequestration (CCS) projects in industry. However, short-term fiscal considerations, competitiveness concerns and preferences for direct regulation or incentive-based schemes in some countries, have slowed their uptake world-wide. Australia is planning to repeal its carbon tax and a range of related legislation and instead aims to reach its emissions reduction target through the Emissions Reduction Fund, an incentive-based scheme.

Clean energy is another area of continued public action and investment. The energy sector emits more CO_2 than any other sector. Electricity-related emissions account for more than 40% of emissions from the energy sector. Increasing the share of renewable energy technologies and expanding the sources beyond current technologies (e.g. biomass and hydro) are key policy goals. Demand-side policies that lead to increases in energy efficiency and demand for renewables (and lower demand for conventional sources) such as smart grids are also an important part of energy transition policies.

- Canada's Economic Action Plan 2013 has expanded the tax incentives that encourage businesses to invest in clean energy generation and energy efficiency equipment with an accelerated capital cost allowance (CCA) to encourage investment in particular assets or sectors in specific circumstances. The programme expands eligibility for the accelerated CCA for clean energy generation equipment to include a broader range of biogas production equipment and equipment used to treat gases from waste. This expansion applies to eligible assets acquired on or after 21 March 2013 that were not used or acquired for use before that date.
- France's *Plan d'Investissement d'Avenir* (PIA) has earmarked USD 2.7 billion PPP (EUR 2.3 billion) for energy transition, thermal renovation and the city of tomorrow. For sustainable industry, some measures will focus on environmental and energy issues, such as the development of a new generation of biofuels and the spread of smart grids. The PIA now generally includes as a criterion for project selection its direct or indirect contribution to environmental issues and sustainable development. While 30% of PIA2 will be issued in the form of grants, most of the funding will take the form of repayable advances, loans or equity interventions.

- The Irish government earlier committed almost USD 17.9 billion PPP (EUR 17 billion) for investments in the low carbon sector for 2008-20. This figure included private-sector investments in renewables through the feed-in tariff (REFIT) scheme, investments in the electricity transmission and distribution network, and investments in public transport and the Ocean Energy Programme.
- Italy has strengthened its White Certificate and created a new low-interest fund to promote energy efficiency. Incentives have also been introduced to encourage the use of renewables, in producing both electricity and thermal energy. A 2013 decree foresees a simplification of authorisation procedures for innovative bio-energy plants. In addition, the Italian Green Building Council has issued a new LEED-Historic Building (HB) protocol for retrofitting and renovating historic buildings.
- The US Department of Energy's Advanced Research Projects Agency-Energy (ARPA-E) has awarded nearly USD 400 million to more than 100 research projects that seek fundamental breakthroughs in energy technologies.

Greening industry through eco-innovation – innovations that reduce the use of natural resources and decrease the release of harmful substances across the entire life cycle – is another trend. Eco-innovation initiatives involve both technological and non-technological change. Eco-innovation policy instruments include regulations, economic incentives, negotiated agreements, public procurement and eco-labels.

- In 2013 Denmark extended its Fund for Green Business Development to 2016. The fund provides grants for companies, organisations, partnerships and others for: product innovation and redesign of company products, cradle-to-cradle; development of new business models; promotion of sustainable materials in product design; sustainable transitions in the fashion and textile industry; reduction of food waste; and sustainable bio-based products based on non-food biomass. The fund also promotes green industrial symbiosis, whereby waste or reserves of a given resource, e.g. water or materials, of one company become a resource in another.
- The Eco-Innovation Sicily project supports co-ordinated projects for the environmental protection and industrial development of southern Italy. It promotes the eco-sustainability of significant sectors in the region, encourages environmentally friendly business strategies through collaborative R&D, technological tools and methodologies, and raises awareness, especially among SMEs, of the need to interact in a knowledge and skills system.
- In the Netherlands, negotiated agreements at sectoral level between government and industries have committed Dutch firms to be among the "best in class" with respect to energy consumption. For some sectors these agreements have been complemented with benchmarking agreements.
- Sweden's Environment-Driven Business Development Programme, funded by the Swedish Agency for Economic and Regional Growth (formerly NUTEK), aims to strengthen the competiveness of SMEs in environment-driven markets. Most projects aim to improve possibilities for business development and financing of eco-innovations and to spread information and tools to encourage environment-driven business development and environmental technology exports.

- The United States is spurring private-sector innovation through new fuel efficiency and greenhouse gas emissions standards, with efforts to develop standards over the 2017-25 model years for light vehicles and new standards for medium- and heavy-duty vehicles. As the single largest consumer of energy, government procurement provides an additional important means of catalysing demand for innovative energy technologies. In October 2009, President Obama signed an Executive Order that calls on agencies to cut petroleum use in the federal government's fleet by 30% by 2020.

On the supply side, R&D remains important, particularly in specific research areas or technologies relevant to green growth.

- In 2013 Chile approved the installation and operation of two research centres for activities related to green growth under an initiative to attract centres of excellence in innovation. They are in the fields of marine energy and solar energy.
- Germany has launched several R&D programmes to increase resource efficiency in materials, water and land use under the Framework Programme Research for Sustainable Development (FONA). With the establishment of the new Helmholtz Institute Freiberg for Resource Technology (2011), the Federal Government and the Ministry of Education and Research (BMBF) aim to strengthen Germany's strategically important research competences to ensure a secure and sustainable supply of raw materials along the entire value chain.
- The Netherlands Top Institute Water, co-ordinated by the Wetsus Institute in Leeuwarden, is the national knowledge centre for water technology. It involves Dutch water companies and research, marketing and commercial activities.
- Norway has established eleven new centres for environment-friendly energy research to promote innovation through long-term research in selected areas of energy, transport and CO_2 management, in close co-operation between prominent research communities and users. Three of the research centres will study the interactions between technology and society and will examine Norway's energy policy challenges from a social science perspective.

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Innovation for social challenges

Rationale and objectives

Innovation can make a substantial contribution to dealing with social challenges such as poverty, ageing, social exclusion and health. Rapid technological change, and in particular the wide application of information and communication technologies (ICTs), can also affect overall well-being, thanks notably to the sharp decline in the cost of ICTs, which are now largely accessible to all categories of the population, including in developing economies.

Policy plays a critical role in shaping the contributions that science, technology and innovation (STI) can make to social challenges, as market mechanisms often do not address these challenges sufficiently. First, areas such as solutions to health challenges require basic research and therefore rely on contributions from public universities and public research institutes (PRIs). Second, social gains from solutions to such challenges can be particularly important, but may not be matched by private-sector returns. Not-for-profit initiatives can also be relevant but will require adequate policy frameworks to operate successfully.

Major aspects

There is no single definition of social innovation, although most tend to emphasise the objective of meeting social goals and, to some extent, the types of actors involved (e.g. not-for-profit, individuals, universities, government agencies, enterprises). Social innovation is therefore defined more by the nature or objectives of innovation than by the characteristics of innovations themselves. Social innovation seeks new answers to social problems by identifying and delivering new services that improve the quality of life of individuals and communities and by identifying and implementing new labour market integration processes, new competencies, new jobs, and new forms of participation that help to improve the position of individuals in the workforce.

There are several reasons why social challenges are increasingly important today and why STI is critical for meeting them. First, it has becoming increasingly clear in recent years that growth alone no longer guarantees well-being. The benefits of growth do not always trickle down automatically. In fact, for a range of OECD countries there is evidence to suggest that, with growth, those at the bottom of the income distribution have benefited little if at all, unlike those at the top. This has resulted in growing within-country inequalities (OECD, 2011a). Many emerging and developing countries that have experienced positive growth dynamics have also found that poverty and exclusion continue to be a challenge (OECD, 2013a). The role of innovation, an important driver of growth, in shaping inequalities and in helping to support well-being is therefore critical.

Second, a large number of OECD and non-OECD countries are undergoing a substantial demographic change. An increasingly large share of the population is aged 65 and older. In 2010, the share of the OECD population over 65 years old was around 15%; it is expected to reach 26% by 2050 (OECD, 2011a). This will increase the demand for health care and put further pressure on public expenditures related to health care. Low labour force participation of older age groups increases the strain on social security and pension systems. Thus, findings ways of reducing and improving health care and related expenditures and encouraging the continued participation of the elderly in economic activities are challenges that call for innovations to support conditions for the elderly. Innovation can also help address health challenges, which increase in an ageing society, by providing more personal, predictive and preventive health-care products (OECD, 2013b). The rising cost of many health technologies, however, poses a challenge to the wider uptake of these technologies that needs to be addressed.

Third, it is more widely recognised that innovation can offer new ways to address social challenges. Inclusive innovation and innovative products for lower-income groups have been very successful in helping the poor improve their welfare. For instance, mobile health and education services, low-cost cars, and portable, pedal-powered washing machines have brought, at lower cost, some of the benefits of products often taken for granted by others (OECD, 2013). Their scale is, however, often limited due to obstacles businesses need to overcome to cater for those markets.

A critical factor for innovation policies that aim to address social challenges is the public perception of science and technology's contributions to well-being. The extent to which policies help orient science and technology towards addressing well-being can help reduce negative views and help generate greater interest in STI and a wider willingness to adopt new technologies, two critical elements for stimulating STI (see the policy profile on "Building a science and innovation culture").

Recent policy trends

STI efforts to address social challenges continue to be high on the innovation policy agenda of most countries. Mexico's National Development Plan 2013-18 will guide development and promote social inclusion over the next years. Responding to major societal challenges is also a key focus of the European Union's Horizon2020 programme. Naturally, countries' innovation policy priority areas differ. They may emphasise ageing, health, exclusion of various types (disability, minorities, etc.), or poverty in the development context. Technological change and ICTs also present challenges. Belgium implemented the Society and Future Programme to gather scientific knowledge to respond to future challenges. Norway recently implemented a Research Programme on Societal Security and Safety. The future of the workplace and exploring the implications of changes due to ICTs are among the topics of Wallonia's Germaine Tillion Research Programme in Social Innovation. Some programmes focus on using ICTs to address social challenges, e.g. Costa Rica's Community Centres. Colombia implemented a Strategy for the Social Appropriation of Knowledge to promote citizen participation in building public policy for STI as a way to promote STI and its contributions to addressing social challenges.

Dealing with poverty and exclusion is high on the innovation policy agendas of Chile, Colombia, India and South Africa. India recently launched its Inclusive Innovation Fund to promote businesses that target the poor. Several OECD countries have STI programmes to support development. They include Japan's S&T Research Partnership for Sustainable Development, an activity of the Japan Science and Technology Agency (JST) in co-operation with the Japan International Co-operation Agency (JICA). This programme supports and promotes international joint research projects that advance science and technology by addressing global issues (e.g. climate change and food security) based on the needs of developing countries. The question of exclusion is not only an issue in the development context. Some projects explicitly address the costs of exclusion for the STI system. For instance, South Africa's Thuthuka Programme aims, via preferential funding of research projects, to support human research capacity at South Africa's higher education and research institutions, particularly among previously disadvantaged socio-economic groups. Countries that implement education policy programmes to ensure that science, technology and engineering skills are provided to young people independently of their backgrounds include Australia, Colombia, Estonia, Hungary, New Zealand and Poland.

A number of countries have established funding programmes to direct research efforts towards specific social challenges. The Academy of Finland has launched research programmes on the health and welfare of children and young people and on the future of learning and knowledge and skills. The US BRAIN Initiative (USD 100 million) aims to revolutionize the understanding of the human brain by advancing brain research through innovative neurotechnologies and new ways to treat and prevent brain disorders, such as Alzheimer's disease, epilepsy, and traumatic brain injury. Policy efforts also focus on creating networks to address social challenges, often by placing more emphasis on interdisciplinary approaches. Examples include BRAIN-be, the Belgian Research Action through Interdisciplinary Network Initiative, and Australia's Science of Learning Research Centre, which was set up in 2012 to bring together education professionals and high-quality researchers in areas ranging from neuroscience and cognitive development to educational technology to improve the quality of education. Similarly, the Human Brain Project, funded by the European Commission, has partners from 24 European countries, led by researchers from Germany, France, Spain, Sweden, Switzerland and the United Kingdom.

An interesting approach some countries have adopted consists in seeking business and entrepreneurship support in addressing social challenges. Chile's Social Innovation and Entrepreneurship Programme, with public investment of USD 2 million, supports organisations that promote innovation and social enterprises. Switzerland's Ambient Assisted Living offers SMEs transnational co-operation opportunities for projects that address the challenges arising from demographic change, including projects aimed at ICT-based solutions for the prevention and management of chronic conditions of elderly people. The United Kingdom's Centre for Challenge Prizes at NESTA, which opened in April 2012, is an example of a prize-based mechanism to reward entrepreneurial initiative.

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OECD Science, Technology and Industry Outlook 2014

PART II

Chapter 5

STI policy profiles: Innovation in firms

Policy mix for business R&D and innovation

Rationale and objectives

The term "policy mix" is generally taken to refer to the balance of and interactions among policies. It can refer to the different policy goals pursued by government or the different rationales for policy intervention, but it refers more commonly to the mix of instruments used in pursuit of a particular policy goal, in this case, the promotion of business R&D and innovation. This is the perspective adopted in this policy profile.

Recent years have seen increased interest in the policy mix to support business R&D and innovation. Whereas much emphasis was previously placed on the design and evaluation of individual instruments of innovation policy, there is now greater interest in understanding the effectiveness of the larger portfolio of policy instruments used to improve a country's innovative capabilities. This view of the policy landscape reflects a growing appreciation of the interdependence of policy measures and an understanding that the performance or behaviour of innovation systems requires a more holistic perspective. Yet, while there is evidence that the complementarities and trade-offs among policy instruments are significant for assessing a country's STI policy and its impact on innovative and economic performance, they remain poorly understood.

Major aspects

For the policy mix concept to be useful in policy making and analysis, individual policy instruments and the interactions among them need to be defined. Policy instruments can be characterised in several ways: by their target groups, their desired outcomes, or their mode of intervention (e.g. funding, regulation). Some of the most popular characterisations are binary in nature, e.g. supply-side versus demand-side instruments. They should not necessarily be interpreted as alternatives but as possible complements. In fact, a key challenge is to strike an appropriate balance, taking into account the current state of the innovation system concerned and a vision for the future.

Interactions among policy instruments can be characterised as complementary, neutral, alternative (substitutable) or conflicting and are likely to demonstrate emergent properties in terms of their effects and impacts, which has made their study difficult. Much of the empirical work on innovation policy mixes has been concerned, for the most part, with discussing balances (and by extension, policy gaps). Far less attention has been paid to interactions, no doubt on account of the conceptual and practical challenges involved. Yet, the effectiveness of a policy instrument almost always depends upon its interaction with other instruments, sometimes at different times and for different purposes.

Countries' instrument mixes will differ, as they will have accumulated over time and will have been adapted to the country's specific political and socio-economic circumstances. Furthermore, finding an appropriate policy mix is not a task that is solved once and for all, since the scope and content of government policies evolve, driven by changes in external factors as well as in the level of economic and institutional development and the level of sophistication of government itself. These in turn influence both the set of attainable goals and the ability to achieve them. This is confirmed by countries' replies to the OECD STI Outlook policy questionnaire 2014.

Recent policy trends

The OECD STI Outlook policy questionnaire 2014 invited countries to rate the balance in the policy mix for business R&D and innovation over time (ten years ago, today and in the next five years) for five sets of policy instruments: population-targeted versus generic instruments; sector- or technology-targeted versus generic instruments; financial versus non-financial instruments; competitive versus non-competitive instruments; and supply-side versus demand-side instruments (Figure 5.1).

Population-targeted versus generic (non-population-targeted) instruments: Population-targeted instruments are those targeted towards specific types of firms, especially SMEs or new-technology based firms (see the policy profiles on "Start-ups and innovative entrepreneurship" and "Financing innovative entrepreneurship"). Figure 5.1(a) indicates that many countries have moved towards more population-targeted instruments over the last decade and that this will continue in the next five years. There are, however, important exceptions: Poland's policy instrument mix has been and will remain predominantly generic, while those of France, Germany, Sweden and the United Kingdom have increasingly moved away from population-targeted instruments, a trend that is set to continue over the coming years.

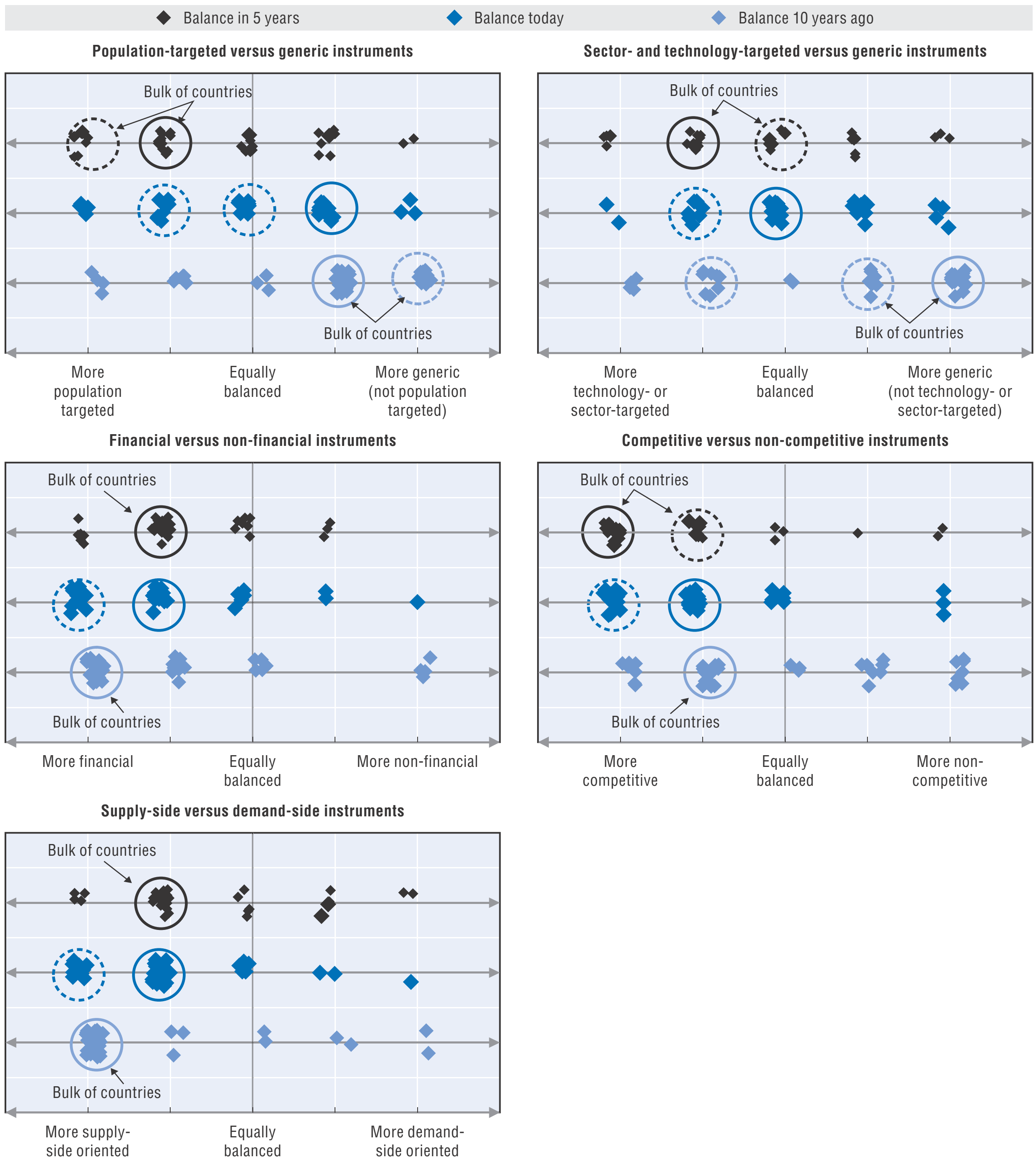
Sector- and technology-targeted versus generic (non-technology-targeted) instruments: Sector- and technology-targeted instruments support specific fields of R&D and innovation or specific industry sectors (see the policy profile on "New industrial policies"). Figure 5.1(b) shows that countries vary markedly in the balance of sector- and technology-oriented and non-sector/non-technology-oriented instruments. Of those answering this question, close to half claim that their policy instrument mix is becoming more sector- and technology-oriented than previously, owing, perhaps, to an interest in "new industrial policy". A few OECD countries are moving in the opposite direction. Sweden expects policy to move from what was a strong sector and technology orientation a decade ago to a strong generic orientation in the next five years; over the same period, Finland and Germany expect to move from a policy mix that was slightly more sector- and technology-oriented to one that will be slightly more generic. Outside of the OECD, China expects to move from a policy mix with a strong sector and technology orientation ten years ago to one that is equally balanced in the next five years.

Financial versus non-financial instruments: Financial instruments include both direct (e.g. credit loans and guarantees, repayable advances, competitive grants, innovation vouchers) and indirect funding (e.g. R&D tax incentives), while non-financial instruments include a variety of tools, including business innovation services, organisation of events, and information campaigns that promote business innovation (see the policy profiles on "Government financing of business R&D and innovation", "Tax incentives for R&D and innovation" and "Financing innovative entrepreneurship"). Figure 5.1(c) shows that the bulk of support to business R&D and innovation has been financial in nature. While there has been some movement towards more non-financial instruments in about half of the countries answering this question, the balance in about three-quarters remains at the financial instrument end of the spectrum.

Competitive versus non-competitive instruments: Competitive policy instruments selectively allocate funding on the basis of criteria such as expected performance and relevance. Non-competitive policy instruments may be granted universally or after a selection process based on eligibility criteria. Figure 5.1(d) shows a strong preference for competitive instruments. Close to half of the countries answering this question indicated

Figure 5.1. **Changing balance in the policy mix for business R&D and innovation, 2014**

(based on own country ranking)



Note: The balance in the policy mix for business R&D and 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 in your country? How has this balance shifted, if at all, over the last ten years? In what broad directions is this balance forecasted to shift, if at all, over the coming five years?" Responses are provided by Delegates to the OECD Committee for Scientific and Technological Policy.

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

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a shift towards more competitive instruments. However, among OECD countries, Canada, the Netherlands and, to a lesser extent, the United Kingdom indicate that their policy mix is and will remain more non-competitive, which may partly reflect the strong reliance on R&D tax credits in their support for business innovation.

Supply-side versus demand-side instruments: Supply-side instruments aim to boost knowledge production and supply, with a view to accelerating knowledge spillovers and externalities. Demand-side instruments focus on boosting market opportunities and demand for innovation, as well as on encouraging suppliers to meet expressed user needs (see the policy profile on "Stimulating demand for innovation"). Figure 5.1[(e)] confirms the long-standing focus on supply-side instruments but also the recent emergence of demand-side policy to stimulate and articulate public demand for innovative solutions and products from firms. Many countries indicate that the next five years will see increased emphasis on demand-side instruments, though the majority expect supply-side instruments to remain dominant. Notable exceptions among OECD countries are Austria, Germany, Hungary and Portugal, which expect demand-side instruments to be more prominent.

In summary, based on countries' self-assessments, it is evident that the balance of their policy mixes differs and that these balances change over time. Overall, more countries have been moving towards more targeted policy mixes, involving more competition and mobilising a broader diversity of instruments. Of course, given the nature of the data, results should be interpreted with caution. They provide an indicative rather than a fully reliable picture of variation and change. Nevertheless, the results tend largely to confirm common beliefs regarding policy mix balances and their directions.

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Government financing of business R&D and innovation

Rationale and objectives

Firms are major drivers of innovation but tend to underinvest in R&D. They engage in R&D to differentiate themselves from competitors, to be more successful in business and to increase profits. However, the costs and uncertainty of R&D, the time required to obtain returns on investment, and the possibility that competitors can capture knowledge spillovers – owing to the non-rival and non-excludable nature of R&D – often reduce their incentives to undertake R&D. The funding of innovative entrepreneurship raises further issues, addressed in the policy profile on "Financing innovative entrepreneurship".

The effectiveness of public financing policies can be questioned on three main grounds (Guellec and van Pottelsberghe, 2000). First, government spending can crowd out private money, for example by increasing the demand for and cost of R&D through higher wages for researchers. Second, governments may support projects that would have been implemented anyway so that firms simply use public money instead of their own. Third, governments often allocate public funds less efficiently than market forces, thereby distorting competition and resource allocation. By trying to "pick winners", they may end up supporting less promising research areas or favour incumbents and lobbying groups to the detriment of new and innovative firms.

Major aspects

Governments finance business R&D and innovation through a mix of direct and indirect instruments. Governments offer direct support through public procurement for R&D and a variety of grants, subsidies, loans or equity funding (Table 5.1). They provide indirect support through fiscal incentives, such as R&D tax incentives. Direct funding allows governments to target specific R&D activities and steer business efforts towards new R&D areas or areas that offer high social returns but low prospects for profits, e.g. green technology and social innovation; direct funding instruments depend on discretionary decisions by governments. Tax incentives reduce the marginal cost of R&D and innovation spending; they are usually more neutral than direct support in terms of industry, region and firm characteristics, although this does not exclude some differentiation, most often by firm size (OECD, 2010a). While direct subsidies are more targeted towards long-term research, R&D tax schemes are more likely to encourage short-term applied research and boost incremental innovation rather than radical breakthroughs.

Direct financial support is offered through competitive grants and debt financing, such as loans for R&D projects. Risk-sharing mechanisms are widely used to provide lenders with insurance against the risk of default and improve firms' access to credit. A loan guarantee implies that in the event of a loan default, the credit guarantee scheme will reimburse a pre-defined share of the outstanding loan to the lender.

Some direct support is also linked to public procurement (see policy profile on "Stimulating demand for innovation"). In France and the United States, a large share of public support for R&D is provided to firms in the defence industry to develop military equipment and potentially civil applications. While governments retain the intellectual property (IP) of research results developed in the framework of public procurement programmes, the research results belong to R&D-performing firms under other funding schemes (Guellec and van Pottelsberghe, 2000).

Table 5.1. **Major policy instruments for financing business R&D and innovation and some country examples**

Financing instruments			Key features	Some country examples
Direct public funding	**Grants, subsidies**		Most common funding instruments. Used as seed funding for start-ups and innovative SMEs. Granted on a competitive basis and in some cases, on the basis of private co-funding. No repayment is usually required. Supply-side, discretionary instruments.	ANR subsidies (Argentina), Central Innovation Programme for SMEs (Germany), R&D Fund (Israel), Small Business Innovation Research (SBIR) Program (US)
	Debt financing	**Credit loans**	Government subsidised loans. Require sorts of collateral or guarantee. Obligation of repayment as debt. The investor/lender does not receive an equity stake.	Novallia (Belgium), High-Tech Gründerfonds (Germany), Public Investment Bank (France), Microfinance Ireland, Slovene Enterprise Fund, British Business Bank (UK)
		Repayable grants/advances	Repayment required, partial or total, sometimes in the form of royalties. Could be granted on the basis of private co-funding.	Repayable Grants for Start-Ups (New Zealand)
		Loans guarantees and risk-sharing mechanisms	Used widely as important tools to ease financial constraints for SMEs and start-ups. In the case of individual assessment of loans, can signal ex ante the creditworthiness of the firm to the bank. Often combined with the provision of complementary services (e.g. information, assistance, training).	Small Business Financing Program (Canada), Mutual guarantee schemes (Confidi) (Italy), 7(a) Loan Program (US), R&I Loans Services (European Commission)
	Debt/Equity financing	**Non-bank debt/ equity funding**	New funding channels. Innovative lending platforms and non-bank debt or equity funds.	Business Finance Partnership (UK)
		Mezzanine funding	Combination of several financing instruments of varying degrees of risk and return that incorporate elements of debt and equity in a single investment vehicle. Used at later stage of firms' development. More suitable for SMEs with a strong cash position and a moderate growth profile.	Guarantees for Mezzanine Investments (Austria), PROGRESS Programme (Czech Rep.), Industrifonden and Fouriertransform (Sweden), Small Business Investment Company (US)
	Equity financing*	**Venture capital funds and funds of funds**	Funds provided by institutional investors (banks, pensions funds, etc.) to be invested in firms at early to expansion stages. Tends to increasingly invest at later -less risky- stage. Referred as patient capital, due to lengthy time span for exiting (10-12 years). The investor receives an equity stake.	Innpulsa (Colombia), Seed Fund Vera (Finland), France Investment 2020, Yozma Fund (Israel), Scottish Co-investment Fund (UK)
		Business angels	Provide financing, expertise, mentoring and network facilities. Tends to invest in the form of groups and networks. Financing at start-up and early stage.	Seraphim Fund (UK), Tech Coast Angels and Common ANGELS (US)
	Public procurement for R&D and innovation*		Create a demand for technologies or services that do not exist, or, target the purchase of R&D services (pre-commercial procurement of R&D). Provide early-stage financial support to high-risk innovative technology-based small firms with commercial promise.	Small Business Innovation Research (SBIR) Program (US) and SBIR-type of programmes (UK)
	Technology consulting services, extension programmes		Expand the diffusion and adoption of already existing technology, and contribute to increase the absorptive capacity of targeted firms (especially SMEs). Provide information, technical assistance, consulting and training, etc. Of particular importance in low income countries.	Manufacturing Extension Partnerships (US)
	Innovation vouchers		Small lines of credit provided to SMEs to purchase services from public knowledge providers with a view to introducing innovations in their business operations.	Innovation vouchers (Austria, Chile, China, Denmark, etc.)
Indirect public funding	**Tax incentives***	**Tax incentives on corporate income tax**	Used in most countries. Broad range of tax arrangements on corporate income tax, including tax incentives on R&D expenditure and, less frequently, tax incentives on IP-related gains. Indirect, non-discriminatory.	SR&ED tax credit (Canada), R&D Tax Credit (France), exemption on payroll withholding tax (Netherlands), patent box (UK)
		Tax incentives on personal income tax and other taxes	Available in many countries. Broad range of tax incentives on R&D and entrepreneurial investments and revenues that apply to personal income tax, value added tax or other taxes (consumption, land, property, etc.). Indirect, non-discriminatory.	Personal wage tax reduction for foreign researchers and key staff (Denmark), wealth tax exemption for business angels (France), Business Expansion and Seed Capital Schemes (Ireland)

* See the related policy profiles on "Financing innovative entrepreneurship", "Stimulating demand for innovation" and "Tax incentives for R&D and innovation".

Source: Based on Innovation Policy Platform; OECD (2014), *Financing SMEs and Entrepreneurs 2014: an OECD Scoreboard*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/fin_sme_ent-2014-en*; OECD (2013), *Financing SMEs and Entrepreneurs 2013: an OECD Scoreboard*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/fin_sme_ent-2013-en*; OECD (2011), *Business Innovation Policies: Selected Country Comparisons*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/9789264115668-en*; OECD (2011), *Financing High-growth Firms: The Role of Angel Investors*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/9789264118782-en*; and country responses to the STI Outlook policy questionnaire 2014.

Many OECD countries have schemes and funds to access early-stage finance, particularly for equity. Support is provided to the venture capital industry, with some governments actively providing equity funding (OECD, 2011a; Wilson et al., 2013). A common approach is to facilitate the growth of venture funding through public venture capital funds, co-investment funds with private investments and "funds of funds" (see policy profile on "Financing innovative entrepreneurship").

Direct support for innovation, other than R&D-related schemes, includes measures to facilitate the commercialisation of innovation, support the development of networks, promote regional innovation hubs, and ease access to information, expertise and advice (OECD, 2011b). Innovation vouchers or technology consulting services and extension programmes are major policy instruments in this respect.

Tax incentives applicable to different tax arrangements, including corporate and personal income taxes, are also widely used to encourage private investments in R&D and the exploitation of IP assets, to attract business angels and leverage early-stage finance, and to attract foreign talent or foreign multinationals (see policy profiles on "Tax incentives for R&D and innovation", and "Financing innovative entrepreneurship").

Recent policy trends

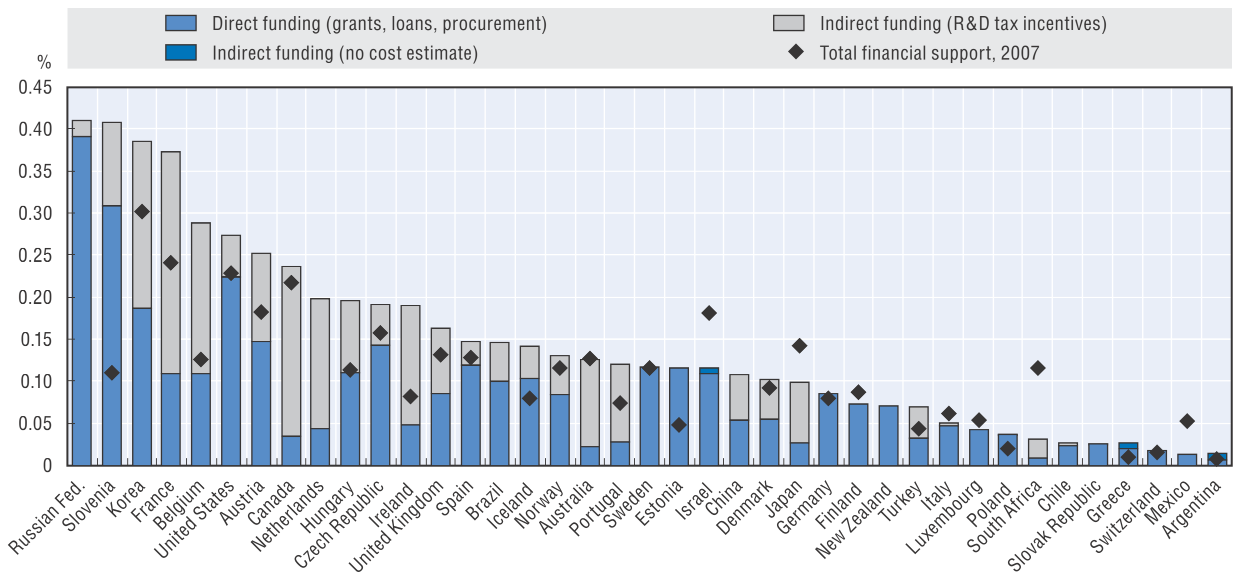
Public funding of business R&D and innovation has increased in most countries over the past decade. The policy mix used to finance business innovation has seen growing use of R&D tax incentives and a shift of emphasis in direct support towards new purposes (e.g. knowledge transfer or equity financing). There has also been more focus on evaluation (OECD, 2011b).

In most countries, 10% to 20% of business R&D expenditure is funded by public money (see Chapter 1, Figure 1.20). The Russian Federation, Slovenia, Korea and France are the most generous, with central government support to business R&D accounting for more than 0.35% of GDP (Figure 5.2). Overall public funding of business R&D and innovation increased between 2006 and 2011, both in real terms (see Chapter 1) and as a percentage of GDP. The increase has been particularly marked in Belgium, Estonia, Ireland and Slovenia, where direct support and tax concessions to firms combined have more than doubled since 2006.

Several countries increased public spending for business R&D and innovation between 2012 and 2014. Canada signalled its commitment to a new approach to support for business innovation by simplifying the R&D tax credit programme and redeploying funds to direct support initiatives; by launching Canada's Venture Capital Action Plan and supporting business incubators and accelerators; by making the innovation procurement programme permanent; by doubling funding to the Industrial Research Assistance Program and launching a vouchers programme for SMEs; by transforming the National Research Council to deliver more effective support to business-based innovation; and by establishing a concierge service to provide easier access to federal innovation programming and resources. In the Czech Republic, the establishment of the new Technology Agency came with an increased financial endowment for firms. Public budgets for competitive R&D grants have been rising in Iceland, New Zealand and Norway. In Iceland, the amount of tax revenues foregone through the recently implemented R&D tax credit has also increased.

Figure 5.2. **Government funding of business R&D, direct funding and R&D tax incentives, 2012**

As a percentage of GDP



Notes: The estimates of R&D tax incentives do not cover sub-national R&D tax incentives.
Estonia, Germany, Luxembourg and Switzerland do not provide R&D tax incentives. Mexico and New Zealand repealed their R&D tax incentive in 2009 and 2009-10, respectively. Finland and Sweden recently introduced R&D tax incentive schemes for companies for which cost estimates of foregone revenues are not yet available.
In Austria, Poland and South Africa, R&D tax incentive support is already included in official estimates of direct government funding of business R&D (OECD, 2013a). It is removed from direct funding estimates to avoid double-counting. Greece and Israel provide R&D tax concessions but cost estimates of R&D tax relief are not available and therefore not included in the total. For Estonia, Finland, Germany, Greece, Poland, Slovenia, Switzerland, the United Kingdom and the United States, data refer to 2012. For Australia, Belgium, Brazil, Chile, Ireland, Spain and South Africa, figures refer to 2010. For China and Luxembourg, figures refer to 2009. Otherwise data refer to 2011.
For more technical information about R&D tax data coverage, please see the OECD Directorate for Science, Technology and Industry webpage on Measuring R&D tax incentives at *www.oecd.org/sti/rd-tax-stats.htm*. For Australia, Iceland, Portugal, the Russian Federation, Slovenia, the United Kingdom and the United States, cost estimates are drawn from country responses to the OECD STI Outlook policy questionnaire 2014. For Brazil, data for direct funding of BERD refer to 2010 and come from the OECD (2013), *OECD Science, Technology and Industry Scoreboard: Innovation for Growth*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/sti_scoreboard-2013-16-en*.
Source: Based on OECD R&D tax incentive data collection, 2013, country responses to the OECD STI Outlook policy questionnaire 2014 and OECD (2014), *OECD Main Science and Technology Indicators (MSTI) Database*, June 2014, *www.oecd.org/sti/msti*. Data retrieved from OECD IPP.Stat on 8 July 2014, *http://stats.oecd.org//Index.aspx?QueryId=57863*.

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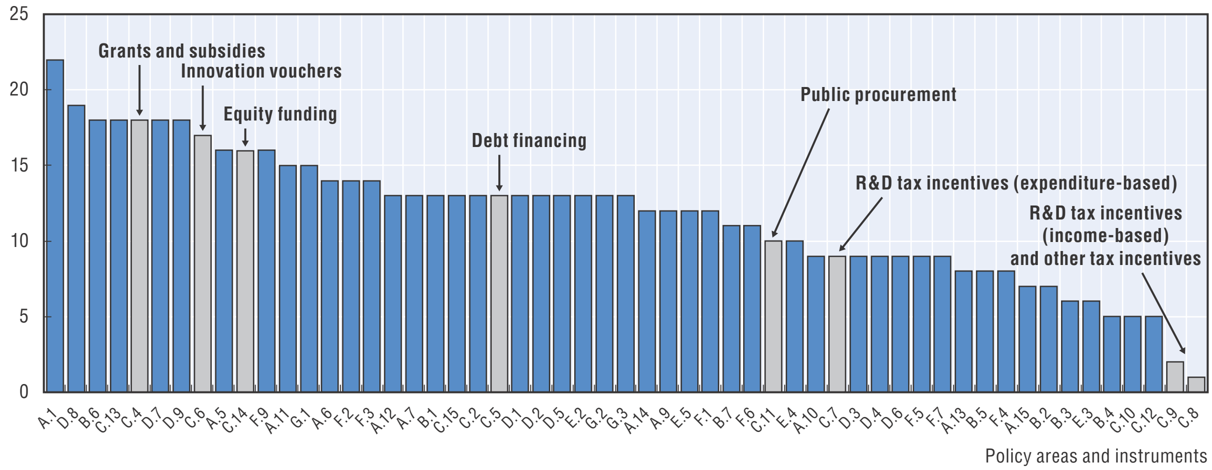
Public support through indirect tax instruments has also increased over the past decade. France's policy mix for business R&D has undergone a full reversal since 2008. Belgium, Ireland, South Africa and Turkey have also reinforced indirect funding through R&D tax relief since 2006 (OECD, 2013a). More than half of the countries participating in the STI Outlook policy questionnaire 2014 confirmed the stronger role of R&D tax incentives in the policy mix for business R&D and innovation in recent years (Figure 5.4, Panel 2). However, national tax schemes for R&D have been relatively stable since 2012 compared to other public funding instruments (Figure 5.3). Countries have reported more substantial changes in the design and governance of direct funding instruments.

Direct funding instruments, especially competitive grants, remain major levers of innovation policy (Figure 5.4, Panel 1). Direct support is provided through an increasing variety of tools for an increasing variety of purposes (e.g. to encourage knowledge transfer, growth of high-technology start-ups, venture capital activity, green innovation) (OECD, 2011b).

Figure 5.3. **Initiatives to finance business R&D and innovation among other areas of STI policy change, 2012-14**

Countries reporting a substantial change in the policy area, compared with other STI policy areas



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 2014 questionnaire). The y-axis shows the number of countries reporting that the situation has substantially changed in each policy area. Simple counts do not account for the magnitude and impact of policy changes. In the case of income-based tax incentives and other taxes that are not widely applied, countries may not report changes. Responses are provided by Delegates to the OECD Committee for Scientific and Technological Policy.

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

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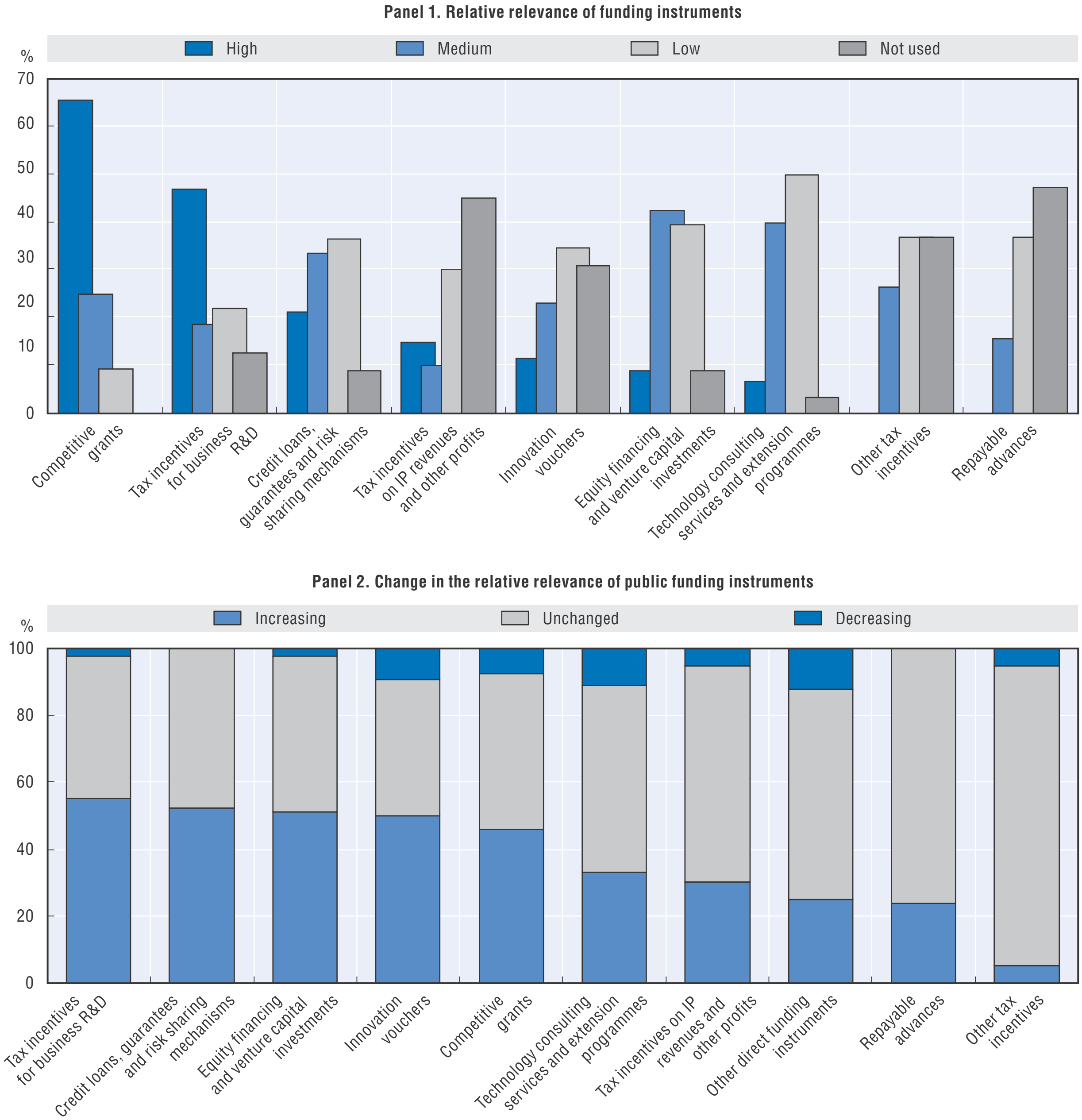
Innovation vouchers and equity financing instruments are of increasing relevance in the policy mix in most countries (Figure 5.4, Panel 2) and have been among the STI policy areas that have changed the most since 2012 (Figure 5.3).

Use of innovation vouchers has spread across the OECD and emerging economies. The United Kingdom has allocated at least USD 2.8 million PPP (GBP 2 million) a year, for three years, to its innovation voucher programme, starting in 2013. Canada is providing USD 16 million PPP (CAD 20 million) over three years for its innovation voucher programme, the Business Innovation Access Program. Korea and Sweden are also running pilot voucher schemes. Latvia, Poland and Turkey have implemented similar funding instruments, while Australia (the State of Victoria), Belgium (Brussels-Capital Region) and the Czech Republic (Prague) have introduced innovation vouchers at the state or local level. A new Italian voucher scheme, administered at regional level, supports the digitisation of business processes (website, e-commerce, broadband and ultra-broadband connectivity). Austria has announced a new EUR 5 000 voucher scheme for innovation in creative industries.

Some countries have recently used grants to reinforce public funding to R&D and innovation. New Zealand replaced its Technology Transfer Vouchers with Callaghan Innovation R&D Grants in 2012. The Canadian Economic Action Plan 2012 proposed to streamline the SR&ED tax incentive programme and to invest the savings in direct support for business innovation. The United States 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.

Figure 5.4. **Relevance of major funding instruments in the policy mix for business R&D and innovation, 2014**

As a percentage of total country self-reported responses



Note: Simple counts of country responses to the question: "Which of the following are the principal instruments of public funding of business R&D and innovation in your country? How has the relative balance between these instruments changed recently, if at all? Please rate the relative relevance of the following financial instruments in your country's policy mix and indicate whether their share in the total has increased/decreased or is remained unchanged". Responses are provided by Delegates to the OECD Committee for Scientific and Technological Policy.

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

StatLink http://dx.doi.org/10.1787/888933151731

Debt funding mechanisms are prominent in the policy mix but have recently undergone few changes (Figure 5.4, Panel 1 and Panel 2). Governments have responded to the credit difficulties faced by small and medium-sized enterprises (SMEs) by injecting capital into their direct lending and loan guarantee programmes (OECD, 2013b). Austria has broadened and expanded its loan initiatives for innovative start-ups, through programmes such as the AWS Pre-Seed and Seed Financing for high-technology companies and a new Frontrunner Initiative for innovation and technology leaders. The Danish Growth Fund has introduced a new programme of subordinated loans for SMEs and merged it with the former loan guarantee schemes. Hungary has granted USD 224 million PPP (HUF 28 billion) under the New Széchenyi Loan Guarantee Scheme to improve credit options for micro-firms and SMEs. Ireland introduced a Credit Guarantee Scheme and established the Microenterprise Loan Fund in 2012. Turkey has developed a New Soft Loan Programme to target niche technologies (e.g. clean, biomedical or advanced materials technologies). The United States continues to propose expansions of loan guarantees and other risk-sharing mechanisms to encourage business innovation, particularly in the clean-energy sector.

Governments have also focused more on non-conventional debt funding. The United Kingdom is currently setting up the British Business Bank, a new national development bank that will administer the Enterprise Finance Guarantee for SMEs and programmes aimed at strengthening non-bank financing. A new USD 432 million PPP (GBP 300 million) Investment Programme has been launched to increase the supply of lending through non-bank lending channels and potentially to direct investment towards the capital structures of smaller providers. It complements the USD 1.7 billion PPP (GBP 1.2 billion) Business Finance Partnership initiated in 2011 to encourage innovative lending platforms and non-bank debt funds.

Direct funding instruments for business R&D and innovation have become more market friendly, encouraging competition-based selection and streamlining public support schemes. In 2013 Belgium (Brussels-Capital Region) revised its Grant for Grants scheme, which finances the preparation of EU R&D projects, to make it more accessible. Finland is implementing a joint customer strategy to improve public service delivery; it includes the creation of joint service packages for high-growth enterprises and a systematic exchange of customer data within public services. The financing of traditional, fast-growing, young or early-stage firms has also been concentrated in a single agency (Tekes). New Zealand established Callaghan Innovation to gather various initiatives beyond R&D funding and to provide a one-stop shop for firms. Norway has implemented a new information-technology-based system that simplifies applications to the Skattefunn R&D tax schemes, and the qualification requirements for the national entrepreneurship grants have been standardised.

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TAX INCENTIVES FOR R&D AND INNOVATION

Rationale and objectives

R&D tax incentives aim to encourage firms to perform R&D by reducing its costs. Compared with direct subsidies, R&D tax incentives allow firms to decide the nature and orientation of their R&D activities, on the assumption that the business sector is best placed to identify research areas that lead to business outcomes. R&D tax incentives are market-friendly instruments that are by nature more neutral than direct support instruments. In addition, direct subsidies under World Trade Organization (and European Commission) rules are subject to ceilings (50% of upstream R&D, 25% of downstream R&D) that do not apply to indirect support, provided the tax relief remains non- discretionary and applies evenly across firms and sectors.

Potential downsides of R&D tax incentives include:

- A windfall effect if public money subsidises business R&D that would have been committed anyway, particularly a lack of input additionality;
- The application of a single rule to different business situations at the detriment of firms that might need more support (e.g. small firms that may have less resources and capacity to process complex tax claims, domestic enterprises that may not be able to elaborate tax optimisation strategies across borders, young firms that may need more or differently designed financial support due to their intrinsic difficulties to access funding and their higher probability of being in a financial loss position);
- An increase in the demand for research skills and – given the inelastic supply of researchers in the short-term – a subsequent increase in researcher wages to the detriment of the volume of R&D;
- Possible tax competition for R&D that could result in a zero-sum game at international level while reducing government revenues in all countries involved.

Major aspects

A variety of tax incentives for R&D and innovation apply to corporate income tax, payroll withholding taxes and social security contributions, personal income tax, value-added tax or other consumption, land and property taxes, etc. Tax breaks are granted on the basis of expenditures incurred for R&D activities (expenditure-based) or gains from innovative activities (income-based) (Table 5.2).

Although a few countries – Estonia, Germany, New Zealand and Switzerland – do not offer specific tax arrangements for R&D and innovation at central or federal level (Table 5.2[f]), R&D tax incentives are universally used.

Enhanced deductibility of R&D-related expenditures and accelerated depreciation of R&D investments are imputed on corporate income tax in a broad range of countries (Table 5.2[a]). In certain cases, firms may be granted special exemptions on R&D wages and social security taxes (Table 5.2[b]). Preferential import and value-added tax rates (Table 5.2[d]) are also applied for the purchase of science and technology (S&T) equipment (e.g. imported S&T equipment in Colombia and the Russian Federation), or for firms in strategic S&T sectors (e.g. software in China). Young innovative firms (France) or firms in special economic zones (Russian Federation) may also benefit from exemptions on land and property taxes (Table 5.2[e]).

Several governments offer preferential tax treatment for corporate income from royalties, licensing and R&D capital gains in order to encourage the commercialisation of R&D results and to attract or retain intellectual property (IP) (Table 5.2[(g)]). The so-called "patent box" schemes, in reference to the box to tick on claim files, allow firms to lower corporate tax rates on income from patents and similar IP. Since 2011, Italy offers micro firms and small and medium-sized enterprises (SMEs) the double Brevetti+ programme to increase the number of national patent applications and their extension abroad ("Award for patenting") and to encourage their commercialisation ("Incentives for the economic exploitation of patents").

The "patent box" schemes are related to tax incentives for R&D expenditures, because they may help anchor the exploitation of patented knowledge in the country in which the R&D is performed and help complete an innovation chain from knowledge production to commercialisation. In fact, most countries provide IP income-based tax incentives in combination with R&D expenditure-based tax incentives. International restrictions may also apply to the location of R&D performance (Hungary) or of IP development (Netherlands).

Other income-based regimes aim to leverage private investments in R&D or to attract S&T talent. Colombia, Korea and Poland propose a reduced income tax rate on firms' gains that constitute an R&D reserve (Table 5.2[(h)]). Denmark and Hungary offer a tax deduction for donations to qualified R&D institutions (Table 5.2[(c)]). Colombia, Denmark, Korea and Turkey target highly skilled workers by exempting them from personal income tax (Table 5.2[(i)]).

Table 5.2. **Overview of tax incentives for R&D and innovation, selected OECD and non-OECD economies**

	Tax incentives for R&D and innovation	
	Expenditure-based (e.g. R&D expenditure including wages, capital)	Income-based (e.g. salaries, IP profit, royalties, capital gains)
Tax arrangements		
Corporate income tax (CIT)	(a) Argentina, Australia, Austria, Belgium, Brazil, Canada, Chile, China, Costa Rica, Czech Rep., Denmark, Finland, France, Greece, Hungary, Iceland, Israel, Italy, Japan, Korea, Latvia, Norway, Poland, Portugal, Russian Fed., Slovak Rep., Slovenia, South Africa, Spain, Turkey, UK, US	(g) Brazil, Belgium (Fed.), China, Colombia, Greece, Hungary, Italy, Luxembourg, Netherlands, Spain, UK ("patent box") (h) Colombia, Korea, Poland (R&D reserve)
Payroll withholding and social security taxes	(b) Belgium (Fed.), France, Hungary, Netherlands, Russian Fed., Spain, Sweden, Turkey	–
Personal income tax (PIT)	(c) Denmark, Hungary	(i) Colombia, Denmark (foreign researchers and key staff), Korea (foreign researchers), Turkey (R&D staff)
Value-added tax (VAT) & other consumption taxes	(d) Colombia (imported equipment), China (software, high-tech firms, small firms), Poland (special zones), Russian Fed. (special zones, imported equipment, IPR transfer)	–
Other taxes (e.g. land taxes)	(e) France (young firms), Italy (SMEs and young firms), Portugal, Russian Fed. (special zones)	–
No tax arrangements	(f) Estonia, Germany, Mexico, New Zealand, Switzerland	

Note: This table does not include tax incentives for entrepreneurship (e.g. tax exemption for business angels). Information for Brazil, Chile, Luxembourg, Spain and Sweden come from country responses to the STI Outlook policy questionnaire 2012 and national sources. In Belgium, the federal government retains responsibility for R&D tax policy while most other aspects of STI policy have been decentralised to regions and communities.
For a more detailed overview of tax incentives for R&D and innovation, see the *Science, Technology and Industry Outlook policy database*, edition 2014, R&D and Innovation Tax Incentives, available at *http://qdd.oecd.org/Table.aspx?Query=DA5EA407-45F1-4832-ACFF-582DAECB6100*.
Sources: Based on country responses to the OECD STI Outlook policy questionnaire 2014.

The major divergence in R&D tax design across countries concerns the calculation of tax relief. There are four types of R&D expenditure-based tax incentives for firms: R&D tax allowances, R&D tax credit, accelerated depreciation for R&D capital, and exemption of R&D wage and social taxes (Table 5.3). The first three apply to the corporate income tax regime, and the last applies to payroll withholding and social security contributions.

Table 5.3. **Differences in R&D expenditure-based tax incentives for firms, selected OECD and non-OECD economies**

Design of the R&D tax incentive schemes	***Corporate income tax (CIT)***	*R&D tax allowance*		Brazil, China, Colombia, Czech Rep., Denmark, Finland, Greece, Hungary, Israel, Netherlands, Poland, Slovenia, Slovak Rep., South Africa, Turkey, United Kingdom
		R&D tax credit	*Volume-based*	Argentina, Australia, Austria, Canada, Chile, France, Iceland, Italy, Korea, Norway, Russian Fed., Spain, United States (energy)
			Incremental	Ireland, United States
			Hybrid	Japan, Korea, Portugal, Spain
		R&D tax allowance or tax credit (excluding each other)		Belgium
		Accelerated depreciation for R&D		Brazil, Canada, China, Denmark, Hungary, Latvia, Poland, Russian Fed., South Africa, Turkey, United Kingdom
	Payroll withholding and social security taxes			Belgium, France, Hungary, Netherlands, Spain, Sweden
	No carry-back/forward and refundable options			Brazil, Hungary, Korea
	Patent and intellectual property rights (IPR) expenditures			Argentina, Belgium, Brazil, Chile, France, Hungary, Poland, Portugal, Slovenia, Spain
Targeting firms	*SMEs*			Argentina, Australia, Canada, France, Hungary, Italy, Japan, Korea, Norway, Turkey, United Kingdom
	Young firms and start-ups			Belgium, France, Netherlands, Portugal, United States
	Large firms and multinationals			Costa Rica (Free Zone Regime), Turkey, United Kingdom
	Excluding large firms			Australia
	Firms hiring PhD or researchers			Brazil, France, Hungary, Portugal, Spain
Targeting R&D areas or industries	*Energy and environment*			Belgium, Hungary, United States
	Design and creative industries			France, Hungary
	Agriculture			Hungary
	Collaborative and subcontracted R&D			Chile, France, Hungary, Ireland (subcontractors), Italy, Norway, United Kingdom (SMEs and subcontractors)
	Excluding collaborative and subcontracted R&D			Czech Rep.

Note: Information for Brazil, Chile and Spain come from country responses to the STI Outlook policy questionnaire 2012. Information for Finland come from the OECD/NESTI data collection on R&D tax cost estimates 2013 and information for Iceland and Sweden come from national sources.
For a more detailed overview of R&D tax incentives, see the *Science, Technology and Industry Outlook Policy Database*, edition 2014, R&D and Innovation Tax Incentives, available at *http://qdd.oecd.org/Table.aspx?Query=DA5EA407-45F1-4832-ACFF-582DAECB6100* and the OECD Directorate for Science, Technology and Industry webpage on Measuring R&D Tax Incentives at *www.oecd.org/sti/rd-tax-stats.htm*.
Source: Based on country responses to the OECD STI Outlook policy questionnaire 2014.

R&D tax allowances and R&D tax credits are the most common schemes. R&D tax allowances offset taxable income by deducting a certain percentage of qualified R&D expenditure. R&D tax credits reduce the amount of tax that must be paid (tax liability) by the R&D expenditure (volume-based), or, less frequently, by the R&D expenditure in excess of some baseline amount (incremental). While volume-based schemes are simpler to implement and less subject to fluctuations, incremental design is less expensive and more efficient for governments as it minimises the amount of subsidised R&D that would have been undertaken even in the absence of support (OECD, 2010). Japan, Korea, Portugal and Spain offer hybrid arrangements combining volume and incremental features. Belgium offers either tax credit or tax allowance as alternatives.

Accelerated depreciation of R&D capital is also widely used and allows deduction of R&D investments (machinery, equipment, buildings, but also intangible capital, etc.) from taxable income under more favourable conditions than for assets of the same class.

Exemptions from payroll taxes and social security contributions for R&D personnel are less frequent (Belgium, France, Hungary, Netherlands, Spain). Since they act as a subsidy for early-stage costs whereas tax credits generally subsidise later-stage profits, they are particularly important for firms with cash flow constraints, notably small and young firms (OECD, 2010).

Cross-country differences in the design of R&D tax schemes also include the definition of eligible expenditures (e.g. labour costs, capital costs, costs of intellectual property rights), the nature of eligible firms (in terms of size, age, domiciliation, sector of activity, etc.), deductibility rates, caps and thresholds on qualified R&D expenditure or on the maximum amount of tax deduction (in absolute terms or as a percentage of firms' turnover, profit or tax liability), special provisions for collaborative R&D projects, or different technologies. Most countries allow carry-forwards for firms whose tax bill is lower than their allowable R&D credit. Some provide refunding options for start-up firms and non-profitable firms.

Many countries have fine-tuned their R&D tax schemes to target specific types of firms (e.g. start-ups or SMEs), industries (e.g. creative industries, such as textiles in France or films in Hungary), or research areas (e.g. energy and green technology). R&D tax incentives are also a tool to spur collaborative R&D and to strengthen industry-science linkages (e.g. France, Hungary) and industrial networks (e.g. Ireland).

The diversity of national R&D tax arrangements makes cross-country comparisons difficult. In addition, the relative generosity and attractiveness of national R&D tax incentives depends not only on eligibility rules and design features, but also on the taxation system of a country, e.g. the level of corporate taxation, or on firms' ability to claim and use incentives, such as their capacity to make a profit against which potential tax relief on taxes can be applied or their human and financial capacity to administer claims for R&D tax incentives and incur the related costs.

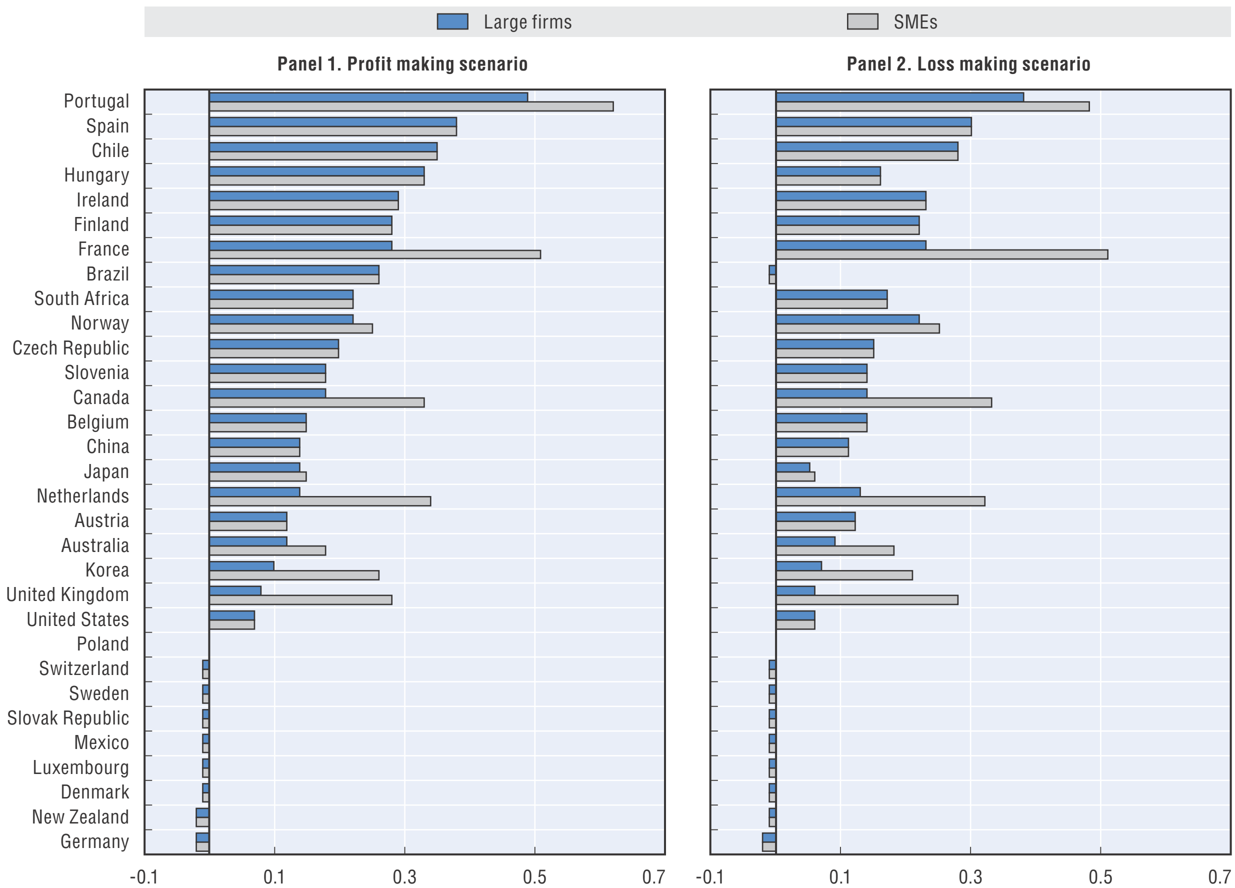
In a profit-making scenario, Portugal, Spain and Chile provided the most generous tax mix for R&D and innovation in 2013 (Figure 5.5, Panel 1). However, tax arrangements are more favourable for SMEs and young innovative firms in Canada, France, Korea, the Netherlands, Portugal and the United Kingdom where start-ups and small firms benefit from higher deduction rates. In France since 2004, new firms classified as young innovative firms (JEI) get large exemptions on corporate income tax and social security contributions.

In a loss-making scenario, the tax subsidy rate on R&D expenditure is markedly lower for both large and small firms (Figure 5.5, Panel 2). The gap is particularly significant in Brazil and Hungary, whose R&D tax allowances do not include any carry-forward or refundable options (Table 5.3). Carry-forwards and refundable options may partially compensate for the loss of the benefit of the incentive by reporting tax provisions when they can be applied or by providing firms with immediate repayments. Such tax arrangements may be particularly beneficial for small and young firms (OECD, 2013b).

Firms also incur costs to assemble their case, pay contingent fees, or absorb non-compliance costs. Indirect costs may reduce incentives to claim for R&D tax assistance and make it difficult for small and young firms with less internal capacity or higher liquidity constraints to access external expertise. Lengthy delays in cash repayments may also reduce the incentive effect of R&D tax breaks.

Figure 5.5. **Generosity of tax subsidy for R&D expenditures by profit scenario and firm size, 2013**

Tax subsidy rate as measured by 1 minus B-index



Note: The B-index is a measure of the before-tax income needed to break even on USD 1 of outlays (Warda, 2001). A decline in the B-index reflects an increase in R&D tax generosity. The B-index traditionally assumes that the "representative firm" is profitable and generates a sufficiently large profit to achieve the incentive's full potential benefit. An adjusted B-index is reported for a loss-making firm that is unable to claim tax benefits in the reporting period, using an adjusted effective tax rate that takes into account refund and carry-forward provisions.
The subsidy rate calculations only include expenditure-based tax incentives on corporate income tax and payroll withholding taxes and do not account for income-based tax incentives or incentives for taxpayers other than companies.
For more details on definitions and measurement, see the OECD Directorate for Science, Technology and Industry webpage on Measuring R&D Tax Incentives, *http://www.oecd.org/sti/rd-tax-stats.htm*.
Source: Adapted from OECD (2013), "R&D tax incentives", in *OECD Science, Technology and Industry Scoreboard 2013: Innovation for Growth*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/sti_scoreboard-2013-16-en*.

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Administrative requirements for obtaining R&D tax assistance vary widely across countries, as does the assistance provided. Practices differ in terms of the documentation required of claimants, the maximum delays for firms to submit claims, and the administrative formalities, e.g. pre-registration (Australia, Japan), prior approval or accreditation (China, the Netherlands, South Africa, Turkey), prior audit (Austria, Hungary, Poland), or extra certification, e.g. environmental certificate (Belgium) or tax clearance certificate (Brazil). Complex administrative formalities involve business costs that may discourage claimants and prolong unduly the time required to process claims and refund firms.

Many countries offer services to assist firms in tax procedures (e.g. online information and simplified claim form) and to improve the speed and predictability of claims processing. Canada proposes a first-time claimant programme and offers assistance in the form of pre-claim reviews to help firms identify eligible R&D activities, plan investments, and reduce the time and cost of preparation. Australia and Canada provide eligibility self-assessment tools. Austria, France, Hungary and Spain provide a rescript (or certification) that binds national tax authorities on tax breaks.

There are also differences in terms of the cost-effectiveness of the administration of R&D tax incentives on the government side. Countries' R&D tax schemes are also administered differently, and not necessarily by the central tax authorities. The duties of the responsible institutions (claims administration, controls, assessment of qualified expenditures, etc.) differ as well. The administrative co-ordination of R&D tax schemes with other support programmes (including grants), is specific to each country. The French Tax Credit is administered by the Ministry of Higher Education and Research (MESR). The Netherlands Enterprise Agency, a division of the Dutch Ministry of Economic Affairs which is responsible for various programmes in the field of sustainable economic growth, reviews applications and manages the R&D deduction (RDA) programme to which firms apply as well as the tax credit for R&D wages (WBSO). The Australian R&D Tax Incentive is jointly administered by Innovation Australia, an independent body in charge of innovation support programmes, including venture capital programmes, and the Australian Taxation Office. In Canada and the United Kingdom, the national tax authorities are in charge of the SR&ED tax credit and the UK R&D tax relief, respectively.

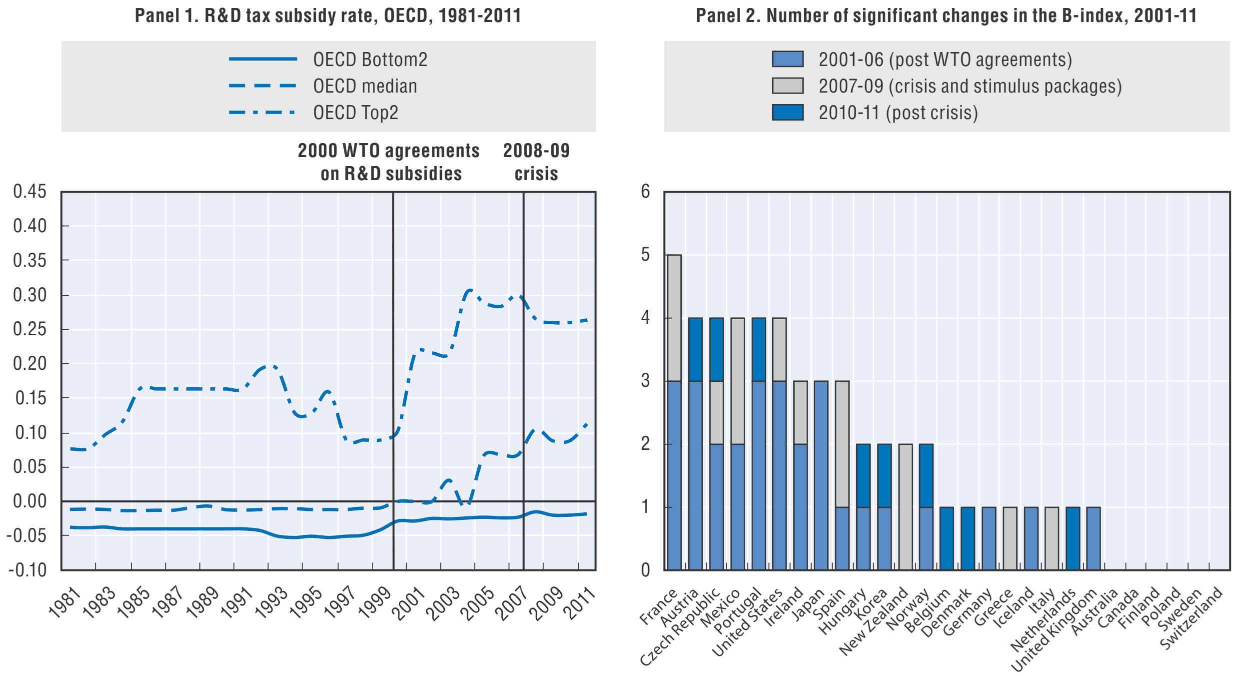
Differences also exist in compliance controls, programme monitoring and evaluation. *Ex post* controls, conditions applicable in case of infringement, and non-compliance costs incurred by firms are very diverse. Australia, Canada and France have a system to monitor R&D tax schemes and have developed performance metrics. In 2007 Canada surveyed R&D tax claimants and the main stakeholders to obtain feedback on the administration of the SR&ED programme and to optimise delivery of public services.

The lack of internationally comparable information on R&D tax governance and administration is striking, especially when compared with the growing amount of public money provided through R&D tax schemes and the pressing need for many governments to rationalise their spending. Likewise, little information is available on the size and evolution of national administrative units in charge of R&D tax relief, compared with the number of R&D tax claims and the amount of foregone revenue (in terms of budget, staff, tasks, educational background, S&T expertise, etc.).

Recent policy trends

The general trend over the past decade has been to increase the availability, generosity and simplicity of use of R&D tax incentives in the OECD area and beyond (Figure 5.6, Panel 1). Countries have redesigned their tax arrangements to make them more generous and attractive by raising thresholds on R&D expenditures and tax concessions or by increasing deduction rates and enlarging eligibility criteria. Many countries have abandoned incremental design for volume-based schemes that are simpler to implement for tax authorities and simpler to adopt for firms. As a consequence, public funding allocated to business R&D through tax incentives has increased markedly and R&D tax incentives have become a major instrument of STI policy in many countries (see Chapter 1 and the policy profile on "Government financing of business R&D and innovation").

Figure 5.6. **Trends in R&D tax generosity and potential loss of predictability in tax regimes, 2001-11**



Note: The tax subsidy rate is measured by 1 minus the B-index. The B-index is a measure of the before-tax income needed to break even on USD 1 of outlays (Warda, 2001). A decline in the B-index reflects an increase in R&D tax generosity. B indexes refer to all firms and are based on "no tax exhaustion" assumption (no refund or carry-forward).

In Panel 1, the OECD top 2 and bottom 2 values refer to the second highest and lowest tax subsidy rates among OECD countries for which data are available. The OECD aggregates do not include Chile, Estonia, Israel, Luxembourg, the Slovak Republic, Slovenia and Turkey.

In Panel 2, the number of significant changes in the B index over 1981-2011 is used as a proxy for the stability and predictability tax schemes. A threshold of a minimum 0.01 point change in the B index is applied to identify significant tax policy changes. This accounting approach does not take into account the revisions that may be introduced in R&D tax scheme design, procedures and management and that could improve or hamper their predictability (e.g. self-assessment eligibility tool, rescript).

Source: Based on J. Warda (2013), *B-index time series 1981-2011*, December, mimeo.

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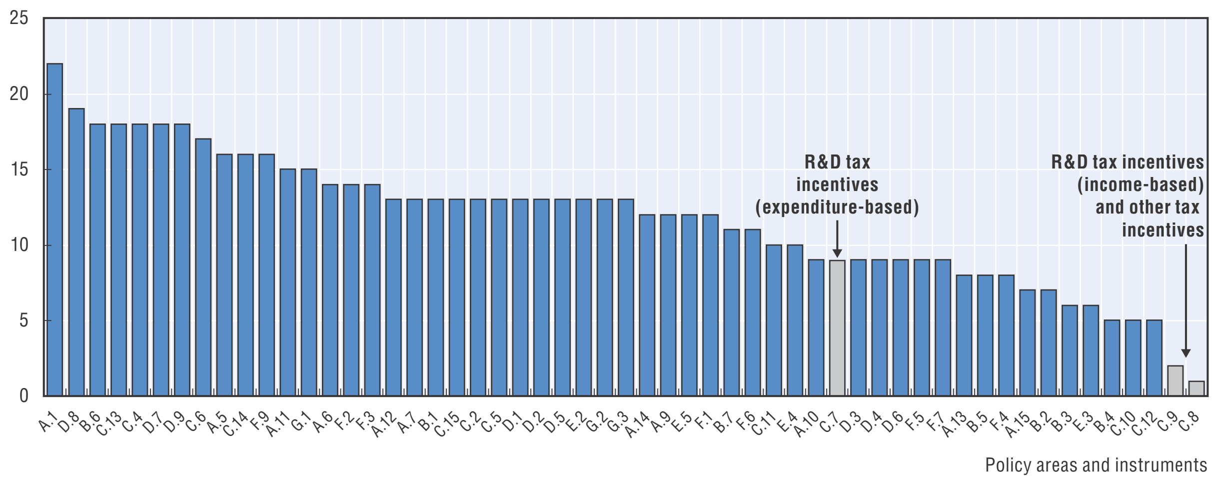
The stability of tax schemes -and more broadly R&D public support- has long been acknowledged as a key factor of their uptake and their impact. Evidence has shown that the effect of R&D policies can be undermined if they are particularly "unstable" (Guellec et al., 2003). A stable policy environment and predictable tax relief improve cost certainty for firms to plan their R&D investments. The stability of R&D tax schemes may also reduce indirect costs incurred by firms in assembling cases and encourage them, especially the smaller ones, to claim for public support. There have been significant cross-country differences in tax predictability over the past two decade –as measured by the cumulative number of reversals in the B-index- (Westmore, 2013). A similar approach comparing sharp changes in B index values over 2001-11 illustrates the comparative stability of R&D tax policy across countries (Figure 5.6 Panel 2). In many countries, the first half of the 2000s -post WTO agreements period- has been marked by significant changes in R&D tax arrangements with an effect on overall tax generosity and potentially on R&D tax predictability. Although the tax schemes seem to have experienced less substantial revisions since then, this policy area remains active. France, Mexico, New Zealand and Spain have made significant adjustments in their R&D tax policy during the 2008-09 crisis

– albeit for very different purposes –, and several countries have also implemented substantial changes after 2010. By contrast, Australia and Canada have shown a relative R&D tax continuity until 2012.

Few countries participating in the STI Outlook policy questionnaire 2014 reported substantial changes in their tax arrangements for R&D and innovation since 2012 (Figure 5.7). While most changes are in line with past policy trends, some countries, among the most generous, have slightly tightened their tax policy and have reinforced compliance and control mechanisms.

Figure 5.7. **Tax incentives for R&D and innovation among other areas of STI policy change, 2012-14**

Countries reporting a substantial change in the policy area, compared with other STI policy areas



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 2014 questionnaire). The y-axis shows the number of countries reporting that the situation has substantially changed in each policy area. Simple counts do not account for the magnitude and impact of policy changes. In the case of income-based tax incentives and other taxes, which are not widely applied, few countries may report changes. Responses are provided by Delegates to the OECD Committee for Scientific and Technological Policy.

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

StatLink http://dx.doi.org/10.1787/888933151761

Finland, Latvia and Sweden have recently adopted a new R&D tax allowance, an accelerated depreciation scheme for R&D capital and a tax reduction on social security contribution, respectively. The US government has made permanent the US Research and Experimentation Tax Credit in 2014.

In 2013 Ireland raised the ceiling on R&D expenditures (from USD 248 000 PPP-EUR 200 000- to USD 372 000 PPP -EUR 300 000-). Slovenia further reinforced its R&D tax allowance by increasing the enhanced deduction rate to 100% of qualified expenditure, compared to 40% before (plus an additional 20% in less developed regions).

More and more is expected from R&D tax incentives. They are increasingly designed to serve multiple purposes. For instance, temporary increases in ceilings (Japan, the Netherlands), longer carry-forwards (Japan) and exceptional refund of pending claims (France) helped firms cope with the financial crisis. The scope of tax incentives has broadened to include non-technological innovation. In 2013 France created an "innovation tax credit" that covers, only for SMEs, non-R&D expenditures, e.g. design prototypes and pilot plants for new products.

R&D tax incentives have become an instrument to raise the attractiveness of a national research ecosystem and, for some countries, to attract foreign R&D centres. Recent policy interest in patent box regimes indicates a search for a better combination of tax arrangements. In 2012 Costa Rica reformed its Free Zone Regime (FZR) to encourage companies to establish operations in Costa Rica and dedicate 0.5% of their local sales to local R&D activities. The Portuguese System of Tax Incentives for Company investments in R&D (SIFIDE) has been revised to ease access conditions for large companies: some R&D audits and IPR costs are now eligible for tax breaks and the ceiling on personnel costs has been repealed. In 2013 the United Kingdom introduced an expenditure credit scheme (RDEC) to make R&D tax relief more attractive to large firms and to leverage domestic R&D activity. The UK tax credit will replace the existing tax allowance as from 2016 –both running in parallel until then- and be payable to companies both with and without tax liability.

In a context of fiscal constraints, issues of the cost-efficiency of R&D tax incentives, the actual impact on innovation performance, and the sustainability of the current tax mixes are raised. France has marginally reduced the eligible expenditure base and repealed enhanced deductibility for new claimant firms. Australia established an R&D Tax Incentive Advisory Committee to monitor the implementation of the R&D Tax Incentive. Canada has consulted on contingency fees charged by SR&ED tax preparers in 2012 to assess possible negative impacts on the programme. While no evidence has been found that this results in higher compliance costs for businesses, many stakeholders have recommended enhancing the stability and predictability of the R&D tax incentive regimes. Consequently, additional funding has been granted to the first-time claimants programme to implement a new in-person service and web-based seminars. Resources and guidelines have also been provided to strengthen claim reviews and to apply non-compliance penalties. These developments are in line with the institutional and organisational reforms of tax systems and administrations that have taken place in the last few years in OECD countries and emerging economies with a view to improving cost-efficiency, monitoring and services delivery of tax administration (OECD, 2013c).

Further evaluation and impact assessment of R&D tax breaks will be needed as few evaluations have assessed the additionality of R&D tax incentives (Köhler et al., 2012).

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Financing innovative entrepreneurship

Rationale and objectives

Access to financing is crucial for creating and growing an innovative business, in particular at the seed and early stages. The main sources of finance for start-ups are: the founder's own funds (plus money from friends and family), bank loans, equity capital (including from business angels and venture capitalists) and government support. It is well documented that young innovative businesses find it difficult to obtain financing. For instance, surveys show that innovative small and medium-sized enterprises (SMEs) in the euro area consider access to finance one of their most pressing problems in the wake of the sovereign debt crisis of 2011 (EC, 2011). The difficulties arise from the high risk of entrepreneurial activities and from information asymmetries between investors and entrepreneurs. New ventures also have capital and human resource constraints, insufficient collateral and lack of a track record. The quality of an innovators' business plan and their overall readiness for investment often play a determining role in their ability to secure funding.

Such market and system failures justify public intervention in entrepreneurial financing. In addition to setting good framework conditions for investment in R&D and innovation, governments promote access to finance via policy instruments such as grants, loans, tax incentives and direct provision of capital (Table 5.4). Grants and subsidies can mitigate financing constraints in young and small R&D-intensive, technology-based enterprises in the early stages. Seed and early-stage funding can help entrepreneurs gain access to finance and overcome the "valley of death" that can result from the difficulty of obtaining project or debt financing or venture capital for higher-risk projects.

Major aspects

Venture capital remains an important source of financing for innovative ventures and new start-ups, although the VC market remains volatile. Against a background of global economic uncertainty, global VC investments fell in 2012 to their lowest level since 2009 (Ernest & Young, 2013). Overall investments declined by 20% year on year to USD 41.5 billion, while the number of venture capital investment rounds declined by 8% to 4 970. Average round size decreased to USD 8.4 million in 2012 from USD 9.6 million in 2011. Furthermore, the amount of money generated by initial public offering (IPOs) declined globally by 27% from USD 22.1 billion in 2011 to USD 16.1 billion in 2012; the decline was led by the United States and China. Similarly, VC-backed merger and acquisitions (M&A) declined from 787 deals in 2011 to 618 deals 2012, continuing the decline from the 2010 post-financial crisis peak of 856 deals. Activity in the United States and Europe, which comprise over 90% of VC-backed M&A deals, fell by about 24%, offsetting an increase in M&A in India. Globally, there is a trend for venture capital investments to shift towards less risky, later-stage investments and with a heavy concentration in the ICT sector. This may reflect both the lack of growth and innovation potential in certain sectors or increased risk aversion as a result of economic uncertainty.

Meanwhile, investments by business angel groups fell significantly in the United States in 2009, following the 2008 crisis, but in Europe they rose slightly. As experienced, wealthy and informal investors, business angels tend to invest in early and riskier stages and play a crucial role in filling the financing gap between the early and the later growth stages. The access to credit deteriorated for SMEs in most countries, largely as a result of higher small business interest rates and greater demand for collateral (OECD, 2013). There were also modest or no increases in credit volumes, except in a few countries.

Table 5.4. **Examples of recent government programmes or instruments to promote entrepreneurial financing**

Financing instruments		Key features	Policy examples
Direct financing	**Grants, subsidies**	Used as seed and early-stage funding for innovative start-ups and SMEs in most countries, filling financing gap between innovators and investors. Relatively small amounts of money for feasibility study, proof of concept and prototype development. Awards are generally granted on an open and competitive basis.	ANR Bio, ANR PDT (Argentina); Single Business Service (Australia); EXIST (Germany); Repayable grants for start-ups (New Zealand); START (Russia); Industry Innovation Partnerships (South Africa); SBRI (Small Business Research Initiative) (United Kingdom), SBIR (Small Business Innovation Research) (United States)
	Venture capital	Public venture capital provides strategic funds designed to accelerate entrepreneurial activities at the seed and early stages. In contrast, private venture capital provides equity finance for later, less risky stages. Public venture capital funds are often managed by private fund managers. Exits can be made through mergers and acquisitions or IPOs (initial public offerings). Corporate venture is another exit channel.	Clean Energy Finance Corporation (Australia); Seed Fund Vera (Finland); Investment Grant for Business Angels (Germany), FSI France Investment 2020; Development & Growth Fund (Chile); Seed & Venture Capital Scheme (Ireland); Innovation Bridge & ALMI Invest (Sweden)
	Loan/loan guarantee	One of the most common tools for access to finance for entrepreneurial companies during the entire technology life cycle. Loans are paid back (principal and interest). Governments can offer reduced interest rate loans (soft loans) or make loans repayable only if the project succeeds. Governments often provide loan guarantees for start-ups and SMEs because they lack collateral or a track record.	Technological Modernisation, CAE (Argentina); Credit Guarantee Scheme for SMEs (Hungary); INNPULSA (Colombia); Vaekstfonden (Denmark); Loan Service for R&I (EU); Loan Fund for Start-ups (Poland); Enterprise Finance Guarantee (United Kingdom); TTGV's Soft Loan Programme (Turkey)
Indirect financing	**Tax incentives**	An instrument that is combined with direct government finance in most countries. It includes exemption from personal or corporate income tax or capital gains tax depending on the nature of the intended policy objective to stimulate private investment in R&D and innovative entrepreneurial activities.	In 2013, 27 OECD countries provided tax incentives for R&D. There are also VAT exemptions on imported equipment and components (Colombia); a tax scheme for foreign researchers and key employees (Denmark); tax incentives for business angels (Finland); LSVCC (Canada); ESVCLP (Australia)
Third party financing	**Crowdfunding**	A collective Internet fund-raising tool enabled by advances in ICT and social networks. It is growing rapidly and allows even novice entrepreneurs access to finance and it engages people with science and innovation. Concerns include regulatory issues, the need for scientific integrity and the risk of cyber fraud.	Over 700 platforms globally: e.g. Kickstarter, CrowdCube, RocketHub, IndiGoGo. JOBS Act (USA); University of Utah's Technology Commercialisation Office (TCO) in agreement with RocketHub

Source: Country responses to the OECD STI Outlook policy questionnaire 2014; OECD (2013), *OECD Science, Technology and Industry Scoreboard 2013: Innovation for Growth*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/sti_scoreboard-2013-en*; and other sources.

Recent policy trends

Promoting innovative entrepreneurship through better access to finance remains an issue for OECD economies. The problem is how to increase and broaden the sources of public and private financing in order to stimulate innovation, given the increasingly short-term focus of investors following the financial and sovereign debt crisis. As reforms to the banking and financing system in the wake of the financial crisis, such as banks' increased capital requirements, may have reduced traditional investors' appetite for risk, governments are promoting new ways to stimulate access to finance for innovative entrepreneurship.

New institutional investors and sovereign wealth funds can be sources of innovation financing. The Internet is also providing new channels for financing small ventures through crowdfunding. In the United States, new legislation on crowdfunding (the JOBS Act in 2012) has drawn growing attention to this phenomenon, both in that country and elsewhere. Crowdfunding is rapidly emerging as a complementary source of funding. Although it is still in its infancy, there are already more than 700 crowdfunding platforms worldwide. Besides providing research and seed funding, crowdfunding also plays a role in linking and engaging citizens with science.

On the institutional level, tax incentives can stimulate innovation and entrepreneurship. Most OECD countries currently have tax incentives to stimulate R&D as well as other types of tax breaks for innovative ventures. Australia, Canada, France, Korea, Japan, Norway and the United Kingdom provide preferential tax treatment to SMEs relative to large firms. Colombia, Denmark, Israel and Finland have introduced new or additional tax incentive schemes that target the promotion of entrepreneurial activities.

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START-UPS AND INNOVATIVE ENTREPRENEURSHIP

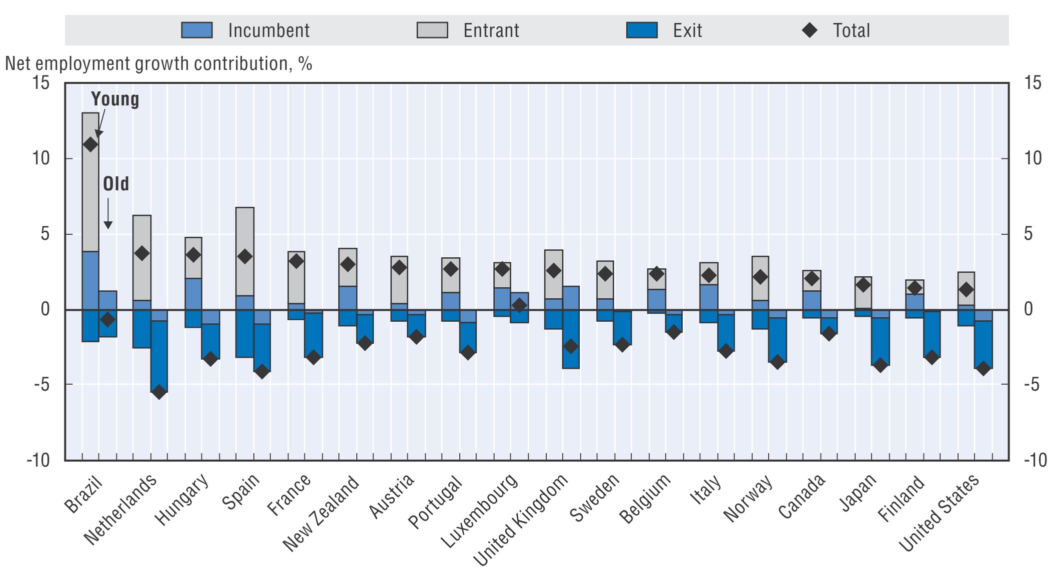
Rationale and objectives

The process of business entry and exit as well as post-entry firm growth enhance productivity and drive economic growth. New enterprises exert competitive pressure on incumbents and improve resource allocation by forcing less efficient firms out of the market, a process which Schumpeter called “creative destruction”. This process is especially important during a post-recession phase, as business creation can help renew productivity growth and job creation (OECD, 2010; Criscuolo et al., 2014). New start-ups can exploit knowledge that is not used or is underused by existing companies and draw on existing knowledge to enter new or established markets (Acs et al., 2009). This is especially true in knowledge-intensive sectors.

The positive spillover effects of entrepreneurship and the barriers faced by start-ups are the main rationale for policy intervention in favour of innovative entrepreneurship. New OECD evidence indicates that most net job creation originates in young and fast-growing firms. Young firms less than five years old have represented about 20% of non-financial business sector employment over the last decade but have generated nearly half of all new jobs (Figure 5.8 and Criscuolo et al., 2014). Over the recent economic crisis, young firms continued to generate jobs, with most job losses due to the downsizing of older firms. In the United States, from 1980 to 2005, almost all net job creation occurred in firms less than five years old (Stangler and Litan, 2009). This disproportionate contribution

Figure 5.8. **Contribution of young firms to net employment growth, 2001-11**

As a percentage of aggregate non-financial business sector employment



Note: Contributions are calculated as the net job creation by the group over total employment in manufacturing, non-financial business services and construction. Young firms are aged 5 years old or less, old firms are at least 6 years old.

Averages across all available years. The period covered is 2001-11 for Belgium, Canada, Finland, Hungary, the Netherlands, the United Kingdom and the United States; 2001-10 for Austria, Brazil, Spain, Italy, Luxembourg, Norway and Sweden; 2001-09 for Japan and New Zealand; 2001-07 for France; and 2006-11 for Portugal.

Owing to methodological differences, figures may deviate from officially published national statistics. For Japan data are at the establishment level, for other countries at the firm level. Data for Canada refer only to organic employment changes and abstract from merger and acquisition activity.

Source: Criscuolo, C., P. Gal and C. Menon (2014), “The Dynamics of Employment Growth: New Evidence from 18 Countries”, *OECD Science, Technology and Industry Policy Papers*, No. 14, OECD Publishing, Paris, *http://dx.doi.org/10.1787/5jz417hj6hg6-en.*

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to net job creation, however, reflects an up or out dynamics typical of young businesses: most start-ups exit within 5 years, but those that survive grow very fast on average and contribute more than proportionally to employment and productivity growth (Haltiwanger et al., 2013 and Criscuolo et al., 2014). The positive relationship between productivity growth and business churning, as measured by net business entry (Bartelsman et al., 2009), corroborates the contribution of "creative destruction" to productivity growth. Finally, fast-growing firms account for most net job creation; a review of the empirical research finds that between 4% and 6% of fast-growing firms generate half to three-quarters of new jobs (Henrekson and Johansson, 2010).

However, business start-ups face various barriers to their development. For example, business rules and regulations (e.g. registration fees, complexity of the taxation system, costs of hiring and firing, penalising bankruptcy legislation) affect the ability of firms to enter a market, experiment with a new technology or business model, and exit the market when needed. Innovative start-ups face additional obstacles owing to the uncertainty of the innovation process or lack of collateral, and in many countries are not able to attract the capital they need to scale up (Andrews et al., 2013) (see the policy profile on "Financing innovative entrepreneurship").

Major aspects

Start-up and innovative entrepreneurship policies can be defined as those that seek to improve the business environment for existing and future entrepreneurs. They can be grouped in three categories:

- Policies that shape the recognition of opportunities: they include entrepreneurship promotion (e.g. awareness-raising campaigns, awards programmes and entrepreneurship events), entrepreneurship education (i.e. from primary to tertiary education, including vocational and educational training), and information and advice on business creation (e.g. mentoring and coaching, including through business incubation).
- Policies that facilitate market entry and enable firms to experiment with new technologies and business models: they are primarily competition policies (e.g. anti-trust laws), business regulations (e.g. administrative burdens on start-ups, regulations that affect firm growth, bankruptcy legislation), taxation (e.g. tax, licences and fees required of new firms), labour market policies (e.g. employment protection legislation) and social security rules (e.g. non-wage labour costs and social insurance entitlements).
- Policies that influence market opportunities: they include policies affecting technology development, public procurement and business financing (especially equity finance), but also programmes that provide information and advice on expansion and internationalisation (e.g. business accelerators).

Finally, start-up policies increasingly target certain segments of the population, on the assumption that there is an entrepreneurial gap in some social groups (e.g. women, youth and immigrants) or that some social groups are more likely than others to form companies that generate value (e.g. university or corporate spin-offs). Targeted entrepreneurship policies are often transversal, combining different elements of the three above-mentioned policy categories.

Recent policy trends

Business incubators and entrepreneurship education have been used to help new entrepreneurs better respond to market opportunities. Incubators have a longstanding tradition in OECD countries, and some have decided to include incubators in their national innovation systems to improve the quality of publicly sponsored advice and training (e.g. Mexico, Poland and Sweden). However, entrepreneurship education is still largely delivered through ad hoc initiatives at the local level (e.g. Germany and Spain). Finland is an exception in having made entrepreneurship education part of the national curricula of primary and secondary schools.

As the economic crisis led to an increase in firm closures, many OECD countries simplified business regulations to ease market entry for new businesses. Some have specifically targeted innovative start-ups. For example, Italy has reduced registration fees, taxation and social contributions for R&D-based start-ups through a new law on innovative start-ups (OECD, forthcoming, 2014a). Similarly, Belgium gives favourable fiscal treatment to young innovative companies with a view to reducing the cost of R&D staff in the business sector.

Business accelerators in many OECD countries help fast-growing entrepreneurs harness opportunities for market expansion through skills development and mentoring services (e.g. business advice, business coaching, training and peer learning activities). Most business accelerators involve public-private partnerships in which programme activities are delivered by private-sector organisations such as business consultancies and business advisors (Belgium, Finland, Germany, the Netherlands and the United Kingdom).

Government investment funds have also been used to bolster innovative start-ups. Korea has set up a public-private Future Creation Fund worth USD 471 million, two-fifth of which is reserved for investment in start-ups and firms less than three years old (OECD, forthcoming, 2014b).

Finally, entrepreneurship support programmes that target specific segments of the population have gained strength since the onset of the global crisis. Greece, the Netherlands, Poland and Portugal operate policies to encourage self-employment in certain groups (youth, seniors, women, the disabled, the long-term unemployed and international migrants) through a combination of financial assistance and business advice. However, while Greece and Poland mainly use grants, the Netherlands and Portugal primarily offer loan guarantees and interest rate subsidies. Germany and Slovenia run income-subsidy schemes that support start-ups founded by unemployed people in the first period of business operations (six months in Germany, two years in Slovenia) (OECD and European Commission, 2013).

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New industrial policies

Rationale and objectives

Industrial policy has many meanings, not all of them specific to manufacturing industry. A broad definition is "any type of intervention or government policy that attempts to improve the business environment or to alter the structure of economic activity toward sectors, technologies or tasks that are expected to offer better prospects for economic growth or societal welfare than would occur in the absence of such intervention" (Warwick, 2013).

There has been renewed interest in industrial and manufacturing policies over the past decade. Following the recent economic crisis, many policy makers are looking for new sources of economic growth. Concerns about a loss of manufacturing capabilities and growing competition from emerging economies have also contributed to this surge in interest, as have the prospects for a "new industrial revolution".

The rapid emergence of China and India as low-cost manufacturing countries has led some analysts to conclude that manufacturing in traditional manufacturing economies, such as Germany, Japan or the United States, has declined. In nearly all OECD countries manufacturing sector output has been shrinking consistently as a share of GDP and employment for several decades as a result of: *i)* saturated local demand for manufactured goods; *ii)* high productivity growth, which requires less employment to produce a given output; *iii)* the blurring of manufacturing with services, as manufacturing firms increasingly capture value in the services they provide; and *iv)* growing globalisation of industrial production through outsourcing of labour-intensive, and more recently knowledge-intensive, activities to lower-wage economies (Pilat et al., 2006) (see Chapter 1).

Yet, manufacturing still plays a central role in OECD economies. The structural shift of OECD countries towards services has raised concerns about their capacity to maintain productivity growth, as productivity gains have been smaller in services than in manufacturing over the past decade. Concerns over the loss of manufacturing are also related to an erosion of the industrial base, which could affect adjacent activities in the value chain, including innovation and design (OECD, 2013) (see Chapter 1). Other observers note that mature economies can adapt and improve their manufacturing prospects (Marsh, 2012), owing to advances in technology (e.g. new advanced materials, 3D printing), a greater focus on tailor-made goods aimed at specific individuals and industry users, "lean manufacturing", and the introduction of sustainable forms of production.

Environmental pressure has also led governments to reconsider the merits of intervention in the field of industrial policy (Aghion, 2011). Because innovation is path-dependent, it is biased towards existing technologies. Governments can redirect technological change towards cleaner technologies and spur private investment in new environmentally friendly activities.

A number of countries have therefore been looking for new ways to strengthen industrial output and, as the financial and economic crisis of 2008-09 accentuated structural imbalances in many economies, to move away from overemphasis on the financial and non-tradable (e.g. real estate) sectors towards advanced manufacturing, low-carbon technologies and new technologies.

Industrial policy had fallen into disfavour because it was considered to prevent competition by allowing governments to "pick winners" and favour incumbents to the detriment of young innovative firms. However, there is now a growing consensus that the risks associated with selective industrial policy can be minimised through a new approach to government's facilitating and co-ordinating role and through new ways for government and industry to work together and avoid undue influence from vested interests (Warwick, 2013). This new approach tends to reconcile industrial policy and competition policy (Aghion, 2011). The evolution of industrial policy thinking is shown in Table 5.5.

Table 5.5. **Evolution of theory and practice in industrial policy**

Phase	Rationale and key approaches	Policy practices and instruments
1940s to late 1960s	Industrialisation is necessary for development. Market failures prevent this from happening automatically. Market failures are pervasive in developing countries.	Industrial policy is needed, particularly infant industry protection, state ownership and state co-ordination.
1970s to 1990s	Government failure is worse than market failure. Industrial policy is an invitation to waste and rent-seeking. Practical obstacles to industrial policy are significant.	Trade liberalisation (export), privatisation and attraction of foreign direct investment (FDI) together with macroeconomic stability and minimum government interference are the basic requirement for growth and industrialisation. Ubiquity of structural adjustment programmes.
2000s to present	Market and government failures are present. The "how" rather than the "why" of industrial policy is important. Differences exist with respect to the extent to which comparative advantage needs to be defined, not the principle.	Institutional setting matters but design is difficult. Flexibility in the practice of industrial policy is important. Innovation and technological upgrading should be a central objective of industrial policy. Promoting national innovation systems should also be an important objective.

Source: Based on Naudé (2010), details on representative authors/contributors to the debate on industrial policy shown in the original source.

Major aspects

New industrial policies often have the following features:

- A focus on improving framework conditions: innovation is driven by business, and for innovation to occur businesses must be operating in favourable conditions: enforcement of competition rules, trade openness, availability of skills (education and vocational training), etc.
- Supporting linkages: innovation activities rely on various types of links between actors (firms, universities, individuals, intermediaries). Many of these do not operate efficiently and lead to market or systemic failures, thereby motivating government intervention to support research co-operation, knowledge sharing between firms or between firms and universities. As linkages can have a geographical or a sectoral dimension, cluster policies can be effective (see the policy profile on "Cluster policy and smart specialisation").
- Supporting technologies upstream: government support is provided more at the upstream stage and for generic technologies, so as not to impede downstream competition or infringe the state aid rules embodied in international treaties (WTO, EU). This approach contrasts with the "picking winners" focus of the previous period.
- Using a variety of instruments and attempting to optimise the policy mix: some countries give public procurement a specific role in fostering innovation (see the policy profile on "Stimulating demand for innovation"). As lead user, governments can influence the diffusion of innovation. Demand-side initiatives are considered particularly effective in

stimulating issue-oriented or mission-oriented innovation by creating a market for technology in areas where it is needed to meet environmental and societal challenges (e.g. health and healthcare).

- Supporting entrepreneurship: in many technology fields new companies are essential for developing innovations, and they maintain a fruitful competitive pressure on established firms. But they face various barriers (e.g. access to finance, markets, skills) that government can help address.
- Attracting foreign multinationals and strengthening the role of domestic companies in global value chains: governments recognise that international linkages are essential to modern industry and that technology flows are global (see the policy profile on "Attracting international S&T investment by firms").
- Evaluation is essential: it should be independent and effective, so that failing programmes are terminated or reoriented (the inability to do so was a major failure of previous industrial policies).

Recent policy trends

A number of OECD countries have launched industrial and manufacturing policy initiatives in recent years. While targeting STI priority areas or sectors is common in many countries, only Denmark and the United Kingdom have implemented major initiatives in new industrial policy (see the policy profile on "National strategies for science, technology and innovation").

- Denmark has commissioned eight "growth teams" in thematic areas in which Danish businesses have an international competitive advantage and potential. It is currently designing new industrial policies to enhance competitiveness in these areas.
- The United Kingdom launched its Industrial Strategy in 2012. It focuses on technologies, skills, access to finance, partnerships with sectors and procurement. Eleven sectors were identified and strategies developed in partnership with industry with a view to building confidence and investment over the longer term. Significant industry-government funded initiatives include the Aerospace Technology Institute with USD 2.9 billion PPP (GBP 2 billion), the Automotive Advanced Propulsion Centre with USD 1.5 billion PPP (GBP 1 billion), and the Centres for Agricultural Innovation and an Agri-Tech Catalyst with USD 232 million (GBP 160 million). In addition, the government has committed USD 870 million PPP (GBP 600 million) to eight emerging technologies with potential cross-sectoral applications in which the United Kingdom has research expertise and business capability. The government also supports high-value manufacturing and energy generation technologies, e.g. through a USD 217 million PPP (GBP 150 million) programme focused on the development of ultra-low emission vehicle technologies. The network of innovation centres (Catapults) complements public support mechanisms by providing a business-led, capital-intensive infrastructure to commercialise new and emerging technologies. The Technology Strategy Board has invested over USD 203 million PPP (GBP 140 million) over six years in the first High Value Manufacturing Catapult and has been granted an additional USD 267 million PPP (GBP 185 million) in its 2015-16 budget to expand the Catapult network to cover energy systems and precision medicine.

Many countries have adopted a sector-oriented approach in their national strategy or plan for STI and, in some cases, have implemented sector-oriented initiatives combining direct funding (e.g. subsidies, equity funding) and indirect funding (e.g. tax incentives) instruments.

- The "Our Plan – Real Solutions for all Australians" of the new Australian government outlines, among other things, innovation policy priorities to boost the competitiveness of Australian manufacturing. A USD 104 million PPP (AUD 155 million) growth fund has been established to support initiatives in regions under pressure in their manufacturing sectors, particularly in the automobile sector, in an attempt to support a transformation from heavy industry manufacturing to higher value-added production. This initiative follows up on the Steel Transformation Plan legislation passed in 2011, which provided USD 198 million PPP (AUD 300 million) of assistance to eligible steel manufacturing businesses to support innovative activity, investment or production.
- France adopted the New Industrial France in 2013 with 34 strategic sector-based initiatives (electric planes, digital hospitals, e-education, green cars, big data, robotics, cybersecurity, etc.) that offer substantial potential in terms of value added and jobs.
- Korea upgraded its 2nd S&T Basic Plan (the 577 Initiative) with the 3rd S&T Basic Plan (2013-17) with a view to economic prosperity and public well-being through the High Five Strategy and identification of and support for new industries.
- The Netherlands presented its Top Sectors initiative following the 2010 general election. The new enterprise and innovation policy introduces a sector approach across government policy for nine top sectors: water, food, horticulture, high technology, life sciences, chemicals, energy, logistics and creative industries.
- In its National Science, Technology and Innovation Strategy (UBTYS) (2011-16), Turkey defined automotive, machinery and manufacturing technologies, energy, information and communications technologies (ICTs), water, food, defence and aerospace as priority sectors for R&D. The Scientific and Technological Research Council of Turkey (TUBITAK) subsidises investments in the manufacturing of high-technology products and parts developed through related R&D projects.
- Canada wishes to strengthen the competitiveness of the manufacturing sector, and in particular, the automobile, aerospace and shipbuilding industries. The government offers a two-year extension of its accelerated capital cost allowance for new machinery and equipment investment in the manufacturing sector, representing a total USD 1.1 billion PPP (CAD 1.4 billion) in tax relief over the 2014-15 to 2017-18 period. The government also committed to provide stable funding of close to USD 813 million PPP (CAD 1 billion) over five years for the permanent Strategic Aerospace and Defence Initiative, part of which is being directed to an Aerospace Technology Demonstration Programme, in addition to new funding. An Advanced Manufacturing Fund has also been implemented in Ontario with a USD 163 million PPP (CAD 200 million) endowment for five years. As part of the 2014 budget, USD 607 million PPP (CAD 750 million) was provided for the Automotive Innovation Fund over the next five years.
- The United States aims to become a "magnet for manufacturing" and to create high-quality manufacturing jobs by bolstering a national effort to bring together industry, universities and government to invest in emerging technologies. The 2014 Federal Budget provides USD 2.9 billion to expand R&D on innovative manufacturing processes, advanced industrial materials and robotics.

A cluster approach has been reinforced through smart specialisation frameworks in Belgium, Chile, Estonia and Slovenia. In 2014 Chile launched the Growth, Innovation and Productive Agenda to promote a diversified economy through key sectors for social and economic development. Japan also recently renewed its Industrial Cluster Plan for 2014 to revitalise Japanese industry and regions.

China and emerging economies are traditional practitioners of industrial policy and have deployed large sectoral plans in the aftermath of the global economic crisis.

- Brazil launched *Plano Brasil Maior* in 2011, which put innovation at the centre of industrial policy and made significant changes to the innovation support framework, including to the National Economic and Social Development Bank (BNDES), which is now responsible for financing innovation and investment. The Plan includes tax breaks for labour-intensive industries such as clothing, footwear, furniture and software.
- India approved a national manufacturing policy for the first time in 2011 to create jobs and bolster economic growth through the next decade (Warwick, 2013). The aim is to raise the share of manufacturing from the current 16% of GDP to 25% by 2022. The new policy proposes developing national investment and manufacturing zones, or mega-industrial parks so as to reduce the regulatory burden on industry. The government has identified seven locations across India for such parks, developed with private participation on the Chinese model.
- China has set up the 2012 Plan for National Strategic Emerging Industries to increase their share in GDP by 8 percentage points by 2015 and by 15 percentage points by 2020.

Italy focuses on FDI to support micro-enterprises and small-sized companies, combining traditional farming, craftsmanship and manufacturing with high-end high-technology sectors. The Invest in Made in Italy Fund will invest in the equity of micro-enterprises, with average "vouchers" of between EUR 50 and 500 000. New Zealand Trade and Enterprise also provides information on investment opportunities inland and helps link high-growth New Zealand businesses and international investors. The focus is on biotechnology, food and beverages, clean technology, infrastructure, ICTs, manufacturing and petroleum and minerals. Costa Rica has targeted FDI by multinationals through fiscal incentives to companies in strategic high-technology manufacturing sectors.

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Stimulating demand for innovation

Rationale and objectives

Demand-side innovation policy is often understood as a set of public measures to increase public and private demand for innovations, to improve conditions for their uptake or to improve the articulation of demand in order to spur innovation and facilitate diffusion (Edler, 2007). It usually aims at lowering barriers to the market introduction and diffusion of innovations.

Recently, governments have focused attention on a range of demand-side innovation policies – from public procurement of innovations, to standards and regulations, to lead markets and user-/consumer-driven innovation initiatives – to "pull" innovation (see the policy profile on the "Policy mix for business R&D and innovation"). This reflects the adoption of a broader approach to innovation policy that addresses the full extent of the innovation system and cycle. In a context of fiscal consolidation, there is also interest in using demand-side policies to leverage demand for innovation without creating new public spending. An additional goal of public policies for demand-side innovation is to boost innovation capacity in sectors with strong societal demand for innovation such as the health, environment and energy sectors (see the policy profiles on "Innovation for social challenges" and "Green innovation").

The rationale for demand-side innovation policies is to stimulate innovation in areas of pressing societal need for which government action can complement market mechanisms, ideally with minimal financial outlays. However, individual demand-side instruments have specific rationales. For example, procurement processes can help accelerate the emergence of technologies for which there is an urgent societal need. Innovation-oriented public procurement can also be designed to help lessen gaps in the supply of risk finance for small early-stage ventures. By contrast, the rationale for government action in the area of technical standards corresponds to the public-good characteristics of standards and the spillovers generated from the sharing of technical knowledge. By itself, the market may provide too few standards or inappropriate ones (e.g. they may be anti-competitive). Governments can catalyse industry-led standards setting that are not anti-competitive through its role as large consumer and as regulator. The process by which standards typically are set, involving the development of consensus among producers, requires the sharing of knowledge and accelerates the diffusion of technology.

Major aspects

Demand-side innovation policies take a variety of forms, with innovation-oriented public procurement, innovation-related regulations and standards the key instruments. User-driven innovation, design-driven innovation and eco-labelling initiatives also fall into the category of demand-side innovation as they seek to respond to consumer needs. Small business R&D grant programmes such as the SBIR scheme in the United States and variants in Australia, the Netherlands and the United Kingdom fund R&D in the early stages of product development and as such are supply-side programmes. However, the competitive call for solution element of such schemes places them close to "pre-competitive procurement of innovation". Environmental regulations, which have been a key driver of technological innovation to reduce CO_2 emissions and a range of industrial pollutants, are another example of demand-side innovation policies. In addition, consumer policies or tax policies that affect demand for innovation (e.g. for green innovation) are also important.

Pricing of environmental externalities and markets for carbon (i.e. carbon pricing) can also increase demand for innovation. Some governments have reintroduced prizes and competitions to induce R&D and innovation activities.

However, demand-side innovation policies, notably public procurement of innovation, are not without risk, as they may favour large firms over small firms or specify certain technologies and lead to technology lock-in. Public procurement agencies also often seek efficiency goals such as "value for money" that are not easily reconcilable with innovative solutions, although many public procurement agencies have recently broadened their missions to include such criteria. Public procurement is also highly fragmented across city, regional and national agencies and much policy action focuses on improving communication for procurement. Awareness-raising initiatives and the training of civil servants in public procurement agencies are used in many countries to foster "innovation-friendly" procurement. The limits of using public procurement as an innovation policy instrument (i.e. favouring domestic firms) are due to World Trade Organisation (WTO) rules, which exclude national preferences, and the possible supplementary cost and higher risk of innovative solutions compared with existing ones.

There are relatively few evaluations of demand-side innovation policies except for pre-commercial procurement schemes. This is due both to technical challenges associated with evaluation and the relative novelty of demand-side innovation policies. Evaluation is further complicated by the fact that policies that can be considered demand-side have innovation as one – sometimes secondary – goal among a number of objectives. For example, most studies of regulations on minimum fuel economy standards for vehicles do not focus on innovation but (understandably) seek instead to assess the overall costs and benefits of the regulations. Another issue is that the data are often inadequate to assess both the impact on innovation and the impact on the programme goal. In the case of public procurement, although a majority of countries have special provisions to encourage participation by SMEs, 61% of OECD member countries do not track the number or value of contracts awarded to SMEs. Without such data, measuring effectiveness is extremely difficult (OECD, 2013). Furthermore, while existing data on firm innovation activity (e.g. Community Innovation Surveys) provide a partial picture of potential links between R&D, innovation and procurement activity, it has not been possible to distinguish general procurement from innovation-oriented procurement. The OECD is currently working on measuring the links between R&D, innovation and procurement with a view to better measuring the scale, extent and impact of this demand-side policy tool (OECD, 2014, forthcoming). Closely related to this effort, some countries are beginning to release new survey-based indicators highlighting whether innovations were introduced as part of procurement contracts. Efforts are also ongoing to use public procurement databases as a source of evidence linked to innovation data.

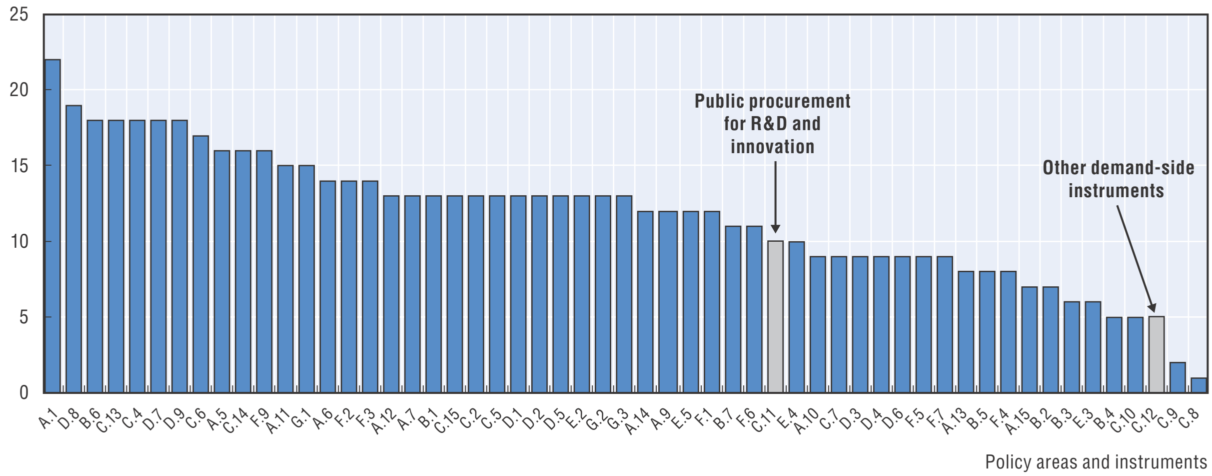
Recent policy trends

Governments at national and supranational level, notably at EU level, have increasingly made policy statements and implemented demand-side innovation policies. However, most measures have been centred on public procurement of innovation, often oriented towards green growth objectives (Figure 5.9). For example:

- The European Commission has fostered several lead market initiatives at EU level, and the European Research Area Committee has called for the EU to dedicate 2% of public procurement budgets to innovation.

Figure 5.9. **Initiatives to stimulate demand for innovation among other areas of STI policy change, 2012-14**

Countries reporting a substantial change in the policy area, compared with other STI policy areas



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 2014 questionnaire). The y-axis shows the number of countries reporting that the situation has substantially changed in each policy area. Simple counts do not account for the magnitude and impact of policy changes. Responses are provided by Delegates to the OECD Committee for Scientific and Technological Policy.

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

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- Finland, the Netherlands, Spain and Sweden have set policy "targets" for public procurement of innovation. Austria and France have suggested the potential for targets in policy documents or statements. Policy targets range between 2% and 5% of public procurement budgets, a significant amount, given that public procurement accounts for 13% of GDP in OECD countries. In Germany alone, public procurement in 2013 totalled around USD 497 billion PPP (EUR 300 billion).
- Austria's innovation-related public procurement concept (*Leitkonzept für eine innovationsfördernde öffentliche Beschaffung*, IÖB) aims to encourage industry to deliver innovative goods and services and to supply public bodies and citizens with advanced and (eco-) efficient goods and services. In 2013, implementation of the concept began through the establishment of a service centre (PPPI Service Point; PPPI = "Public Procurement Promoting Innovation") in the Austrian Procurement Agency; the amendment of the Austrian Public Procurement Law which makes innovation an additional procurement criterion; and the start of pilot projects in the field of pre-competitive procurement and public procurement of innovation.
- In February 2013 the Norwegian Ministry of Trade and Industry and the Ministry of Government Administration, Reform and Church Affairs launched the Strategy for Enhancing the Innovation Effect of Public Procurement. The objectives include making procurement a strategic tool for the work of public authorities and involving the business sector in defining future development needs.

Smart public procurement initiatives such as improved dialogue between procurers and suppliers or subsidies to help suppliers and procurers to design and respond to innovation-friendly public tenders have sprung up in a range of countries.

- Canada launched the military component of the Build in Canada Innovation Programme (BCIP) in 2013. Through BCIP, federal departments test prototypes developed by

Canadian businesses and provide feedback to help improve these innovative products before they are marketed to customers.

- Denmark's new Market Development Fund (arising from the merger of the Fund for Green Transformation and Commercial Innovation) aims to make it easier for public-sector institutions to obtain innovative solutions by specifying requirements in new ways. The public sector can help to target enterprise innovation so as to enable enterprises to develop better and less costly solutions.
- The new German Centre of Excellence for Innovative Procurement (KO-INNO) aims to foster the awareness, readiness and skills public procurers need to procure innovative products and services. Under the responsibility of the German Federal Ministry for Economic Affairs and Energy (BMWi), KO-INNO organises workshops, strategic dialogue and advisory services. An Internet-based project database provides information about innovative products, services and procedures as well as areas in which innovative solutions are required. Best practice examples show how innovation-oriented procurement can function successfully. In addition, new PPPs that link up with business to leverage funding in lead market projects ("Innovation Alliances") are set up under the responsibility of the German Federal Ministry of Education and Research.
- The Netherlands' public procurement expertise centre PIANOO offers guidelines and training to governmental bodies.

Some countries are also offering financial support to bridge the gap between procurement and innovation:

- Following a pilot project, Finland's Tekes provides R&D subsidies to public procurers and to SMEs via the Innovations in Public Procurement programme.
- Korea maintains an insurance-based scheme to reduce risks from innovative procurement, the New Technology Purchasing Assurance and Procurement-conditioned SME R&D programme.
- The United Kingdom operates a Forward Commitment Procurement programme in which public agencies commit to buy non-existing products or services at a specified future date, performance level and cost. Communication of early-user needs and supplier engagement are central features of the scheme.

Simplifying and facilitating innovation-friendly procurement is another trend in many countries. Costa Rica's Merlink integrates the government's procurement activities in one e-platform. In Colombia, new rules (Decree 1510 of 2013, Article 155 on technological disaggregation) allow state entities to disaggregate investment projects to allow the participation of nationals and foreigners and the assimilation of technology by nationals. Technological disaggregation makes it possible to support innovation by Colombian businesses. The Finnish government adopted a Decision-in-Principle in June 2013 on the promotion of sustainable environmental and energy solutions (cleantech solutions) in public procurement.

With a view to balancing procurement and competition goals, the Swedish Competition Authority (KKV) will take over the main responsibility for support for public procurement, including innovation procurement, from July 2014. The Swedish Innovation Agency VINNOVA will continue to retain partial responsibility. The European Commission has established the Multi Stakeholder Platform whose aim is to propose actions for a European standardisation landscape in support of innovation.

Beyond procurement of innovation, standards, and lead market initiatives, prizes have re-emerged as an incentive for governments (and private companies) to procure R&D and innovation-based solutions. In 2012, the United Kingdom's NESTA established a Centre for Challenge Prizes to design, run and facilitate inducement prizes.

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PART II

Chapter 6

STI policy profiles: Universities and public research

PUBLIC RESEARCH MISSIONS AND ORIENTATION

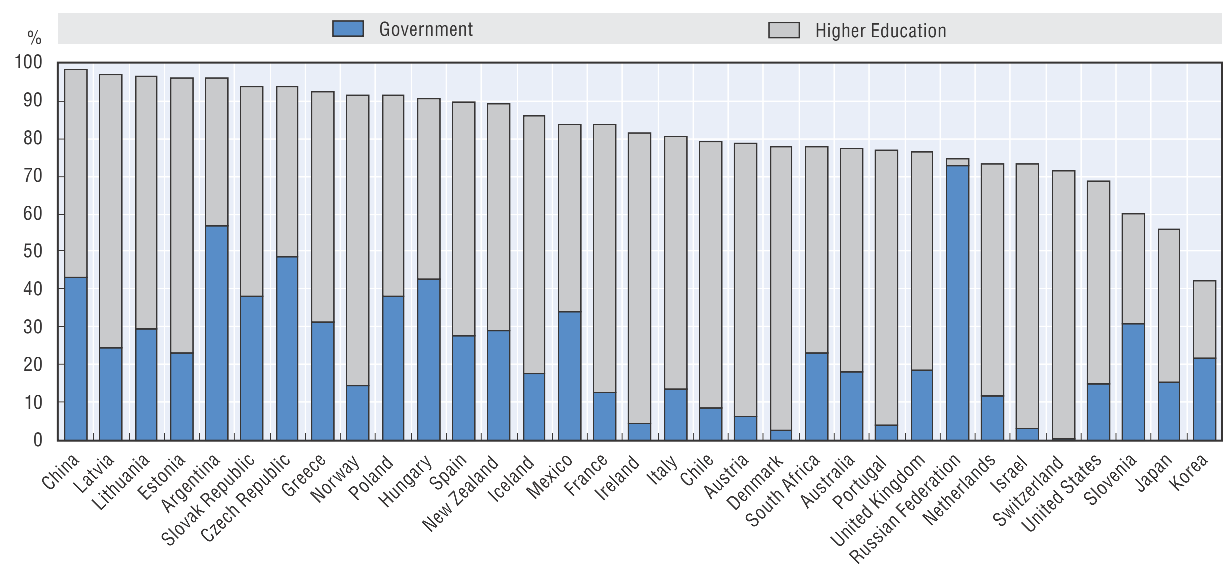
Rationale and objectives

Public research is carried out by research universities and public research institutions (PRIs) which are publicly owned, publicly operated or primarily funded with public money (IPP, 2014). PRIs are very diverse: their missions, activities, governance and performance vary widely across countries. Although some PRIs may offer education and training services, they usually only provide R&D support to business firms and public authorities; they may also act as intermediaries between firms and universities by interpreting the technical needs of the market (OECD, 2011). For universities teaching is an essential function, along with research.

Public research plays a key role in innovation systems by providing new knowledge and pushing the knowledge frontier. Universities and PRIs often undertake longer-term, higher-risk research and complement the research activities of the private sector (OECD, 2010a). Although the volume of public R&D is less than 30% of total OECD R&D (OECD, 2014a), universities and PRIs perform more than three-quarters of total basic research (Figure 6.1).

Figure 6.1. **Basic research performed by the public sector, 2012 or latest available year**

As a percentage of total basic research



Note: The higher education sector may include private organisations, e.g. university hospitals, in some countries. For Chile, China, Norway, the Russian Federation, Spain and the United States, basic research expenditure only covers current costs.
Data for China, the Czech Republic, Israel, the Russian Federation, the Slovak Republic and the United States refer to 2012. Data for Chile and South Africa refer to 2010. Data for Mexico refer to 2009. Data for Australia and Switzerland refer to 2008. Otherwise data refer to 2011.
Source: OECD, *Research and Developments Statistics (RDS) Database*, March 2014, *www.oecd.org/sti/rds*; Eurostat, *Science, Technology and Innovation Databases*, June 2014, *http://epp.eurostat.ec.europa.eu/portal/page/portal/science_technology_innovation/data/database*; UNESCO Institute for Statistics (UIS), *Science, Technology and Innovation Database*, June 2014, *http://data.uis.unesco.org/Index.aspx?queryid=115*. Data retrieved from IPP.Stat on 8 July 2014, *http://stats.oecd.org//Index.aspx?QueryId=57863*.

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In addition to basic research, public research meets specific needs of national interest such as defence, health and energy. It also involves research in areas where there are insufficient incentives to spur private investment such as those related to social and environmental challenges. Universities and PRIs can also shape a region's capacity to innovate by attracting R&D-intensive firms or the R&D facilities of multinationals enterprises (MNEs).

Public research faces several major challenges:

- **Turning science into business:** While scientific research remains at some distance from commercial uses, it is no longer considered cut off from applications and users (OECD, 2010a). Universities and PRIs are increasingly expected to fulfil a "third mission", that of transferring knowledge to industry, and to adapt their governance arrangements, incentive frameworks and academic culture to this new context.
- **Globalisation and openness:** The investments required to keep pace with technological change have increased, as has global competition for increasingly mobile research assets, including talent (see Chapter 1). Universities and PRIs have to compete for resources and talent on international markets, even as science become increasingly open, to achieve economies of scale, anchor knowledge spillovers and increase the visibility of domestic research.
- **Technology convergence:** The convergence of key technologies and interdisciplinary research creates opportunities that may be difficult to seize in discipline-based and "silo"-type public research systems.
- **Ageing workforces:** An ageing scientific workforce requires a renewal of research capacity. Demand for research skills is expected to increase because of governments' sustained commitment to increase national R&D spending at a time when some country-level evidence has shown disinterest in science among young people (see Chapter 1). Science-related fields of study, which include science and engineering, manufacturing and construction, are less popular, with women in particular preferring other fields of studies (OECD, 2014c).

Major aspects

Major aspects of public research policy include the governance of the research system, which encompasses research-performing units and policy implementation agencies, the strengthening of research infrastructures, and the attractiveness of academic research careers. Other relevant issues – the funding of public research activities, for instance through the Research Excellence initiatives (OECD, 2014b), the commercialisation of public research results, linkages with industry, and the internationalisation of universities and PRIs – are discussed in more detail in other policy profiles (see the policy profiles on "Financing public research", the "Commercialisation of public research", "Patent policies", "Intellectual property markets", "Cluster policy and smart specialisation" and the "Internationalisation of public research").

The governance of public research requires a national strategy and co-ordination arrangements, in particular because universities and PRIs have become more autonomous in terms of their resources and staff management in recent years. Governments orchestrate public research by defining research priorities at national level, developing research infrastructure roadmaps and implementing technology platforms, or through agreements or contracts, research accreditation systems, and allocation of public resources. Stakeholders, including researchers, students, industry and local actors, participate in decision making. The presence of the business sector in high-level advisory bodies or on institutional executive boards, as well as the promotion of strategic public-private partnerships, helps create a market perspective in the design and implementation of public research policy (see the policy profile on "Strategic public/private partnerships"). Evaluation and impact assessment of science can be used to inform policy learning, reinforce accountability and reallocate public resources in the most efficient way.

Scientific research requires robust research infrastructure. This includes large and expensive research infrastructures but also libraries and information archives, both of which need to be renewed as they wear out or become outdated (IPP, 2014). According to country responses to the OECD STI Outlook policy questionnaire 2014, strengthening public R&D capacity and infrastructures is currently one of the most important STI policy issues at national level, along with improving framework conditions for innovation and strengthening skills for innovation (see the policy profile on "National strategies for science, technology and innovation").

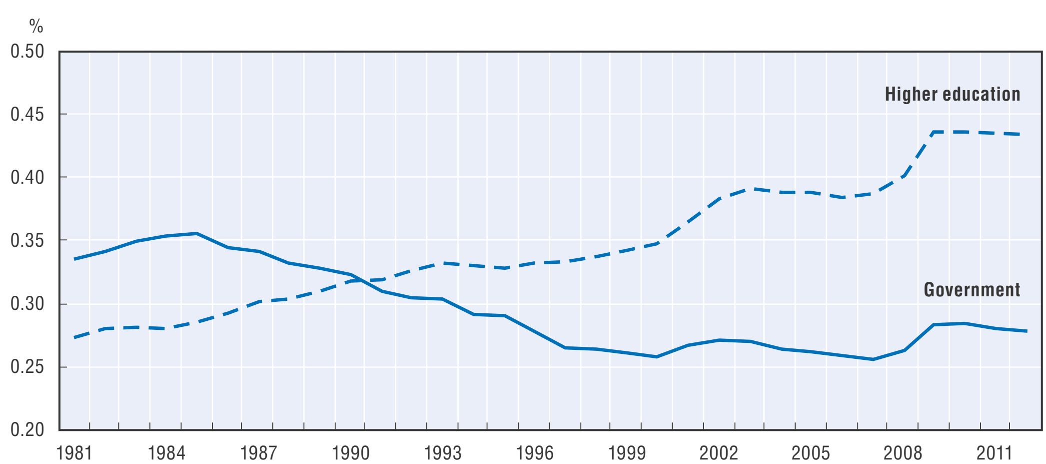
Maintaining research capacity implies attracting new talent, in particular when the scientific workforce is ageing and government are strongly committed to R&D. The attractiveness of research careers depends on research conditions (e.g. academic freedom, early-stage mentoring, access to high-quality research infrastructures, R&D support staff, international visibility), working conditions (e.g. remuneration, tenure track, work-family balance), and public awareness of career opportunities in science (e.g. role models in schools) (see the policy profiles on "Labour market policies for the highly skilled" and "Building a science and innovation culture").

Recent policy trends

Public research has changed in many OECD countries. Universities have taken the place of PRIs as the main performer of public research. Higher education expenditure on R&D (HERD) has increased steadily over the past decades in the OECD area as government expenditure on R&D (GOVERD) has declined (Figure 6.2). An important reason has been the universities' teaching role and the major contribution to innovation of knowledge embodied in persons and skills that research universities nurture (IPP, 2014). This knowledge is especially important for research students, many of whom seek long-term careers in business firms.

Figure 6.2. **Trends in OECD R&D expenditure by the higher education and government sectors, 1981-2012**

As a percentage of GDP



Source: OECD, *OECD Main Science and Technology Indicators (MSTI) Database*, June 2014, *www.oecd.org/sti/msti*. Data retrieved from IPP.Stat on 08 July 2014, *http://stats.oecd.org//Index.aspx?QueryId=57863*.

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The target and focus of public research have also evolved in recent years as missions and mandates change to respond to wider economic and political developments (e.g. green growth, societal issues) and to strengthen the contribution of public research to innovation. In particular, multidisciplinary sciences have drawn increasing attention. Some countries have reinforced an interdisciplinary approach to public research governance, evaluation and funding arrangements to address "grand challenges" such as climate change, ageing societies and development (see the policy profiles on "Green innovation" and "Innovation for social challenges").

- Multidisciplinary research has been integrated in the national strategic agenda of France, Germany and Portugal. The new EU Framework Programme (FP), Horizon2020, marks a clear break with previous FPs by focusing on major societal challenges and by bringing together different technologies, sectors, scientific disciplines and innovation actors. South Africa has recently developed a national bio-economy strategy that aims to ensure that R&D and innovation focus on solutions rather than disciplines.
- In 2014, Norway adopted the Idélab ("idea laboratory") to bring researchers from different disciplines together to exchange ideas across scientific boundaries and generate ground-breaking projects in a given area. Austria's national innovation platform, Ambient Assisted Living, was established in 2012 to build the relevant research community and promote project results to stakeholders. Slovenia established an interdisciplinary research council that is in charge of evaluation and public budget allocation and a web portal for exploring the interdisciplinary aspects of the national scientific community (*http://scienceatlas.si/*).
- The United Kingdom Research Councils have a number of long-term cross-council programmes that address national challenges through multidisciplinary research. A recently conducted review of the UK Research Councils included consideration of whether the peer review process or the council structure impedes multidisciplinary research. Further investigation was recommended. In Costa Rica, some public universities grant extra points during project evaluations for projects that take multidisciplinary approaches.
- The Slovenian Research Agency devotes 2% of its budget to multidisciplinary research activities and aims to raise this to 10%. In 2013, New Zealand allocated USD 50 million PPP (NZD 73 million) to the National Science Challenges to enable a more strategic approach to the government's science investment by targeting a series of goals and focusing collaboration between institutions and disciplines on large and complex issues. This budget appropriation came on the top of USD 41 million PPP (NZD 60 million) granted in 2012 and will be followed by an additional USD 20 million PPP (NZD 30 million) annually in the coming years. Austria's Earth System Sciences (ESS) programme of 2013 supports interdisciplinary long-term research projects on the physical, chemical, atmospheric, hydrological, biological, social, technological and economic processes of the Earth system and their interaction. Calls of the Turkish support programme for research, technological development and innovation projects in priority areas may include special conditions to encourage multidisciplinary research. Costa Rica's Special Fund for the Financing of Public Higher Education provides grants for projects involving more than one university and diverse areas of expertise.

Public R&D budgets have levelled off in real terms in many countries and have started to decrease in others (see Chapter 1). Public R&D expenditure usually has a buffering effect during economic downturns as it partially offsets declines in more market-sensitive business R&D expenditure. Public research played a major role in sustaining national research systems during the 2008 crisis but the current budgetary outlook puts pressure on public R&D spending and has encouraged governments to adjust the design and governance of public research policy. OECD R&D expenditure by the higher education and government sectors has stagnated as a percentage of GDP since 2010 in a context of weak GDP performance (Figure 6.2).

In this context, governments have put greater emphasis on efficiency, prioritisation and concentration of resources, and universities and PRIs faced with global competition have sought to increase critical mass and enhance systemic efficiency (see Chapter 1). The search for greater efficiency has led to a restructuring of research activities: an increase in mergers and in the size of institutes, better co-ordination across research units, and the introduction of new public management approaches in universities and PRIs to reinforce autonomy, accountability and business-like operational models.

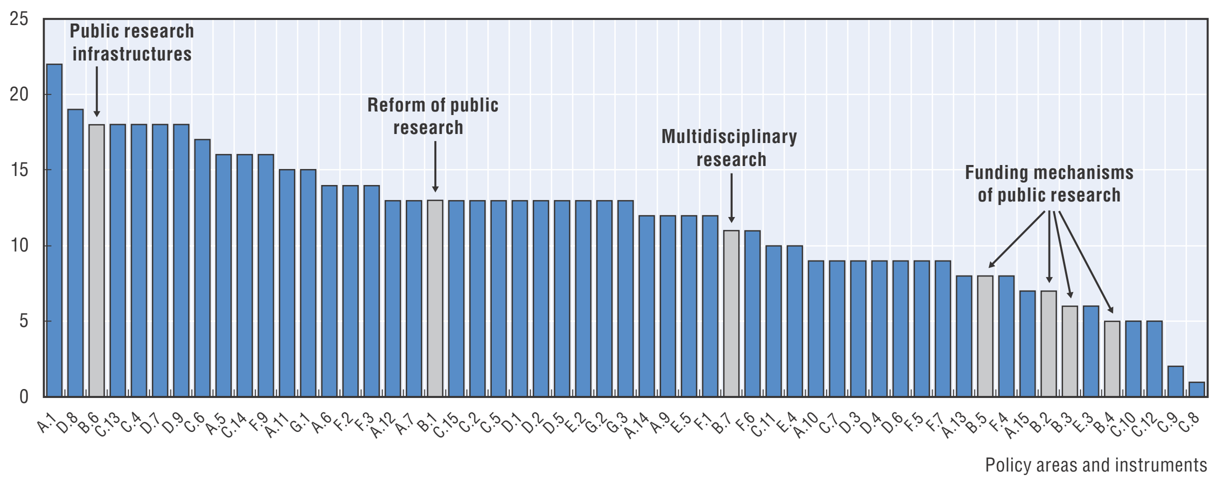
- In France, a 2013 law on research and higher education aims to structure universities and PRIs into regional centres, to encourage scientific partnerships and technology transfer and to strengthen the international visibility of these groupings. Greece adopted new laws for the higher education sector to merge research organisations, to create a critical mass of researchers and to decrease administrative and operational costs. In 2012 Germany adopted a law on academic freedom to increase budgetary flexibility in non-university academic institutions. It gives these institutions a lump sum budget and more flexibility in matters of finance and staffing decisions and for acquisition of shares in companies and in construction projects.
- The Russian Federation started reorganising the Russian Academy of Sciences and its branch academies in 2013 to optimise the governance of basic research. Korea modified the governance of PRIs under the auspice of the Ministry of Science, ICT and Future Planning in 2012 in order to streamline research activities. The portfolios of research councils in charge of basic science and of applied industrial technologies have also been integrated to cover the entire innovation cycle.
- Since 2012 Austria has implemented a comprehensive planning instrument, the Mapping Process for the Austrian Higher Education System, a dialogue-based process to improve the use of resources, establish mutually agreed priorities and define institutional profiles in public universities. Norway's long-term national plan for research and higher education sets priorities and objectives for public investments over a ten-year period for investments in buildings, research infrastructure, fellowships and expanded student enrolments.

Evaluation has also taken on greater importance. The Academy of Finland started to prepare an international review of the state of scientific research in 2012, and all the STI institutions have been evaluated, including the Funding Agency for Technology and Innovation (Tekes), the VTT Technical Research Centre, the Academy of Finland, the Strategic Centres for Science, Technology and Innovation (SHOKs), and the Research and Innovation Council. Also in 2012, the Russian Federation changed the approach and procedures involved in the assessment of research organisations. The Italian quality assurance agency for higher education and research (ANVUR) was reorganised in 2013 and conducted its first overall assessment exercise of Italian research output (2011-13) in all universities and PRIs. The UK Research Excellence Framework (REF) assessment of university research undertaken in 2014 includes an impact assessment component.

Increased attention to excellence in public research has led policy makers to seek to reinforce research infrastructures, and this has been one of the STI policy areas that have seen the most change in recent years (Figure 6.3). The public research system, policy support for multidisciplinary research and public funding mechanisms have undergone less substantial reforms.

Figure 6.3. **Public research initiatives among other areas of STI policy change, 2012-14**

Countries reporting a substantial change in the policy area, compared with other STI policy areas



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 2014 questionnaire). The y-axis shows the number of countries reporting that the situation has substantially changed in each policy area. Simple counts do not account for the magnitude and impact of policy changes. Responses are provided by Delegates to the OECD Committee for Scientific and Technological Policy.

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

StatLink http://dx.doi.org/10.1787/888933151818

To develop and strengthen their public research infrastructures, countries have engaged in long-term planning through roadmaps and master plans, better co-ordination of research units and increased investment in research capacity and platforms.

- Australia renewed its National Collaborative Research Infrastructure Strategy (NCRIS) and provided USD 126 million PPP (AUD 186 million) over 2014-15 to secure access to major existing research facilities and to support the collaborative infrastructure needed to undertake world-class research. As part of the 2014-15 Budget, NCRIS will receive an additional USD 102 million PPP (AUD 150 million) for an additional year until 2016, giving the government time to reassess the existing research infrastructure provision and requirements. In the framework of its Cohesion Action Plan, Italy allocated USD 102 million PPP (EUR 77 million) to strengthen computer networks and digital infrastructures, to consolidate infrastructures for environmental monitoring as well as for collaborative and multidisciplinary research in this area, and to set up a system for long-term digital preservation of research results (through standard open solutions). Portugal has designed its first strategy for research infrastructures and adopted a roadmap to 2020. A roadmap for centres of excellence is also under preparation in the Slovak Republic. As part of their new performance contracts, Austrian universities are encouraged to collaborate on the creation and use of research infrastructures. France has also made co-ordination a top priority and adopted a new roadmap for research infrastructures. The United Kingdom has included science and innovation infrastructure in its national critical infrastructure plans, and a Science Capital Roadmap to be published late 2014 will set out the UK strategy for future investments. The government has also committed USD 1.6 billion PPP (GBP 1.1 billion) a year, indexed to inflation, for science capital from 2015-16.

- To date, Canada has provided close to USD 4.4 billion PPP (CAD 5.5 billion) to the Canada Foundation for Innovation (CFI), including USD 400 million PPP (CAD 500 million) in 2012 to sustain its core investment activities in advanced research infrastructure. The government announced a further USD 182 million PPP (CAD 225 million) in 2013, in particular for the next Leading Edge/New Initiatives Fund competition, support to cyber-infrastructure, and priorities approved by the minister of Industry. Research and teaching infrastructure at post-secondary institutions is also eligible for funding under the Provincial-Territorial Infrastructure Component of the new Building Canada Fund.
- In 2013 Costa Rica, with co-funding from the World Bank, launched a USD 200 million project to improve higher education R&D capacities and upgrade institutional management and infrastructure. Also in 2013 Belgium (Wallonia) issued a USD 2 million PPP (EUR 2 million) call to finance the upgrading and acquisition of S&T equipment, while Iceland established the Infrastructure Fund, which built on and extended the former Equipment Fund. In recent years New Zealand provided direct funding for large-scale, high-cost infrastructures that are beyond the funding capacity of individual institutions in synchrotron sciences, genomics, high-performance computing and e-research services. The Russian Federation launched a competitive programme, Mega-Science Infrastructure Projects, to create and develop a complex of extra-large research facilities over 2014-17 and a competitive programme, 5/100/2020, to support world-leading science and education centres through institutional grants for a total of USD 2 billion PPP (RUR 40 billion) over 2014-16.

The need for greater openness in science has encouraged universities and PRIs to forge more links, notably with industry and across international borders. As a result, the sources of public research funding have changed (OECD, 2011) (see the policy profile on "Financing public research"). The governance of research institutions has also evolved to engage more stakeholders, including researchers, students, firms and local actors.

- The UK Research Councils have encouraged researchers to think about the impact of their research through Academic Beneficiaries, Impact Summaries and Pathways to Impact (formerly known as Impact Plan). This toolkit was developed following discussions with the research community and is implemented as part of the Research Councils' application and assessment process. In 2011 Denmark amended its *University Act* to give universities more autonomy in setting their individual organisational and management structures so as to increase the involvement of staff and students and to strengthen openness, for instance by including external members in nomination and appointment boards.
- Canada reformed the National Research Council (NRC) on the model of the German Fraunhofer Institutes in 2013. The NRC became Canada's national research and technology organisation (RTO) and the NRC's corporate structure was reorganised into three divisions – Engineering, Life Sciences and Emerging Technologies – which interface with industry clients.
- The French Law on Higher Education and Research 2013 aims to enhance co-operation with local government to optimise funding, simplify the administration of performance contracts, empower local actors and reach critical mass at European level.

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Financing public research

Rationale and objectives

Public research plays a key role in innovation systems. It is the source of new knowledge, especially in areas of public interest, such as basic science or fields related to social and environmental challenges, which businesses are not always well equipped or motivated to invest in.

Funding arrangements between the central government, on the one hand, and universities and public research institutes (PRIs), on the other, are an important channel for delivering public research policy and a major driver of change in the public research landscape.

Major aspects

Most countries combine, in different proportions, discretionary institutional core funding ("block grants") and competitive R&D project grants. Institutional funding provides stable funding over the long term and a certain degree of research autonomy, which is essential for basic research (Table 6.1). While roadmaps and master plans help governments anticipate and plan the long-term development of research infrastructures, a longer-term view of research funding is also necessary to maintain research infrastructures at the institutional level. Block grants are granted on the basis of various criteria (e.g. formulae, performance indicators, budget negotiations). Competitive R&D project grants put more emphasis on research outcomes in the shorter run. Project funding is attributed to individuals or groups for specific projects over limited time periods (OECD, 2011). While institutional funding gives institutions more scope to shape their research agendas, project funding provides governments more scope to steer research towards certain fields or issues. Project funding may also allow governments to target the best research groups or support structural change (Lepori et al., 2007).

The results of performance-based research funding systems (PRFSs), which assess institutions' research output and outcomes, may be used to allocate a share of the block funding (OECD, 2010a). PRFSs models vary across countries, as do the methodologies and metrics used (e.g. bibliometrics, external funding, number of graduates, patenting, summary indexes, university league tables, peer reviews). While the amounts involved may be small, the PRFSs can have strong incentive effects, in particular in terms of institutional prestige. However, universities and public agencies incur high application and evaluation costs, and such indicator-based systems also require maintaining a national documentation system and a statistical infrastructure. Aside from these costs, the diversity of research institutions and the heterogeneity of scholarly output – the propensity to publish varies widely among disciplines (e.g. life sciences versus social sciences and humanities) – mean that PRFSs may be less appropriate than other funding instruments for encouraging interaction with industry or capturing the economic benefits of research activities. PRFSs may also increase existing tensions between excellence and equity, notably by reinforcing leading institutions while reducing opportunities for others to improve. Concerns have been raised about the bias of certain PRFSs' criteria and evaluation modes against women, early career researchers or ethnic groups (OECD, 2010a).

Table 6.1. Major policy instruments to finance public research and some country examples

Financing instruments				Key features	Some country examples
Government budget appropriations	**Institutional core funding**	**Non performance-based "block" funding**		Traditional funding channel of public research and primary funding instrument in most countries. Basic funding guaranteed mid- to long-term. Not dependent on applications. Various means of assigning budgets, including budget negotiations and agreements, formulae.	Most countries (General University Funds – GUF), e.g. Australia (mission compacts)
		Performance-based research funding systems (PRFSs)	Indicator-based (university)	Relies on quantitative formulas using bibliometrics, citations and a broad range of indicators (external research funding, completion rates, employment of graduates, faculty size, students population size, number of prizes and awards, university league tables, summary indexes etc.).	Austria, Denmark, Finland, Germany, Greece, Norway, Russian Federation (National Research University), Turkey (Entrepreneurial and Innovative University Index)
			Peer reviews (department/ field/university)	Implemented at the university, department or field-in-university levels. May be informed by metrics, or summary indexes.	Australia (Australian Composite Index), Denmark, Italy (VTR), Poland, Slovak Republic, United Kingdom (REF)
			Individual peer reviews	May affect researchers' remuneration or institutions' rating and the allocation of block funding.	New Zealand (PBRF), Spain (Sexenio)
	Research Excellence Initiatives (REI)			Basic funding guaranteed mid- to long-term. Organised in programmes. Time-bound. Application-based. Competitively organised. Outcome-oriented. Focus on exceptional research quality. System-level perspective (i.e. national science landscape). Frequent reference to socio-demographic issues.	Germany (Excellence Initiatives), France, Poland (Leading National Research Centre – KNOW)
	Project-based funding			Time-bound. Application-based. Competitively organised. Outcome-oriented. Public and private funding may also be combined and involve so-called "matching funds".	Austria (Higher Education Area Structural Fund), France (ANR), European Commission (ERA Communication)
	Towards full economic cost recovery (FCR)			Require pricing and amortising capital, infrastructures and overhead mobilised in research activities in a view to maintain financial sustainability and future capability.	Australia (Sustainable Research Excellence – SRE), Canada Foundation for Innovation (CFI), Estonia, Germany (DFG-BMBF), Slovenia, Switzerland (SNSF Overhead programme)
"Third part" funding	**Universities' and PRIs' own resources***			May encompass a broad range of legal, administrative or regulatory reform to allow universities and PRIs increasing revenues from tuition fees, the provision of knowledge services or the commercialisation of research results.	Germany (Academic Freedom Act), France (France Brevets), Russian Fed. (licensing publicly-funded IPRs),
	Industry investment* (through research contracts, cooperative R&D, corporate patronage)			Encompass various policy instruments targeted to firms in support of collaborative R&D and industry-science linkages (including tax incentives for subcontracted R&D, innovation vouchers, public grants, loans and subsidies for business R&D involving public research partners etc.)	France (enhanced deductibility of R&D tax expenditure on subcontracted R&D), South Africa (DST agreements with multinationals), Spain (CDTI direct aids), Turkey (reform initiative for research institutions)
	Science philanthropy (private foundations, charity, wealthy individuals)			Mainly tax-based incentives to attract private investments.	France (2011 Law on scientific patronage), Norway (tax incentive on private donations), Spain (Law on patronage and sponsorship)

* See the related policy profiles on "Tax incentives for R&D and innovation" (subcontracted R&D), "Government financing of business R&D and innovation" (innovation vouchers), "Commercialisation of public research" (collaborative R&D).

Source: Based on OECD (2010), *Performance-based Funding for Public Research in Tertiary Education Institutions: Workshop Proceedings*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/9789264094611-en*; OECD (2014), *Promoting Research Excellence: New Approaches to Funding*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/9789264207462-en*; country responses to the OECD STI Outlook policy questionnaire 2014.

Research excellence initiatives (REIs) offer an alternative to performance-based block funding. REIs are at the interface of institutional core funding and programme funding and share elements of both (OECD, 2014). Through REIs, governments award a limited number of very large, long-term block grants to universities and PRIs on the basis of competitive proposals. The aim of REIs is to concentrate exceptional researchers in a well-equipped working environment as a way to support research institutions that carry out ambitious, complex research agendas. Country-level evidence shows that REIs also fund doctoral and post-doctoral training (OECD, 2014). Unlike the PRFSs, REIs enhance interdisciplinary research by providing researchers with more opportunities to work across disciplines. They allow for greater flexibility, notably in terms of managing resources and hiring researchers. They can also help research institutions establish or strengthen ties with the private sector and the research excellence centres funded by REIs can engage in transferable skills training.

Full economic costing of research activities is another approach to research funding. It can help research institutions amortise assets and overhead and invest in infrastructures at a rate that allows for ensuring future capability (OECD, 2010b). The capital, infrastructure, maintenance and functioning costs associated with each piece of research are included in the final price. This represents a step towards internal and external market pricing of public research.

Governments also encourage universities and PRIs to increase their own revenues. Legal, administrative or regulatory reforms can give universities and PRIs the autonomy and legitimacy to collect tuition fees, provide and charge for knowledge services, or license and commercialise publicly funded research results (see the policy profile on "Commercialisation of public research").

Policies play a role in channelling and leveraging private sources of funding for public research. Some policy instruments encourage industry investments in public research while others target wealthy individuals or private non-profit organisations (foundations, charities) to boost patronage of science. A variety of government schemes support collaborative R&D, industrial research contracts and industry-science linkages that indirectly fund public R&D activities. Examples include grants or subsidised loans that require performing R&D projects in co-operation with at least one university or PRI, innovation vouchers, or tax incentives on corporate income tax for expenditures incurred on R&D subcontracted to universities or PRIs.

Private philanthropists can secure additional funding for universities and exert a strong influence on the orientation and outcomes of public research. Although private donations account for a minor share of public research funding as a whole, evidence shows that science philanthropy is concentrated in fundamental and translational research areas, as well as in leading institutions at the scientific frontier. Indeed, science patronage is estimated to provide almost 30% of annual research funds to leading US universities (Murray, 2012). Governments generally offer tax-based incentives to encourage private sponsorship. But this raises questions about the future of research for the public good. As private donations are oriented by personal interests, they may be dissociated from market forces or public goals and may skew research towards peripheral fields and have a positive impact on elite universities but have little value for the wider scientific community (Broad, 2014).

Recent policy trends

There is a clear global trend towards more competitive funding with the introduction of performance-based elements in core institutional funding and a move towards more contractual arrangements.

Ireland is introducing a performance-funding framework whereby up to 10% of an institution's core funding will be allocated on the basis of institutional performance criteria. Institutional performance will be assessed through self-assessment and peer reviews in accordance with mutually agreed mission-based contracts. Italy is currently allocating 13% of the university budget to performance-based indicators. Of the USD 1 060 million PPP (EUR 800 million) for 2013, two-thirds reflect research performance. New Zealand appropriated an additional USD 69 million PPP (NZD 100 million) in Budget 2012 to increase the volume of performance-based research funding to USD 200 million PPP (NZD 300 million) a year. The Polish law on higher education was amended in 2012 to foster performance-based financing and to introduce a new management model in university departments and research centres that have been granted the leading national research centre (KNOW) status. Additional funding is provided for employees' remuneration, scholarships and infrastructure upgrade. The reorganisation of the Russian Academy of Sciences included the introduction of transparent performance-based funding mechanisms. In 2012 Turkey adopted a performance-based system to fund research centres and is implementing institutional performance evaluations in universities. A new Entrepreneurial and Innovative University Index was developed to encourage entrepreneurship and innovation in universities; the first ranking was published in 2013.

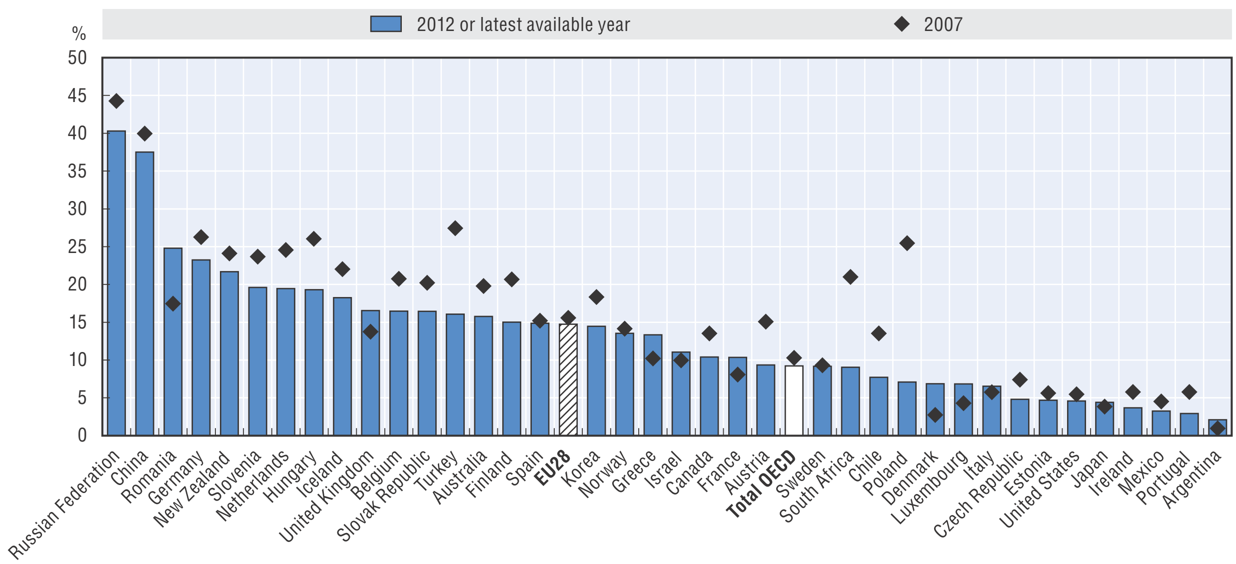
In 2013, Austria replaced the formula-based block funding of public universities in their 2013-15 performance contracts with the Higher Education Area Structural Fund of USD 543 million PPP (EUR 450 million), which combines indicator-based performance and co-operative project-based competitive grants. A 2012 European Research Area communication encourages more competitive allocation of institutional funding to PRIs and supports wider uptake of peer reviews for project-based funding.

The sources of public research funding have also changed as a result of greater industry involvement (OECD, 2011). However, firms' investment in R&D, including in public research, suffered as a result of the global financial crisis. The share of higher education and government R&D expenditure funded by industry dropped significantly over the crisis years and has since exceeded pre-crisis levels in only a few countries (Figure 6.4).

Incentives for industry to invest in public research have been reinforced in several countries and at the EU level. Tax incentives for R&D are increasingly used to leverage private funding for public research (see the policy profile on "Tax incentives for R&D and innovation"). In Italy, the Destinazione Italia plan includes several tax credit measures for enterprises investing in research. The tax credit fund guaranteed about USD 800 million PPP (EUR 600 million) for 2014-16. Germany's Academic Freedom Act 2012 allows non-university academic institutions to make greater use of third-party private funds. Likewise, Luxembourg revised the performance agreements of public research organisations for 2011-13 to bring third-party funding up to 30% of institutions' budgets.

Figure 6.4. **Public research funded by industry, 2007 and 2012**

As a percentage of total higher education and government R&D expenditure



Note: Data for Canada, China, the Czech Republic, Denmark, Estonia, Finland, Greece, Hungary, Ireland, Poland, the Slovak Republic, Slovenia, the United Kingdom and the United States refer to 2012. Data for Chile, Israel and South Africa refer to 2010. Otherwise data refer to 2011. Data for Australia refer to 2004 and 2008. Data for Greece refer to 2005 and 2012.

Source: OECD, *Research and Developments Statistics (RDS) Database*, March 2014, *www.oecd.org/sti/rds*; Eurostat, *Science, Technology and Innovation Databases*, June 2014, *http://epp.eurostat.ec.europa.eu/portal/page/portal/science_technology_innovation/data/database*. Data retrieved from IPP.Stat on 26 June 2014, *http://stats.oecd.org//Index.aspx?QueryId=57863*.

StatLink http://dx.doi.org/10.1787/888933151821

Sweden has been encouraging strategic public-private partnerships since 2013 by providing USD 35 million PPP (SEK 300 million) to support two large national initiatives to address societal challenges and increase international competitiveness through systems innovation, strategic innovation areas and challenge-driven innovation. It aims to leverage USD 25 million PPP (SEK 220 million) of private funding and further USD 80 million PPP (SEK 700 million) in 2016 for a public engagement of USD 80 million PPP. Since 2012, the UK Research Partnership Investment Fund has provided USD 725 million PPP (GBP 500 million) in research capital to support R&D partnerships between universities, business and charities. These partnerships must raise over the double of funding (USD 1.5 billion PPP, or GBP 1 billion) from private sources. At EU level, the Joint Technology Initiatives (JTIs) are new long-term public-private partnerships that support large-scale multinational research with a view to accelerating the development of solutions to social and environmental challenges and to reversing the declining role of industry in Europe. The JTIs will receive about USD 12 billion PPP (EUR 10 billion) from the private sector over the next seven years. Priority areas include aeronautics, medicines, electronic components and systems, transport and bio-based industries.

The impact of science philanthropy is expected to increase as central government budgets remain under severe fiscal pressure. In 2014 Norway reintroduced a scheme for private donations to research that was first implemented in 2006 and repealed in 2012. The donation reinforcement scheme gives a top-off of 25% to private donations above USD 340 000 PPP (NOK 3 million) to long-term basic research. However, Finland repealed tax exemptions on private donations to higher education institutions at the end of 2012.

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Open science

Rationale and objectives

Information and communication technologies (ICTs), new data storage infrastructure and large-scale computing are modifying the way science is conducted and the way the results of research are disseminated. They offer new opportunities to organise and publish the inputs and outputs of research, whether scientific publications or large datasets, to make it available for free, or at extremely low marginal cost, to other scientists and researchers and potential users in the business community and society. Furthermore, even though fields such as physics and medicine have long been data-intensive, ICTs make it possible to collect large amounts of data that can be the basis of scientific experiments and research and help make science more data-driven. This transformation of science into a more open and data-driven enterprise is often known as open science. It is enabled by public policies that encourage greater access to the results of publicly funded research, including publications and data.

The increased access to scientific research results has the potential to make the research system more effective and productive by reducing duplication and the costs of creating, transferring and re-using data; by allowing the same data to generate more research; and by multiplying opportunities for domestic and global participation in the research process. Another reason for public policies to promote open access is the innovation potential of knowledge spillovers from public research. The disclosure and release of public and scientific data can also promote the development of innovative products and services and increase consumers' awareness and choice. Finally, open access and open data initiatives can promote citizens' awareness of and trust in science. In some cases, more citizen engagement may lead to active participation in scientific experiments and data collection.

Major aspects

The existing models for the diffusion of scientific outcomes (publications, but also data and other research material) are evolving towards systems in which scientific outputs are increasingly publicly available. Policy makers, as key funders of public research, can play an important role by promoting access to and use and re-use of scientific research results. In particular, they can remove barriers to open science efforts by setting appropriate incentive mechanisms, developing the infrastructure necessary to make open science happen and, in some cases, adopting mandatory rules for the open disclosure of publicly funded research results. Scientists often compete to achieve excellent scientific results. They therefore have little incentive to share pre-publication data and experiment material. Mechanisms that acknowledge researchers for the publication of datasets and curation of datasets and other scientific material can promote scientific information sharing by removing the current disincentives.

Two main publishing models have emerged to promote open access to scientific articles. *Green open access* refers to the "self-archiving" of the published articles or the final peer-reviewed manuscript by the researcher after or alongside its publication in a scholarly journal. Access to this article is often delayed by a period of embargo. *Gold open access,* or "open access publishing", or "author pays publishing" means that a publication is immediately provided in an open access mode online by the scientific publisher. Associated costs are shifted from readers to the university or research institute to which the researcher is affiliated or the funding agency sponsoring the research or the institution.

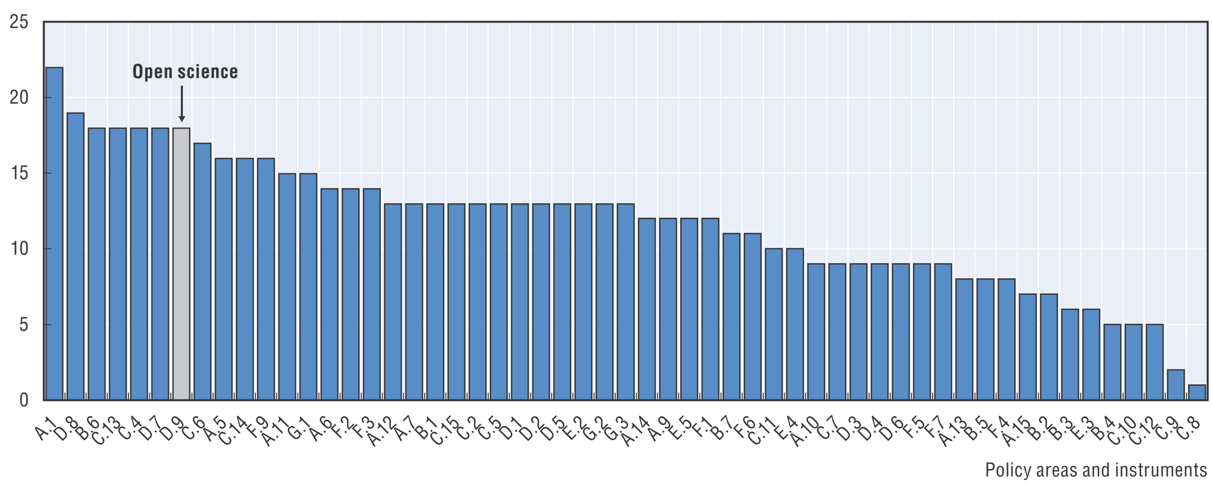
In addition to access to articles, open science requires the development of infrastructure for sharing research results and data, as well as the access to such infrastructure by scientists and researchers. This may involve the creation of publication and data repositories, the use of clean metadata, and the development of skills to enable researchers and scientists to share data and scientific content. Several countries are developing the infrastructure necessary to collect, store and disseminate research results (both articles and data).

Recent policy trends

OECD and non-member countries are increasingly developing frameworks, guidelines and initiatives to encourage greater openness in science. Most of the respondent countries to the STI Outlook policy questionnaire 2014 highlighted recent changes in their policy framework for open science (Figure 6.5). Policy changes related to open science rank equally with areas such as commercialisation of public research results, public research infrastructures, sector- and technology-oriented programmes, grants and subsidies, and industry-science co-operation.

Figure 6.5. **Open science initiatives among other areas of STI policy change, 2012-14**

Countries reporting a substantial change in the policy area, compared with other STI policy areas



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 2014 questionnaire). The y-axis shows the number of countries reporting that the situation has substantially changed in each policy area. Simple counts do not account for the magnitude and impact of policy changes. Responses are provided by Delegates to the OECD Committee for Scientific and Technological Policy.

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

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Examples of recent policy initiatives include:

- The creation of online repositories, databases, archives and digital libraries and platforms containing information on R&D projects and researchers' CVs. Estonia and Poland have created national networks of repositories and digital libraries. Finland has launched an infrastructure roadmap to promote open science. China has developed online platforms for data and publication archiving. Argentina developed the SICyTAR database with information on the CVs, publications and affiliations of researchers, and Colombia has set mandatory guidelines. The European Commission has also been active in promoting the development of EU and member country repositories and platforms.

- Mandatory access. Major funding agencies in Australia, Costa Rica, Denmark, Estonia, Germany, Switzerland, the United Kingdom and the United States have mandated public access to the results of the research they fund. Norway and several other countries are also considering adopting rules for mandatory open access.
- Financial support. Funding agencies in Germany, Norway, the Netherlands, Switzerland and the United Kingdom have adopted funding mechanisms to cover some of the costs of the open access publishing procedure. Elsewhere, governments encourage universities or research organisations to allocate funding for open access initiatives directly. In Europe, the European Commission supports open access and open data efforts, and it requires research results financed by the Horizon 2020 programme to be publicly available after publication (although it allows researchers to choose how they disclose research results). According to Horizon 2020 regulations, fees related to open access publishing are eligible for reimbursement under the conditions of the grant agreement. In addition, a subset of projects funded by Horizon 2020 will participate in a pilot open research data initiative that will mandate the disclosure of research datasets and the associated metadata.
- Open government data. Open science can also be promoted through the disclosure of government data. A number of OECD and non-member countries have adopted policies in this respect. Australia, Canada, Finland, France, the United Kingdom and the United States have disclosed government data on a range of different topics from weather data to Geographic Information Systems (GIS) data in the frameworks of their open government initiatives. China has also implemented a government data-sharing programme covering 24 sectors since the beginning of 2000s.
- Modification of intellectual property rules for research or exemptions. Australia and Finland are currently discussing modifications of the existing legal framework for the publication of publicly funded research results to make the copyright legislation increasingly open science friendly. Germany has amended its copyright legislation, and the United Kingdom has recently passed a series of amendments to its copyright legal framework (coming into force in 2014), which include greater freedom of re-use of copied or recorded material for educational and non-commercial research purposes.

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Commercialisation of public research

Rationale and objectives

The commercialisation of public research is a major goal of national S&T policies and a key function of universities and PRIs, alongside teaching, education and the dissemination of knowledge. Public research has been the source of many of today's innovations, sometimes as a by-product of basic research and sometimes without any prospect of a direct business application. Well-known examples are the techniques of recombinant DNA, the global positioning system (GPS), MP3 technology and Siri, Apple's voice recognition technology. Data on scientific sources of many of today's nanotechnology, ICT and biotechnology patents provide additional evidence of the linkages between technological innovations and public research (OECD, 2013a).

While knowledge and research generated by the public research system diffuses through a variety of channels – mobility of academic staff, scientific publications, conferences, contract research with industry, and licensing of university inventions – much policy attention in OECD countries has centred on promoting knowledge transfers through publications, the patenting and licensing of academic inventions, and the promotion of academic start-ups. More recently, these channels are complemented by public-private partnerships, open science initiatives and entrepreneurial channels, such as student-based start-ups and related financing and mobility schemes. Anecdotal data from the United States, for example, show that start-ups created by university graduates are more numerous and more dynamic than those founded by teachers and researchers.

The rationale for public support for commercialisation has its roots in market and system failures. Weak commercialisation of public research may have several sources: asymmetric information, as potential users may not be aware of university inventions; risk or non-appropriability of the results of public R&D because ownership of university inventions may not be clear enough for industrial partners to engage in commercialisation; demand for research may be weak as companies, especially SMEs, may not carry out their own R&D; co-ordination problems among R&D participants, as firms' and universities' incentives may be misaligned because of their different missions; and lack of finance for developing prototypes and demonstration projects that would help attract private finance for commercialising academic inventions.

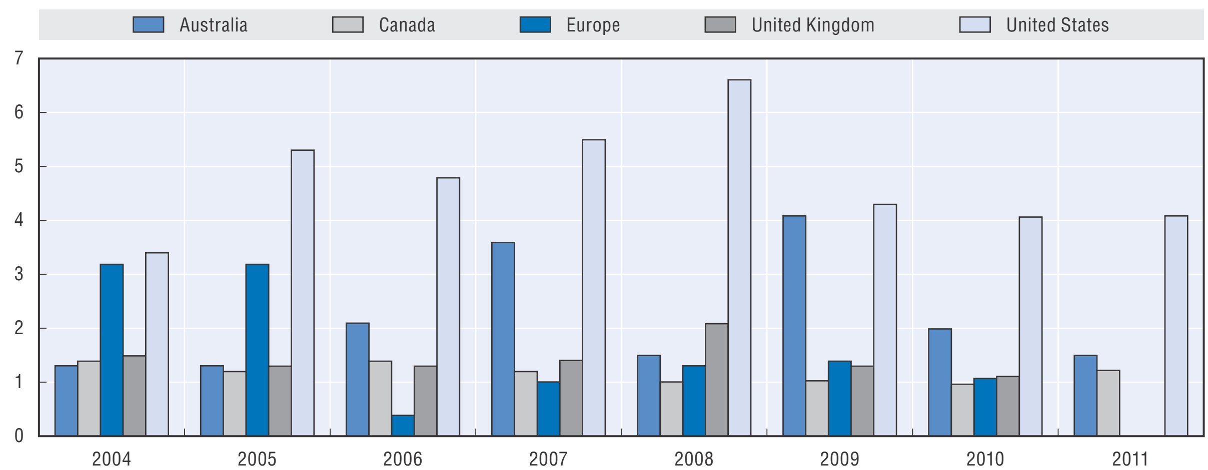
Major aspects

While some countries' universities and PRIs have succeeded in increasing the commercialisation of public research, as measured by the number of disclosed inventions, academic patents, licensing agreements or university spin-outs, recent data show a slowdown in the main commercialisation indicators in many OECD countries. This raises concerns among policy makers and practitioners about the effectiveness of existing approaches to technology transfer and commercialisation.

Average annual growth of university patent applications fell from 11.8% between 2001 and 2005 to 1.3% between 2006 and 2010. PRIs experienced negative growth of -1.3% over the latter period, compared to growth of 5.3% growth between 2001 and 2005. Data on disclosures of invention (the first official recording of an academic invention) per USD 100 million in research expenditures show a slight average drop from 2004-07 to 2008-11. University spin-offs have not significantly expanded, despite continued policy support; in the United States, among 157 universities, the annual average number of spin-offs per university is only four. Data on spin-off companies per USD 100 million in research expenditures in major OECD countries generally hit a low in 2008, with the ratio stabilising in 2009-11 at pre-2008 levels. However, licensing income has remained relatively stable in OECD countries (Figure 6.6), although a few universities account for the bulk of licensing income. In Europe, 10% of universities accounted for approximately 85% of licensing income (OECD, 2013b).

Figure 6.6. **Licensing income from public research, 2004-11**

As a percentage of research expenditures



Source: OECD (2013), *Commercialising Public Research: New Trends and Strategies*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/9789264193321-en*. Based partly on calculations and data from Australia's Department of Innovation, Industry, Science and Research (DIISR) (2011 and 2012), "Australian National Survey of Research Commercialisation: 2008 and 2009" and "2010 and 2011"; European Commission (2012), "Interim Findings 2011 of the Knowledge Transfer Study 2010-12", Bonn/Maastricht/Solothurn; US Association of University Technology Managers (AUTM) (2009-12), "Highlights of the AUTM U.S. Licensing Activity Survey: FY2008 [through] FY2011"; Canadian AUTM (2009-12), "Highlights of the AUTM Canadian Licensing Activity Survey: FY2008 [through] FY2011"; Higher Education Funding Council for England (HEFCE) (2009-12), "Higher Education – Business and Community Interaction Survey 2007-08 [through] 2010-11."

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While the situation may be due in part to the changing ecology of innovation, such as the fact that modern technological innovations are complex and rely on several patents, the slow adjustment of institutional and public policies have also played a role. Many governments and institutions have focused excessively on patenting and licensing as a channel for commercialisation. This has led to a rise in the number of patents filed and a narrow emphasis on exclusive licensing of inventions. Many institutions have also focused on the role of professors in commercialisation and less on student entrepreneurs. Governments, universities and PRIs are now experimenting with new strategies to improve the commercialisation of public research.

Recent policy trends

Given policy trends regarding commercialisation in recent years (OECD, 2012, 2013b), many countries are diversifying their commercialisation policies and promoting two-way flows between industry and science through public-private partnerships (see the policy profile on "Strategic public/private partnerships"), joint research initiatives/centres, outward and inward licensing of IP by universities and PRIs, and incentives for the mobility of entrepreneurial academics (see the policy profile on "Labour market policies for the highly skilled").

Governments have also tried new ways to facilitate co-operation between industry and research staff, such as new models of technology transfer and licensing offices (TTOs/TLOs), the use of collaborative intellectual property tools such as patent pools and patent funds, and initiatives to facilitate access to the results of public research:

- The Australian National Industry Investment and Competitiveness Agenda, anticipated later in 2014, will focus on initiatives to promote national competitiveness and productivity, including the commercialisation of good ideas. The Austrian RTI strategy promotes the establishment of "knowledge transfer centres". The programme is estimated to cost USD 24 million PPP (EUR 20 million) and will be managed by the Austrian operational bank.
- Belgium's TETRA project supports the development of prototypes and demonstrators of innovations by SMEs and social organisations that could commercialised if there is a sufficiently large group of companies in Flanders that would benefit from the results. The project results must also be consistent with the degree programmes of the HEIs or universities implementing the project to ensure that the knowledge is transmitted indirectly through their graduates to Flemish companies.
- The Czech Republic recently implemented a series of measures to support TTOs by: establishing technology transfer points and offices in research institutions; creating instruments to fund the proof-of-concept stage of technologically based projects; and supporting the popularisation of S&T through the creation of science learning centres and improving access to research information and information about research results.
- France has recently created a number of technology transfer companies (SATTs) to reduce the fragmentation of technology transfer services at regional level. Israel is encouraging the development of private or for-profit models for TTO offices, which are often institutionalised in the form of limited liability companies. Internet platforms that provide a market for academic inventions have also been the target of policy support.
- Mexico is creating and strengthening TTOs through the Sectoral Innovation Fund (FINNOVA) to increase opportunities for linkages between institutions that generate knowledge and the private sector through consulting, licensing and start-ups. Support will focus on certification of TTOs and additional support for TTOs to engage in later validation of the commercial potential of research results as well as support to SMEs to cover consultancy costs when they require a certified TTO to solve a problem.
- Turkey's TUBITAK launched the 1513 Technology Transfer Office (TTO) Support Programme to provide funding to TTOs for training, capacity building for university-industry co-operation, project management support, academic entrepreneurship activities, and IPR support.

Governments continue to improve the legal and institutional framework for commercialisation and for collaboration on R&D between academia and industry. Creating standard licence agreements has also become widespread in universities and governments (e.g. the Lambert Toolbox in the United Kingdom, the models of co-operation agreements in Germany, the standard agreements Schlüter Denmark, the consortium agreement DESCA models in EU's FP7 projects) to facilitate the transfer of research to industry. An additional advantage of standard agreements is that they limit the potential for conflicts and disputes related to IP.

Improving and expanding access to the results of public research

Improving access to public research results has become another channel for commercialisation based on partnering schemes (see the policy profile on "Strategic public/private partnerships") and on vouchers that encourage SMEs to collaborate on or purchase public research. Open access policies also facilitate access to public research results (see the policy profile on "Open science").

From 2013 reports funded by the Canadian Institutes of Health Research (CIHR) are freely available on the publisher's website or an online repository within 12 months of publication. New Zealand and Spain also require the publication of the results of funded research in digital format in an open access repository. The Office of Science and Technology Policy (OSTP) of the US White House published in early 2013 a policy memorandum to federal agencies spending more than USD 100 million on research, requiring that the "direct results of public research (peer reviewed publications and scientific digital data) be made available to and useful to the public, industry and scientific community". As open access also requires adequate infrastructure, the European Commission has supported the construction of repositories and infrastructure through Framework Programmes for Research and Technological Development, such DRIVER and OpenAIRE.

Encouraging the circulation of knowledge

Mobility of researchers is an important channel for the circulation of knowledge. Programmes such as Belgium's Doctoris programme and France's industrial agreements for training through research (CIFRE) are two examples of policies to foster mobility and the development of competences of doctoral students (see the policy profile on "Strengthening education and skills for innovation").

Financing and entrepreneurship support for commercialisation

While venture capital tends to attract the attention of policy makers, commercialisation is often held back by a lack of financing at the pre-commercialisation stage. Many government commercialisation programmes now include support for prototype development and early-stage funding. In addition, new modes of funding, such as IP-based financing (securitisation) and crowdfunding, are helping accelerate the transfer and commercialisation of public research and are being examined in many OECD countries.

- Australia's Growth Partnerships (AGP) is a competitive, merit-based pilot funding programme managed by CSIRO. It is designed to help SMEs overcome technical problems and give them an opportunity to accelerate their growth in high-impact industries that are aligned with CSIRO's National Research Flagships Programme. CSIRO has allocated funds for investment through the AGP Programme to high-potential, technology-receptive SMEs so they can access CSIRO R&D capability and IP.
- The People's Republic of China's government has adopted a "carrot and stick" approach to the creation of university spin-offs and to attract venture capital and business angels. On the one hand, the sharp decrease in funds since the 1990s forced many Chinese public universities to develop entrepreneurial activities to support university development. On the other, systematic preferential policies, such as tax treatment and easy access to state loans, promote linkages between academy and industry.
- Canada is providing USD 49 million PPP (CAD 60 million) over five years to help incubator and accelerator organisations expand their services to entrepreneurs under the Canada Accelerator and Incubator Program (CAIP) as part of the Venture Capital Action Plan. The

Economic Action Plan 2014 proposes to provide CAIP with an additional USD 33 million PPP (CAD 40 million) over four years, starting in 2015-16, increasing its total funding to USD 81 million PPP (CAD 100 million). The Business Development Bank will make available a further USD 81 million PPP (CAD 100 million) to invest in firms graduating from these business accelerators.

- New Zealand's Pre-seed Accelerator Fund (PSAF) is shared among five organisations that allocate funding to specific projects. The aim is to undertake early-stage technology commercialisation activities to: maximise the commercial benefits to New Zealand from publicly funded research; improve the commercial capability and skills of PRIs; promote linkages between PRIs and potential private-sector partners, including industry players and capital providers, in New Zealand and offshore.
- The UK's Graphene Global Research and Technology Hub aims to accelerate the development of commercial applications in the United Kingdom, by connecting UK researchers and businesses, and providing specialist equipment and expertise. It will be operational from 2015 and its budget is estimated at USD 74 million PPP (GBP 50 million). In the life sciences, the UK Biomedical Catalyst is a funding vehicle to support innovative ideas in biomedical sciences across the "valley of death". It will provide USD 261 million PPP (GBP 180 million) in support between 2012/13 and 2014/15. In 2014, the government has provided USD 22 million PPP (GBP 15 million) in capital – with twice as much funding from other sources, including private sources –, to four pilot University Enterprise Zones (UEZ) to encourage university-business interaction, support the development of incubators and create a space for businesses combined with a wrap-around business support offer. More broadly, the network of Catapult Centres aims to give businesses access to specialist equipment and emerging technologies and connect them to academic expertise.
- Several universities and PRIs provide additional funding for the creation of start-ups with their own funding mechanisms, either fully funded or co-financed with institutional resources. In Europe, about 73 such funds have been identified. In general, they also provide consultancy services, incubator support, market research and training. Examples include the Seed Fund Chalmers in Sweden and Gemma Frisius Funds at the University of Leuven, Belgium.

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OECD Science, Technology and Industry Outlook 2014

PART II

Chapter 7

STI policy profiles: Networks, clusters and transfers

Innovation and the digital economy

Rationale and objectives

The Internet is an important driver of innovation and growth. It accelerates the diffusion of information, boosts communication efficiency, facilitates networking among firms, and reduces geographical distance. The eco-system of the digital economy is mainly composed of high-speed communications infrastructure, digital content and smart applications.

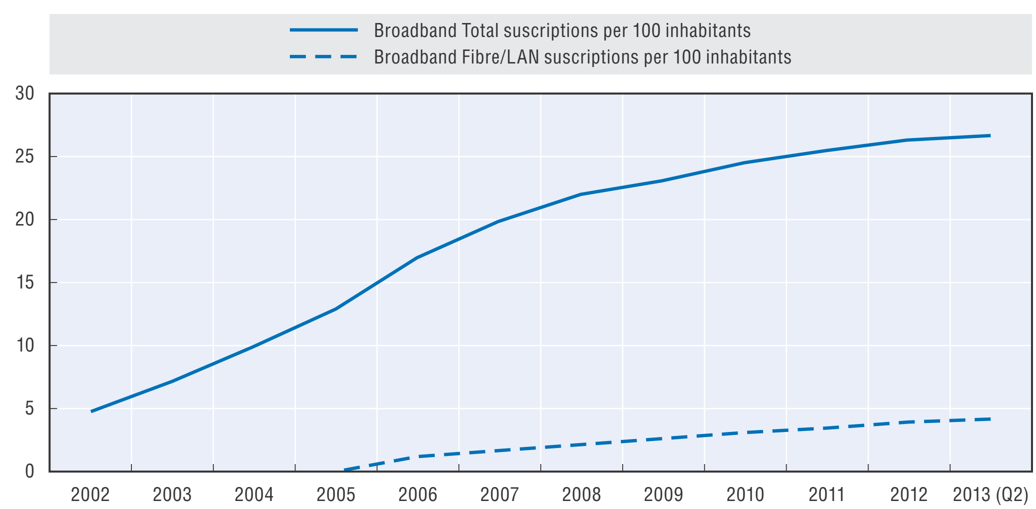
Major aspects

High-speed communication infrastructures

High-speed fixed and mobile networks are the core infrastructure of the digital economy and provide the foundation for applications and services. Access has improved dramatically over the past decade (Figure 7.1) although there are important differences among countries in this respect (Figure 7.2).

Figure 7.1. **Fixed broadband subscriptions per 100 inhabitants, OECD average, 2002-12**

Total and fibre/Local Area Network (LAN)



Source: OECD, *OECD Broadband Portal*, June 2014, *www.oecd.org/sti/broadband/oecdbroadbandportal.htm.*

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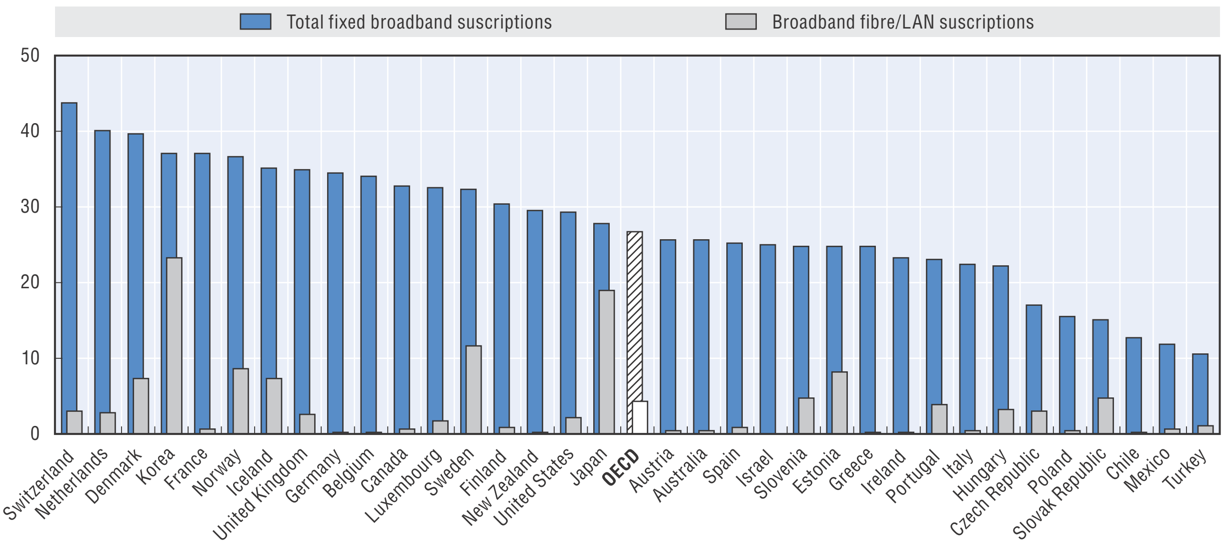
The recent substantial growth in mobile broadband has opened up communication possibilities for people who do not have access to a fixed-line connection. Mobile broadband penetration has risen to almost 60% in the OECD area, according to June 2013 data, and Australia, Finland, Sweden, Japan, Korea and Denmark are now above the 100% penetration threshold. This means that some inhabitants of these countries have more than one mobile broadband subscription for their smartphones, tablets and other devices (Figure 7.3).

As network infrastructure is the physical foundation of the digital economy, governments play an important role in optimising broadband provision to underserved areas and fostering an environment conducive to investment in a range of broadband technologies. Policy makers also place strong emphasis on ensuring sufficient competition among providers of fixed and mobile services to spur innovation and lower prices for businesses and consumers.

Figure 7.2. **Fixed broadband subscriptions per 100 inhabitants, June 2013**

Total and fibre/LAN

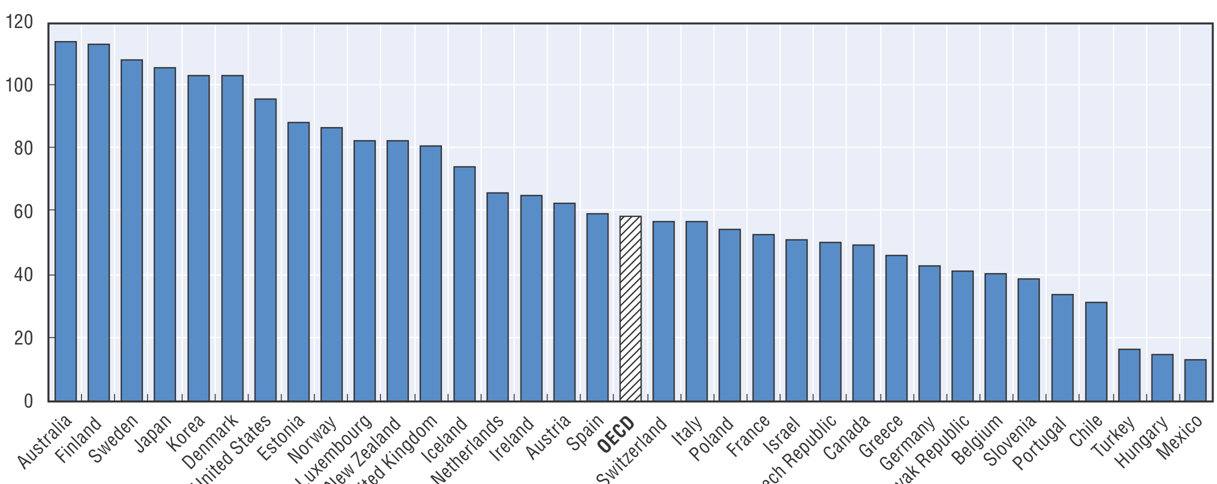


Source: OECD, *OECD Broadband Portal*, June 2014, *www.oecd.org/sti/broadband/oecdbroadbandportal.htm*.

StatLink http://dx.doi.org/10.1787/888933151863

Figure 7.3. **Mobile broadband subscriptions per 100 inhabitants, June 2013**

Standard mobile broadband and dedicated mobile data subscriptions



Source: OECD, *OECD Broadband Portal*, June 2014, *www.oecd.org/sti/broadband/oecdbroadbandportal.htm*. Data retrieved from IPP.Stat on 08 July 2014, *http://stats.oecd.org//Index.aspx?QueryId=57863*.

StatLink http://dx.doi.org/10.1787/888933151872

Digital content

Widespread adoption of broadband has opened up a world of digital content to users. The rapid growth of "apps" highlights the innovative potential of open networks for delivering new content and services (OECD, 2013a, 2013b). Recently, digital content markets have shown strong annual growth rates and online revenue shares have increased considerably. This rapid increase is spurred by the increase in broadband adoption, lower prices for devices and access, improved digital literacy, and network upgrades (OECD, 2013c).

Beyond promoting availability of and accessibility to the underlying information and communication infrastructure, governments have acted to encourage the development of local content. Several initiatives have supported the digital accessibility of their country's cultural heritage and the creation of new forms of interactive cultural content. Furthermore, governments have promoted the use of digital content in the areas of skills development and education.

Smart ICT applications in the data-driven economy

The Internet introduces new opportunities for innovation in traditional sectors. An example is the development of smart electricity grids that can leverage information to operate more efficiently and provide new services to users. For example, over 10% of an individual household's electricity consumption can be cut down simply by providing better information or providing information in better ways. Reductions in "peak demand" can also contribute directly to lowering greenhouse gas emissions since this makes the connection of additional power plants during peak times unnecessary (OECD, 2012).

As the economy is becoming "smarter", many issues need to be better understood. The increasing deployment of smart ICT applications generates large amounts of data, which can become a major resource for innovation and efficiency gains. Data, as an intangible asset, will play a role in creating competitive advantage and driving innovation (OECD, 2013d), on the condition that privacy issues are addressed.

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Cluster policy and smart specialisation

Rationale and objectives

Clusters are a geographic concentration of firms, higher education and research institutions, and other public and private entities that facilitate collaboration on complementary economic activities. While some of the world's leading clusters specialise in high-technology industries (e.g. Silicon Valley, Bangalore) they are also found in sectors ranging from wine making to automobiles to biotechnology.

Clusters are increasingly exposed to global competition (see Chapter 1) and many OECD governments are keen to enhance their competitive advantage and to help firms and entrepreneurs in clusters move up the value chain through innovation and greater specialisation. The main rationale for public policies to promote clusters, through infrastructure and knowledge-based investments, networking activities and training, is an increase in knowledge spillovers among actors in clusters and thus the generation of a collective pool of knowledge that results in higher productivity, more innovation and increased competitiveness.

By promoting "smart specialisation" strategies, national and regional governments are attempting to enhance the competitiveness of firms and clusters. Smart specialisation is an evidence-based policy framework that uses indicators, technology foresight and other priority-setting tools to help entrepreneurs and firms strengthen existing scientific, technological and industrial specialisation patterns while identifying and encouraging the emergence of new domains of economic and technological activity.

Major aspects

Most OECD countries promote a cluster-based approach to innovation (Table 7.1). Argentina, Belgium, France, Portugal and Spain have made cluster policies an integral part of their national innovation strategies or plans. Other countries have programmes to promote the creation of new clusters or to strengthen existing ones. Belgium, Germany and the Netherlands have targeted specific sectors/industries in their national innovation strategies or plans. Several policy tools have been adopted to support clusters and specialisation.

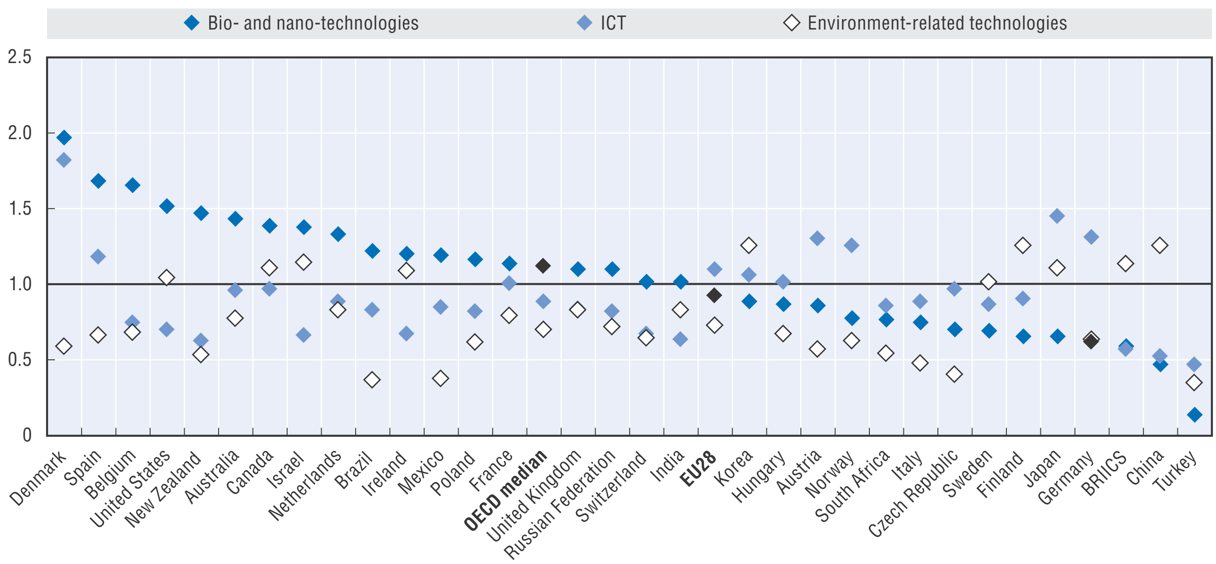
Networking platforms: Most OECD countries and regions have policies to promote the creation of networking platforms and collaboration among cluster members. These networks facilitate science-science interactions (between research centres and universities), science-industry interactions and industry-industry interactions. These networks are increasingly used to support cluster-to-cluster collaboration, including across regions and countries.

Internationalisation of clusters: Globalisation and competition have fostered both the internationalisation and the specialisation of clusters. This has implications for public support policies. France and Germany are encouraging competition between clusters and targeting public support on the basis of excellence, including at international level. The EC European Cluster Excellence Initiative (2009-12) aimed to improve European clusters' capabilities by developing methodologies and tools to support cluster organisations and providing cluster managers with practical advice and training in the management of clusters and networks. A set of cluster management quality indicators has been developed, as well as a quality labelling system for professional cluster management.

Technology specialisation: There is also a growing effort to foster cluster development around enabling technologies (e.g. ICTs, biotechnology, nanotechnology) and emerging industries (OECD, 2010). Indeed, cluster dynamics are a force for the economic, industrial and technological specialisation of a region or country. The RTA index for 2008-10 reveals a strong specialisation in biotechnology and nanotechnology in Denmark, New Zealand and Spain, a strong specialisation in environment-related technologies in Austria, Denmark, Germany, Japan and Norway, and a strong specialisation in ICT in the People's Republic of China, Finland, Japan and Korea (Figure 7.4).

Figure 7.4. **Revealed technological advantage in selected technological areas, 2009-11**

Index based on patent applications filed under PCT



Note: The revealed technology advantage (RTA) index is calculated as the share of a country in patents filed in a given field relative to the share of the country in total patents. When the RTA is equal to 1, no specialisation is observed. When the RTA is equal to 0, no patent is filed in the field. Only economies with more than 250 patents over the periods are included in the figure.

Source: OECD, *OECD Patent Database*, March 2014, *www.oecd.org/sti/inno/oecdpatentdatabases.htm*. Data retrieved from IPP.Stat on 08 July 2014, *http://dotstat.oecd.org//Index.aspx?QueryId=57863*.

StatLink http://dx.doi.org/10.1787/888933151884

Recent policy trends

Many OECD countries and regions are combining clusters policies and specialisation strategies, which are on even footing in terms of recent policy changes (Figure 7.5). The smart specialisation concept has been promoted at EU level through the establishment of the S³ Platform to assist regions and member states to develop regional smart specialisation strategies and identify the high value-added activities that offer the best chances of strengthening their competitiveness. Austria, Belgium, the Czech Republic, Greece, Hungary, Italy, Latvia, the Netherlands, Portugal, the Slovak Republic and Spain have new smart specialisation strategies. A recent EU survey investigated the potential contribution of clusters and cluster policies to the design and implementation of smart specialisation strategies and highlighted potential trans-regional learning and the need for a data infrastructure on clusters and cluster policies, with more advanced mapping indicators and tools, methods and evidence-based findings from evaluations of cluster policies.

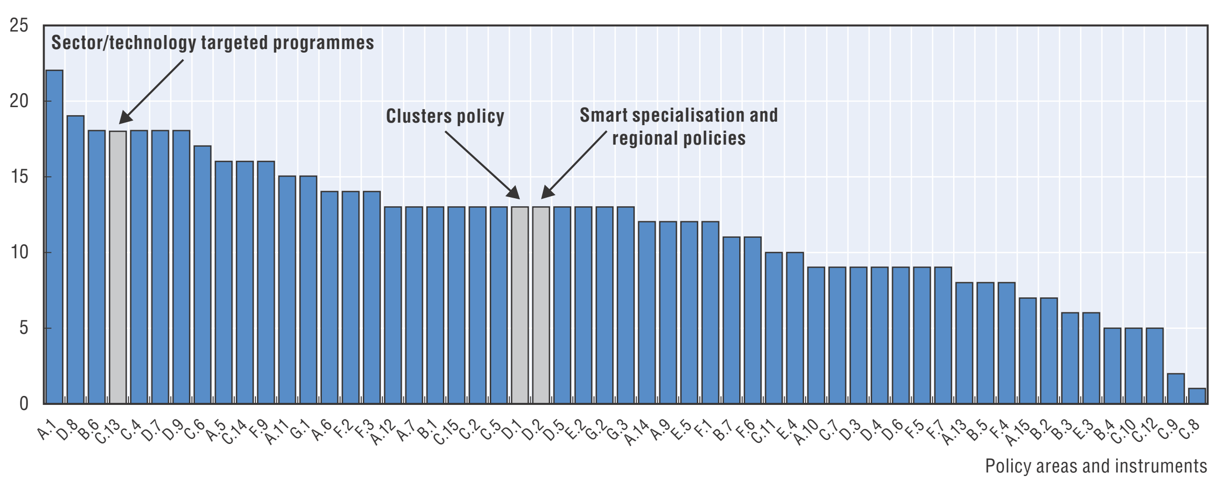
Table 7.1. **Cluster development support policies and specialisation patterns in selected OECD countries**

Creating and consolidating clusters	Creation of new clusters through co-ordinated action for R&D activities (e.g. public funding programmes)	Argentina, Chile, Norway
	Promotion of network structures, service support for entrepreneurs, cluster co-ordination	Argentina, Austria, Australia, Belgium, Canada, China, Colombia, Denmark, France, Germany, Greece, Ireland, Japan, New Zealand, Norway, Sweden
Networking platforms	Science-science (e.g. promotion of collective research centres, centres of excellence)	Belgium, Canada, Denmark, France, Norway, South Africa, Spain, Switzerland
	Industry-science (e.g. promotion of public-private networks, science parks)	Argentina, Australia, Belgium, Canada, Colombia, Denmark, Finland, France, Germany, Italy, Norway, Poland, Portugal, United Kingdom
	Industry-industry (e.g. promotion of sectoral networks)	Belgium, Colombia, Denmark, Germany, Poland, Portugal, Spain, United Kingdom
Technology specialisation (RTA index)	Biotechnology and nanotechnology	Australia, Belgium, Canada, Denmark, India, Ireland, Israel, Netherlands, New Zealand, Poland, Spain, United States
	Environment-related technologies	Australia, Austria, Canada, Czech Republic, Denmark, France, Germany, Hungary, Japan, Norway, Poland, Spain
	ICTs	Canada, China, Finland, Ireland, Israel, Japan, Korea, Sweden, United States
Internationalisation	Cluster competition and cluster excellence programmes	Austria, Belgium, Germany, France, Ireland, Japan, Netherlands, EC
(Towards) smart specialisation	Australia, Austria, Belgium, Czech Republic, Estonia, Finland, Germany, Ireland, Israel, Netherlands, Poland, Russian Federation, Spain, Turkey, United Kingdom, EC	

Note: The revealed technology advantage (RTA) index is the share of a country in patents filed in a given field relative to the share of the country in total patents. When the RTA is equal to 1, no specialisation is observed. When the RTA is equal to 0, no patent is filed in the field. Only economies with more than 250 patents over the periods are included in the ranking.
Source: Country responses to the OECD STI Outlook policy questionnaire 2014 and OECD (2010), *OECD Science, Technology and Industry Outlook 2010*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/sti_outlook-2010-en*.

Figure 7.5. **Clusters and smart specialisation initiatives among other areas of STI policy change, 2012-14**

Countries reporting a substantial change in the policy area, compared with other STI policy areas



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 2014 questionnaire). The y-axis shows the number of countries reporting that the situation has substantially changed in each policy area. Simple counts do not account for the magnitude and impact of policy changes. Responses are provided by Delegates to the OECD Committee for Scientific and Technological Policy.
Source: Country responses to the OECD STI Outlook policy questionnaire 2014.

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Most recent policy attention has focused on strengthening the research component of clusters. In recent years, Australia has adopted a hybrid model for developing specialisation precincts to build on areas of existing research strengths, while also funding national collaborative research infrastructure networks. The first precinct was established in Perth, with the participation of university, government, industry and Australia's national science agency CSIRO (Commonwealth Scientific and Industrial Research Organisation). Four other precincts are under development. Future activities will take place in the framework of the forthcoming National Industry Investment and Competitiveness Agenda. Ireland launched a large-scale Research Centres programme around HEIs in 2012 to develop a dynamic research ecosystem that would evolve with the changing needs of industry and society. In addition the competitive Spokes Programme 2013 offers conditional funding to encourage new industrial and academic partners to join Research Centres projects.

With a broader approach, the Russian Federation launched 25 pilot innovative clusters in 2012 with a USD 67 million PPP (RUB 1.3 billion) federal subsidy covering the purchase of new equipment, education and training, cluster management and networking activities and external consultancy, for instance for the preparation of investment projects in the sphere of innovation, but also for the development of transport and logistics, power, housing and social infrastructure. An additional amount of approximately EUR 125 million will be allocated every year until 2016.

Several governments have seen globalisation as an opportunity for developing clusters. Efforts are being made at European level to strengthen clusters of excellence:

- Costa Rica has implemented a strategy to promote cluster development around FDI in high-technology sectors (e.g. advanced electronics, medical devices, automotive devices, etc.). The Free Zone Regime provides fiscal incentives and benefits to international companies that invest. Costa Rica has also made efforts to better link SMEs to MNEs, for instance through matching programmes to help SMEs with adequate capacities to supply MNEs.
- The EU Regions of Knowledge programme promoted cross-border co-operation among research-driven clusters with a total budget of USD 150 million PPP (EUR 126 million) over 2007-13. In addition the Territorial Co-operation Programme has been identified as a potential lever for the development of cross-border cluster efforts.

The European Secretariat for Cluster Analysis (ESCA) is a one-stop shop for labelling cluster organisations through the Cluster Excellence Management Label System, which benchmarks and certifies clusters on the basis of strict criteria. It has benchmarked 570 clusters. The ESCA also supports cluster policy makers and programme owners with advice on development of cluster programmes.

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- Smart specialisation, available at *http://qdd.oecd.org/Table.aspx?Query=696C719F-9922-46D1-8D63-82D63B5122BE*,
- Sector/technology-targeted policies,
  - biotechnology, available at *http://qdd.oecd.org/Table.aspx?Query=162C9AF5-43DE-456E-852D-0BE31E7BD54D*,
  - nanotechnology, available at *http://qdd.oecd.org/Table.aspx?Query=31E7B2CE-F6F0-4E16-A898-BF1DC8A0A703*,
  - ICT, available at *http://qdd.oecd.org/Table.aspx?Query=97DDD022-0077-4C4A-BB0F-76290E85FA67*, and
  - sector-targeted policies available at *http://qdd.oecd.org/Table.aspx?Query=A16345EE-1C53-4FB9-BCC9-375C4AB1CA6E* .

PATENT POLICIES

Rationale and objectives

A patent is a legal title that gives the holder the right to exclude others from using a particular invention. If the invention is successful on the market, the patent holder will profit from its monopoly power. Patents therefore allow inventors to internalise the benefits they generate. Without such a mechanism, inventions could be imitated, which would reduce inventors' return on their investment. Patents are granted in return for disclosure of the invention and therefore play a role in the diffusion of knowledge. Inventors and firms apply for patents at patent offices, which grant or reject patents for their jurisdiction, mainly the domestic market, in accordance with their legal statutes. Most patent offices are national organisations; the main exception is the European Patent Office (EPO).

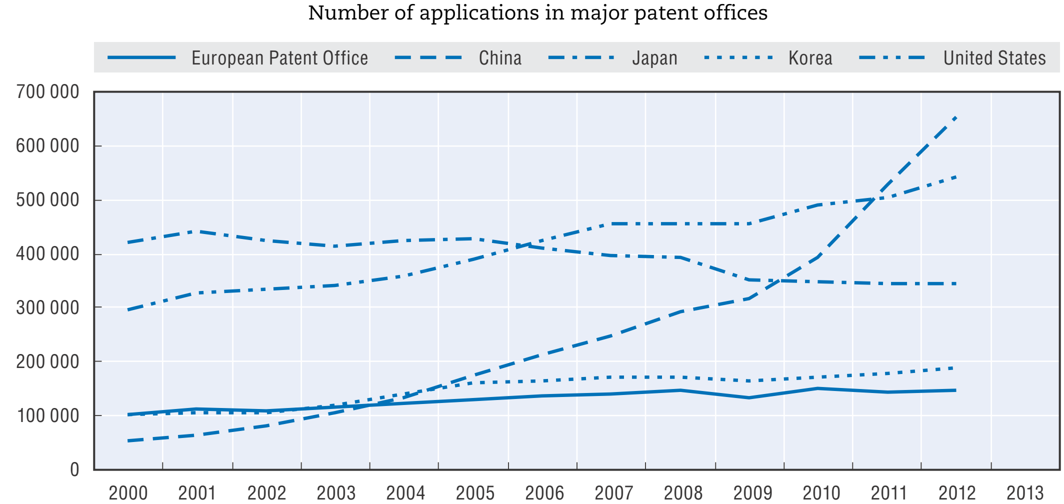
Major aspects

Patent filings have increased sharply worldwide, rising from 997 000 in 1990 to 2 350 000 in 2012, according to the World Intellectual Property Organization (WIPO). This rise was partly driven by a pronounced increase in patent filings in China and, to a lesser extent, in the United States (Figure 7.6 and Chapter 1). Inventors choosing to file in multiple countries have also been an important driver of the global patent surge. However, some observers have recently voiced concerns about a decline in patent quality and ascribe it, in part, to lower legal standards of novelty and a work overload among patent office examiners. Poor quality patents are often held responsible for the increase in dubious litigation for alleged infringement ("trolling") in certain jurisdictions over the past two decades, and patent offices and court decisions have sought to raise patent quality since the mid-2000s.

Over the last few decades, patents have expanded to cover new technical fields, notably software and genetic material, and in some countries to non-technical fields such as business methods. Certain actors have welcomed this trend, but other observers have noted that patenting in these fields potentially hampers the diffusion of technology, with

Figure 7.6. **Patent filings, 2000-12**

Number of applications in major patent offices



Source: WIPO (2013), Statistics on Patents webpage, *www.wipo.int/ipstats/en/statistics/patents* and national patent offices. Data retrieved on 08 July 2014.

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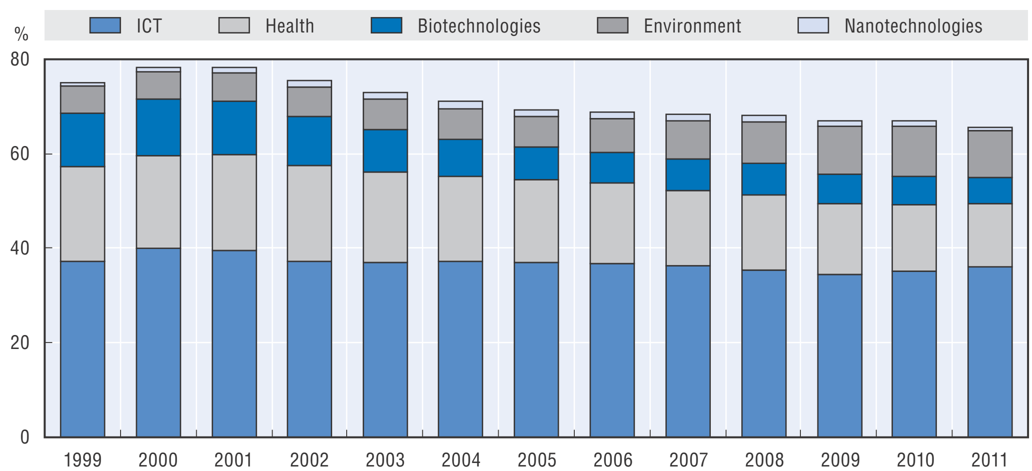
possible negative impacts on inventive activities in areas closely aligned to science and to mental processes (which are non-patentable areas). Patents in information and communication technologies (ICTs), health and biotechnologies represent the majority of patent applications worldwide, although their relative importance has decreased from almost 72% in 2000 to 55% in 2011. The decline has been mainly driven by a gradual reduction in the number of patent applications in health- and biotechnology-related technologies. Patents in nanotechnologies and the environment, instead, which in 2000 accounted for about 7% of all patents, saw their relative share increase to almost 11% in 2011 (Figure 7.7).

Figure 7.7. **Patents by technology fields, 1999-2011**

As a percentage of total patent applications under the Patent Co-operation Treaty (PCT)



Note: The data refer to counts of patent applications filed under the Patent Co-operation Treaty (PCT), at international phase, by priority date.

Patents in biotechnologies, nanotechnologies, health- and ICT-related technologies are based on a selection of International Patent Classification (IPC) classes. Patents in environment-related technologies are defined using combinations of IPC classes and codes Y02 of the European Classification (ECLA).

Sources: OECD, *OECD Patent Database*, March 2014, *www.oecd.org/sti/inno/oecdpatentdatabases.htm*.

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According to WIPO, the average share of non-residents among patent owners worldwide increased from 31% in 1990 to 35% in 2012, coinciding with the globalisation of the economy. Over this period, efforts to make the patent system more global have increased. In particular, the Patent Cooperation Treaty (PCT), administered by WIPO, facilitates simultaneous patent applications in a number of countries (although the processing and the grant remain national). Collaboration among patent offices has sought to improve the compatibility of countries' patent laws. The Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) initiated this trend. This international treaty, established in 1994 and implemented by the World Trade Organization (WTO), established a set of minimum standards for national laws to respect, including a broad definition of patent subject matter (all fields of technology, including drugs), a minimal statutory duration of 20 years, neutrality *vis-à-vis* the nationality of the patent applicant, etc. New procedures to reduce duplication of work by patent offices (notably search) have been set up, such as "patent prosecution highways" and a number of bilateral agreements between national offices to exchange work on particular applications.

The TRIPS agreement applies to all WTO member States, but transitional arrangements are provided for least developed economies under Article 66. Many emerging and developing countries have also implemented the TRIPS to support domestic innovation. The inclusion of pharmaceutical compounds in the compulsory patentable subject matter has raised the issue of access to essential care for the poor. Therefore, some flexibility has been introduced, notably since the Doha Agreement. First, it allows countries without sufficient manufacturing capability to import drugs from other member states utilising compulsory licences. Second, it provides that least developed countries are not obliged to provide patent protection for pharmaceutical products until January 2016. Another issue in some developing countries is enforcement of patent rights. This requires a strong and independent judicial system, without which infringement may flourish. Countries such as China and India have made significant efforts as have others.

Recent policy trends

The United States passed the *America Invents Act* in 2011. It was the most complete reform of the patent system since 1952 and adopts the principle of "first inventor to file" (instead of "first to invent"). It also introduced a post-grant opposition system to revoke patents that are deemed invalid early in the process and at relatively low cost. The Act also introduced a "fast-track option" to process patent applications within 12 months. The option is especially meant to assist start-ups, which are under more pressure to obtain intellectual property (IP) protection quickly. Australia and the United Kingdom have similar fast-track systems in place. Moreover, the US Act includes a provision for alternatives to costly litigation in courts to reduce costs of IP for entrepreneurs.

The Japan Patent Office (JPO) implemented several procedural changes in 2013. It revised the examination guidelines of the "requirement of unity of invention" and of the "amendment that changes a special technical feature of an invention". Moreover, the JPO has introduced the system of "collective examination for IP portfolios", under which JPO conducts examinations of different types of IP and grants rights on a cross-sectional basis in line with the timing of business expansion. In Europe, the new Community patent entered in force on 1 January 2014. It will complement the current European patent, which is a bundle of national rights. The Community patent comes with reduced translation requirements (three languages) and a unified court system. The aim is to reduce the cost for applicants and simplify procedures.

In Australia the *Intellectual Property Laws Amendment Act* of 2012, which took effect from April 2013, aims to raise the quality of granted patents to improve alignment with international standards. In Germany, a recent modification of its IP laws in July 2013 specifies that search reports will include written opinions to give applicants a more detailed view of whether the examiner considers the application patentable.

Emerging countries such as Chile, Colombia, Costa Rica and Indonesia have recently implemented a series of policies to optimise the legislative and procedural aspects of their IP systems (see OECD 2014 for evidence on recent reforms in Colombia and Indonesia).

Reforms have also been introduced to improve IP enforcement. The United Kingdom Patent County Court of England and Wales was reformed to reduce the costs of defending IP rights through procedures to impose a time limit on case hearings. The United Kingdom Intellectual Property Office is currently exploring ways to enhance existing schemes, such as mediation to provide more efficient dispute resolution. Denmark has recently introduced a number of initiatives to improve criminal IP enforcement and to reduce counterfeiting.

Various policy instruments have been implemented to support IP applications. They range from subsidies for preparing and presenting patent applications to the provision of information and advisory services. They mostly target small and medium-sized enterprises (SMEs). Countries that have recently implemented policies of this type include Argentina, Belgium, Canada, the Czech Republic, Sweden and the United Kingdom. One example is Germany's SIGNO programme, with an annual budget of USD 20 million PPP (EUR 16 million), which aims to support SMEs and start-ups, particularly in the crafts industry. Another example is the Business Coaching for Growth programme in the United Kingdom, which aims to help SMEs exploit their innovation potential; their utilisation of IP is an important element of the programme. This initiative follows the recently published Innovation and Research Strategy for Growth, which includes among its key actions helping SMEs protect their IP to support their growth.

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Intellectual property markets

Rationale and objectives

Intellectual property rights (IPRs) – patents, trademarks, industrial designs and copyrights – are increasingly traded in markets. Public policy plays an important role in shaping intellectual property (IP) markets and thus their impact on innovation. In today's highly networked world, the circulation of ideas is vital to innovation. Knowledge flows make possible a broader, more diverse and better use of existing competences and knowledge, beyond the uses or applications foreseen by the sole proprietor. Inventors, designers and authors, particularly researchers in universities and public research institutes, are not always best placed to exploit their own knowledge. Organisations are therefore increasingly looking for ways to trade knowledge capital. However, high transaction costs often impede the successful negotiation of licences or other types of agreements.

IPRs facilitate the transfer of knowledge and technologies by assuring the parties involved that the knowledge will not be misappropriated. IP transactions can sometimes be motivated by strategic considerations, for example to block competitors from entering specific markets or for litigation purposes. By pledging their IP as security, owners may also be able to secure finance. IP market activities may encourage investment in new knowledge creation but can also lead to opportunistic rent-seeking behaviour, with potentially perverse effects.

Major aspects

It is difficult to produce accurate estimates of the size of the IP marketplace because most transactions are proprietary and confidential. Available information suggests an upward trend: cross-country licence and royalty payments and receipts for all types of IP, including among affiliates, increased in the OECD area by an average annual rate of 10.1% between 2000 and 2011 (Figure 7.8), well above the annual average growth rate of OECD gross domestic product (GDP) of 5% over the period. According to Athreye and Yang (2011), the global total reached approximately USD 180 billion in 2009.

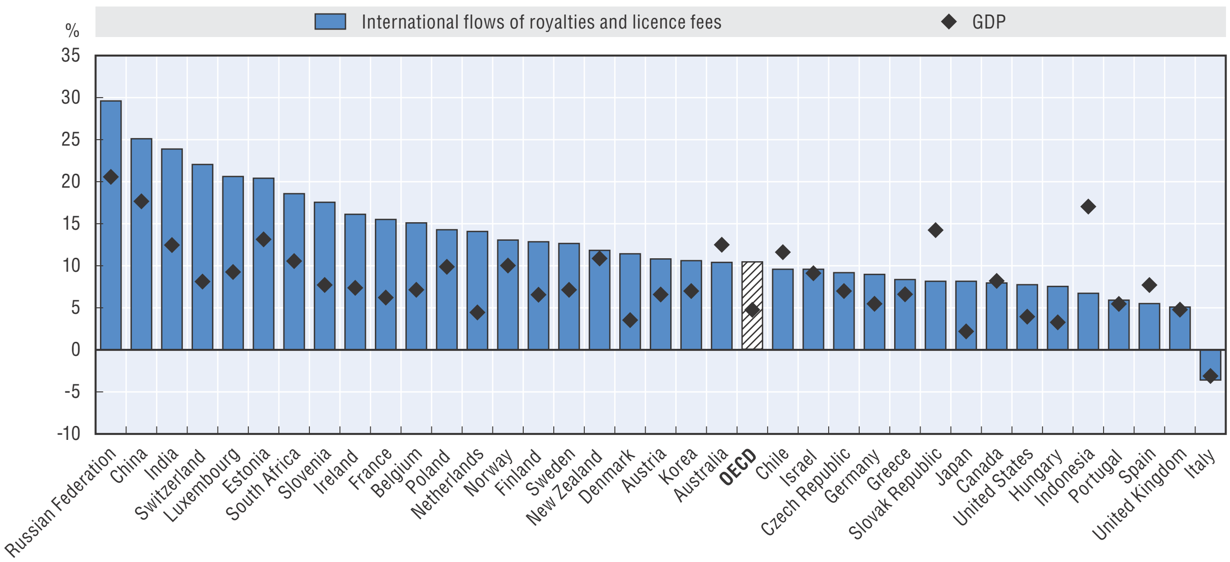
The share of patenting companies that license their technologies to non-affiliated companies was estimated at 13% in Europe and 24% in Japan (Zúñiga and Guellec, 2008). Based on confidential US tax data for 2002, Robbins (2006) estimated US domestic and international licensing of patents and industrial processes at USD 66 billion, or 4.5% of the total private R&D stock (BEA, 2011).

The acquisition of IPRs has become a key strategic tool for companies seeking to maintain and increase their markets, while IP transactions and disputes – especially involving information and communication technology (ICT) patents – have been widely reported in the media. The patent marketplace has also evolved with the appearance of new intermediaries and business models (Millien and Laurie, 2009; Yanagisawa and Guellec, 2009; Chien, 2010; Hagui and Yoffie, 2011). A number of governments have adopted related policy measures to promote the economic use of patented IP rights (OECD, 2013c):

- **Patenting funds** aim to reduce transaction costs and risks of litigation by pooling patents and licensing the entire portfolio to members. However, they may create asymmetries between insiders or incumbents and outsiders.
- **Patent-assertion entities** acquire IP to assert the patents against companies. Although they bring liquidity to the market, their business model is controversial because these

Figure 7.8. **International technology flows of royalties and licence fees, 2001-12**

Average annual growth rate, based on current USD, percentages



Note: Average of receipts and payments. Data for Belgium refer to 2003-12; data for the Netherlands and the Russian Federation refer to 2004-12; data for Denmark, Hungary, Indonesia and Israel refer to 2005-12; data for South Africa refer to 2006-12; and data for Italy refer to 2009-12. OECD excludes Iceland, Mexico and Turkey.

Source: OECD, *Technology Balance of Payments Database*; OECD (2013), "Trade in services – EBOPS 2010", *OECD Statistics on International Trade in Services* (database), *http://dx.doi.org/10.1787/data-00583-en*; World Bank (2014), *World Development Indicators (WDI) Databank*, *http://wdi.worldbank.org*; OECD, *OECD National Accounts Statistics*, *http://dx.doi.org/10.1787/na-data-en* and OECD estimates, June 2014.

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companies are (since they do not manufacture goods or supply services) immune from retaliatory IP suits. This allows them to extract a maximum surplus from unlicensed companies. This could discourage innovation in complex areas of research.

- **New online IP marketplaces** aim to replicate highly successful platforms for standard products, but some adopt more sophisticated approaches. For example, an exchange platform for unit licence contracts, a new form of IP derivative product, was created in 2011.

Another important policy topic related to increasingly global IP markets is taxation rules for IP revenue. These rules can affect where and how companies, particularly multinationals, exploit knowledge (OECD, 2013b). For example, guidelines on the expensing or amortisation of IP purchase costs can influence knowledge-sourcing strategies. Competition policy also plays an important role in evaluating mergers of IP-intensive companies or the creation of patent pools. Authorities have been investigating the use of injunctions against competitors by holders of standard-essential patents, which are often subject to fair, reasonable, non-discriminatory (FRAND) licensing pledges, in order to prevent abuse of market power.

Recent policy trends

Substantial policy efforts have been made to foster the commercialisation of IP. This includes the provision of services to help support firms' commercialisation efforts. Other initiatives have provided IP market platforms: Denmark released IP Handelsportal in 2011, an Internet-based IP marketplace portal where sellers can offer their rights or licences for sale and buyers can get information. The programme also offers tools to help value IP, an important challenge for the operation of IP markets, among other services. Similarly the United Kingdom's Digital Copyright Hub is a central portal that will connect databases of licensing bodies with automatised licensing and cross-sector search for details of rights holders. The objective is to support creative industries. The portal received initial seed funding from the UK government, but its costs are now borne by an industry consortium that runs the project.

Policy efforts are also made to encourage universities and public research institutes (PRIs) to commercialise their IP. Belgium and Slovenia provide support for technology transfer offices. France has established Accelerated Technology Transfer Societies (SATT), 14 of which were in place in 2014. They aim to protect and manage the IP of PRIs. Various countries have also recently implemented awareness programmes as part of their policy tools. In 2014, selected Danish universities will be part of the PATLIB network, which specifically aims to promote awareness. Another approach to supporting commercialisation efforts by universities and PRIs has been adopted by the United Kingdom's Fast Forward Competition, which has a total annual prize fund of about USD 1 million PPP (GBP 750 000) in 2014 and helps fund university-industry collaborations. The United Kingdom is also currently updating the Lambert Toolkit, which provides decision guides, model agreements and other materials for negotiations involving publicly funded universities and research institutes. Updates are based on an evaluation of the toolkit conducted in 2013. South Africa created the National Intellectual Property Management Office in 2013 as a specialised unit of the Department of Science and Technology to support publicly financed institutions in their commercialisation efforts.

Legislative provisions have also been modified to facilitate commercialisation. In Japan, amendments to the Patent Law have enhanced the protection of licence agreements with effect from April 2012. In France, Law 2013-660 requires PRIs to license their patents preferentially to small and medium-sized enterprises and to companies that will exploit them within the EU. It also reaffirms the principle of a single mandate for IPR management, aimed at reducing transaction costs associated with licensing. Beyond patents, the United Kingdom aims to introduce by April 2014 regulatory frameworks to establish codes of practice for societies collecting copyright royalties. Following the recommendations of the Hargreaves Report in 2011, it also plans to implement measures to support creative industries, including extended collective licensing and conditions for using orphan works, i.e. copyright-protected works for which rights holders are not known or cannot be contacted to obtain permission. In Sweden, where researchers have full ownership rights for their research results, they will be required to notify employers of results with commercialisation potential. This is to avoid any possible negative effects of this type of IP ownership on commercialisation.

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PART II

Chapter 8

STI policy profiles: Skills for innovation

Strengthening education and skills for innovation

Rationale and objectives

Education policies play a central role in innovation, by supplying the foundations and skills innovative economies require to develop processes and undertake organisational changes, but also to adopt new products and to adapt to changes over time. A number of OECD and partner countries highlight education and skills as key priorities in innovation policy. Since innovation and technological development in recent decades have had a profound impact on the labour market and the skills required for many occupations, there is an increasing focus on how well the education system equips young people with the skills to participate in and respond to innovation in the workplace.

The skills associated with innovation include specialised knowledge, general problem-solving and thinking skills, creativity, and social and behavioural skills, including teamwork. As many of these skills are developed from an early age, they need to be acquired in part through formal education. The increased recognition of the importance of these broader skills has also highlighted the contribution to innovation of training that goes beyond the traditional focus on science, technology, engineering and mathematics (STEM) disciplines, even though these disciplines occupy a prominent position in innovation policies. A range of education policies aimed at broadening learning can influence different types of innovation, even if innovation does not feature explicitly in the aims of the policy. Skills policies are of growing importance; recent OECD work has highlighted that almost two-thirds of adult population lack the skills to succeed in a technology-rich environment (Figure 8.1) (OECD, 2013).

Major aspects

Increasing students' participation in STEM remains a primary component of policy measures to strengthen education for innovation. Policies include incentives to increase student places, improve teaching, adopt performance targets for schools, and reform national STEM curricula. Figure 8.2 shows the proportion of new entrants to tertiary education who study engineering, science and health fields.

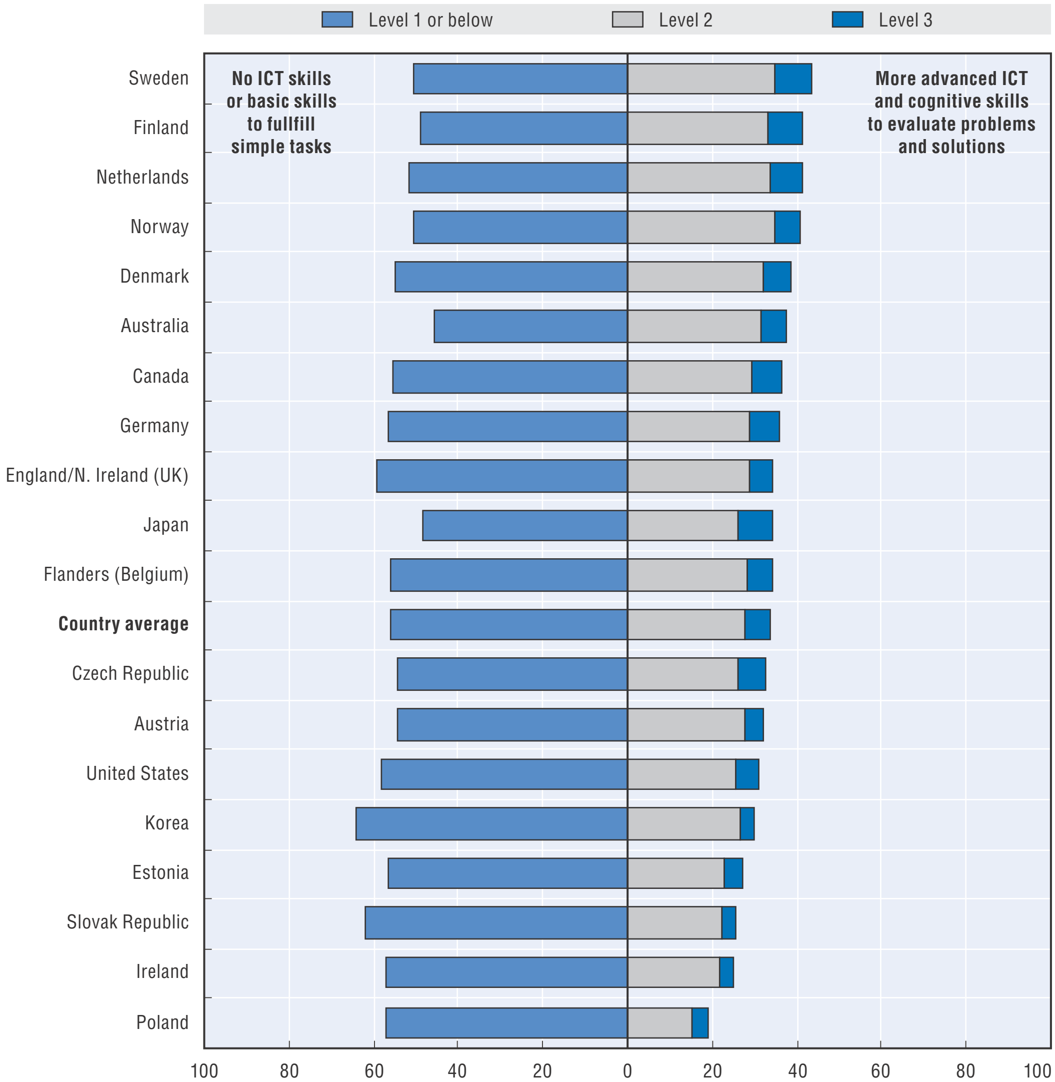
Postgraduate and doctoral-level education also needs to foster skills for innovation, partly because many doctoral students go on to undertake innovation in the higher education, public and private sectors. Figure 8.3 shows net entry rates into advanced research (doctorate) programmes.

Recent policy trends

Despite the continuing focus on science and technology education and careers, a number of recent policy measures in OECD and partner countries address the wider skills required for innovation. 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, while extracurricular activities seek to foster competencies such as creativity. Denmark's national innovation strategy (2012) aims to integrate innovation and entrepreneurship training into mainstream education at all levels through initiatives such as more practice-based instruction. Since 2011, Belgium (Wallonia) has implemented the Creative Wallonia action plan to foster creativity both within and beyond formal education. The scheme uses instruments such as teacher training and encouraging higher education institutions to teach skills linked to creativity and innovation. As part of a five-year plan

Figure 8.1. **Adult population by level of proficiency in problem solving in technology-rich environments, 2012**

As a percentage of 16-65 year-olds



Note: Problem solving in technology-rich environments requires "computer literacy" skills (i.e. the capacity to use ICT tools and applications) and the cognitive skills required to solve problems. The OECD Survey of Adult Skills as part of the OECD Programme for the International Assessment of Adult Competencies (PIAAC) assesses the proficiency of adults aged 16-65 in literacy, numeracy and problem solving in technology-rich environments. It collects in particular a range of information on the use of information and communication technologies at work and in everyday life, and on a range of generic skills, such as collaborating with others and organising one's time.

Source: Based on OECD (2013), *OECD Skills Outlook 2013: First Results from the Survey of Adult Skills*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/9789264204256-en*.

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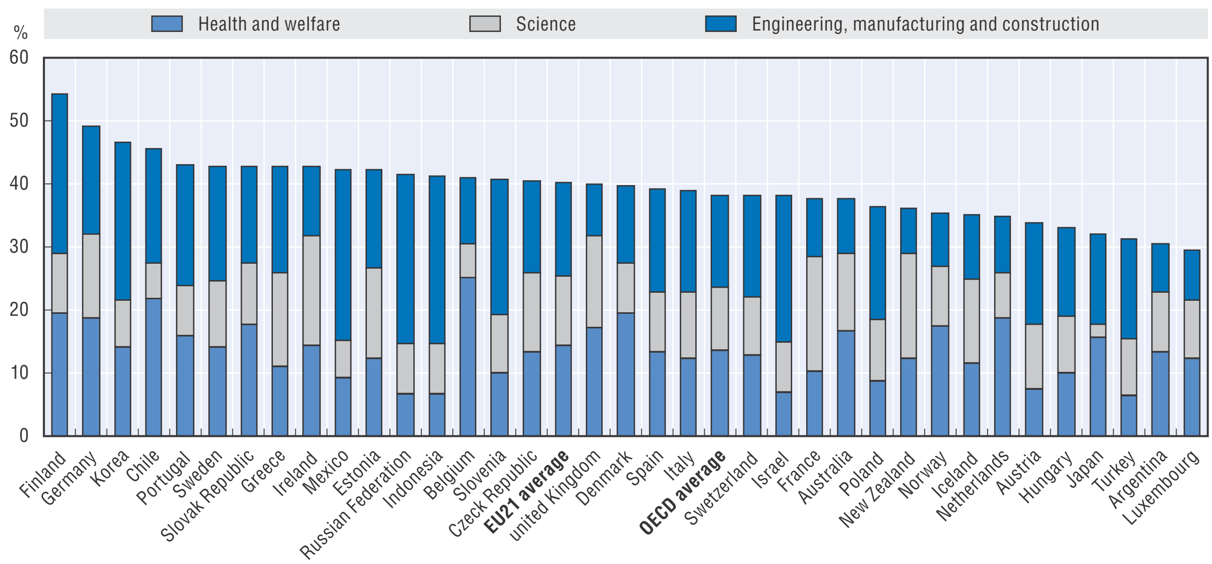
launched in 2013, Korea aims to encourage more problem-solving and practice-oriented instruction in primary and secondary education. In Costa Rica, the Innovating at Home programme teaches parents to develop their children's creativity from an early age.

Fostering students' entrepreneurial skills is one way to increase innovative entrepreneurship. Policy measures can take the form of dedicated entrepreneurship education or efforts to include entrepreneurial skills in curricula and school subjects. The

Figure 8.2. **Percentage of entrants to tertiary education in engineering, science and health fields, 2012**



Notes: Entrants as a percentage of all tertiary-type A, tertiary-type B and advanced research programme entrants according to the International Classification of Education (ISCED 1997). Tertiary-type A programmes (ISCED 5A) are largely theory-based and are designed to provide qualifications for entry to advanced research programmes and professions with high skill requirements, such as medicine, dentistry or architecture. They have a minimum cumulative theoretical duration of three years' full-time equivalent, although they typically last four or more years. Tertiary-type B programmes (ISCED 5B) are typically shorter and focus on practical, technical or occupational skills for direct entry into the labour market. Advanced Research Qualifications (ISCED 6) refer to tertiary programmes that lead directly to the award of an advanced research qualification, e.g. Ph.D. The theoretical duration of these programmes is three years full-time in most countries, although the actual enrolment time is typically longer. The programmes are devoted to advanced study and original research.

Data for Australia, France and Italy exclude tertiary-type B programmes, while data for Belgium, Ireland, the Netherlands, Poland, the Russian Federation and Spain exclude advanced research programmes. Data for Argentina refer to 2011.

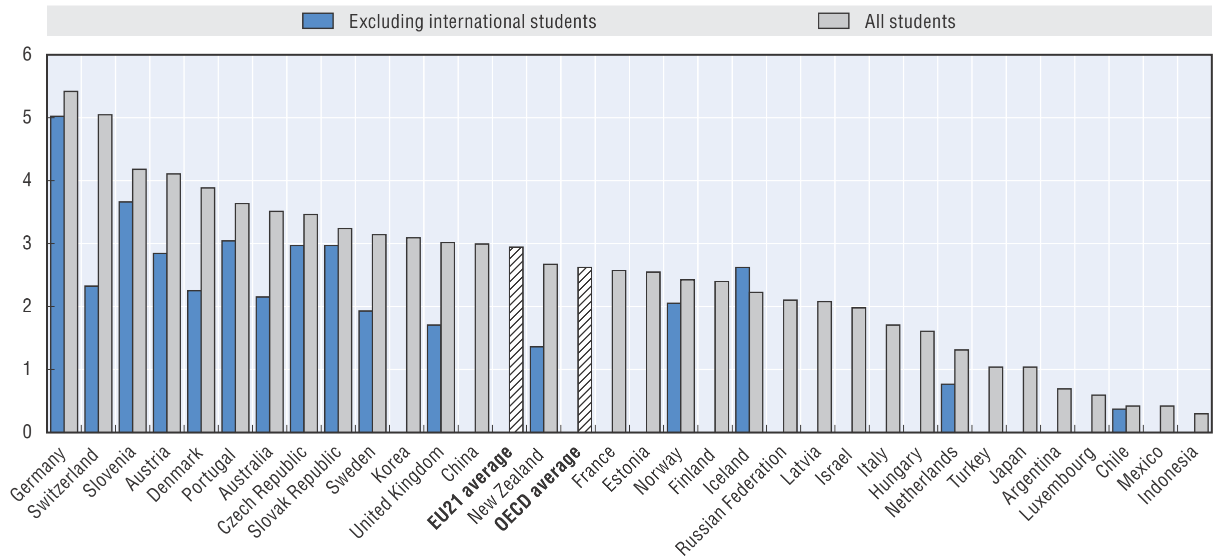
Source: OECD (2014), *Education at a Glance 2014: OECD Indicators*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/eag-2014-en*; UNESCO Institute for Statistics (UIS), *Education Database*, May 2014, *http://data.uis.unesco.org/Index.aspx?DataSetCode=EDULIT_DS* for Argentina, China, Colombia, India, Indonesia and South Africa; Eurostat, *Education and Training (ETR) Databases*, June 2014, *http://epp.eurostat.ec.europa.eu/portal/page/portal/education/data/database* for Latvia.

StatLink http://dx.doi.org/10.1787/888933151941

Action Plan for Entrepreneurship in Education in Norway (2009-14) aims to strengthen skills such as creativity and innovative thinking through their integration in curricula at all levels of education. Similarly, Portugal's National Strategy for Industrial Development for Growth (2014) and the 2013 Spanish Law on support to entrepreneurship and its internationalisation aim to foster entrepreneurial competencies through changes to school curricula. Entrepreneurship is now a mandatory component of primary and secondary school curricula in Sweden and Finland. Since 2012 higher education students in Poland must study an entrepreneurship component, while entrepreneurship has become a part of the training of higher education teaching staff in Estonia. Mexico has reoriented higher education programmes in order to foster entrepreneurial skills and an entrepreneurial culture. A number of countries have implemented training, public information and communication, or mentoring initiatives to promote innovation and entrepreneurship.

Introducing technology into the classroom is another popular policy measure that is seen as a means of facilitating the acquisition of new skills, as well as a way to foster students' interest in topics such as computer programming. Norway's Virtual School Mathematics programme offers secondary school pupils in need of greater challenges an

Figure 8.3. **Net entry rates into advanced research programmes, 2012**



Notes: Net entry rates are sum of age-specific entry rates. Advanced Research programmes lead directly to the award of an advanced research qualification, e.g. Ph.D. The theoretical duration of these programmes is three years full-time in most countries, although the actual enrolment time is typically longer. The programmes are devoted to advanced study and original research.
Data for Argentina refer to 2011.
Source: OECD (2014), *Education at a Glance 2014: OECD Indicators*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/eag-2014-en*; UIS, *Education Database*, May 2014, *http://data.uis.unesco.org/Index.aspx?DataSetCode=EDULIT_DS* for Argentina, China, Indonesia and South Africa; Eurostat, *Education and Training (ETR) Databases*, June 2014, *http://epp.eurostat.ec.europa.eu/portal/page/portal/education/data/database* for Latvia.
StatLink http://dx.doi.org/10.1787/888933151959

online teaching programme with virtual classrooms; this also allows teachers to give more attention to students who require extra support. The United Kingdom has introduced a new computing curriculum, which places more weight on the principles and practice of computer science and covers digital literacy and ICTs. Ireland has launched an ICT strategy for schools in order to help develop an e-learning culture.

Increasing the number of students in STEM subjects at all levels of education is seen as a way to increase the pool of individuals able to enter research occupations or undertake innovation. For example, as part of the Five-Year Strategic Plan for Federal STEM Education (2013), the United States aims to increase the number of graduates in STEM fields by one-third, or one million, over the next decade. Belgium, Latvia and South Africa all have national plans to boost STEM participation at the tertiary or secondary levels, and other countries also have such policies. Since 2013, New Zealand has sought to increase the number of graduates in engineering, in line with the needs of the labour market.

Policy measures to boost participation in STEM disciplines include the funding of new places in tertiary education, and better information and promotion campaigns to inform young people about career opportunities in science and technology or as researchers. The STEM Ambassadors programme in the United Kingdom has created a nationwide network of volunteers in scientific and technological occupations who work with schools across the country to increase interest in STEM subjects. Finland established a national working group on science in 2013, one of the aims of which is to boost interest in science among young people. In addition, many countries have measures to increase STEM participation among under-represented groups, particularly women.

Efforts to boost participation and interest in STEM subjects may have limited benefits in the absence of high-quality and motivating teaching in schools. Policies to improve the quality of STEM teaching, such as raising the skills of teachers or reforming the curriculum, are therefore important complementary initiatives. Japan has used the Super Science High School programme to reform the national school curriculum in science and mathematics education and to explore innovative teaching methods. Australia, Austria, Greece, Ireland, Norway, Slovenia, the United Kingdom and the United States are all undertaking or are exploring policy initiatives to improve STEM teaching. Initiatives to attract top STEM graduates into teaching, particularly in low-performing schools, are another policy option.

There are several examples of national efforts to expand and reform doctoral programmes. The Australian Research Training Scheme, which has been operating for ten years, supports research training for students who undertake research master's and doctoral degrees. It has a budget of USD 600 million PPP for 2013-14. The National Development Plan in South Africa includes a provision to increase the number of doctorates per million population from 34 in 2012 to 100 in 2030. Austria, the Czech Republic, Germany, Finland, Ireland and Mexico have recently reformed postgraduate education. Australia, Canada and the Czech Republic have policies explicitly aimed at attracting high-quality postgraduate students from abroad. To increase the mobility of doctoral students, Belgium has the "Doctoris" programme and France the "Industrial agreements for training through research" (CIFRE) programme. While the primary aim of such policies is typically to improve the link between research conducted in universities and in the private sector, they also help develop a wider set of competencies among doctoral students.

The ability to work across disciplines has become recognised as an important skill for innovation, especially as concepts such as "design thinking" have become more popular in tertiary education. At the doctoral level some countries specifically assist multidisciplinary doctoral programmes. Japan's Programme for Leading Graduate Schools offers financial support for multidisciplinary PhD degree programmes that train graduate students to be creative global leaders through multidisciplinary coursework, laboratory rotations, and internships, in addition to the standard PhD thesis. The South African Young Summer Schools Programme offers doctoral students a three-month training programme in systems analysis (multidisciplinary thinking). In Austria, a number of universities are developing new structural programmes to supplement and broaden doctoral training, while interdisciplinary and transferable skills training are included in Finland's National Guidelines for the Development of Doctoral Training (2012).

Some OECD countries have centres of excellence that seek to strengthen postgraduate research degrees. In Japan an evaluation of the Centres of Excellence programme in 2013, which was designed to enhance education and research in graduate schools, showed that 44% of the centres selected in 2007 "mostly achieved" their objectives and 54% "fully achieved" their objectives. Similarly, Norway's mid-term evaluation in 2012-13 of the first five National Researcher Schools concluded that both the researcher schools and the scheme as a whole are achieving their aims of raising the quality of postgraduate training. In the United Kingdom, Doctoral Training Centres are being extended to new disciplines, with a critical mass of supervisors. The centres are co-funded by the universities, Research Councils and public- and private-sector partners in strategic interdisciplinary research areas in various university departments.

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Labour market policies for the highly skilled

Rationale and objectives

Labour market demand for highly skilled workers has grown rapidly as advanced economies have become increasingly knowledge-based. Given the importance of human resources for innovation, university graduates enjoy better work prospects, a higher wage premium and have more training opportunities than less educated workers (OECD, 2013a; OECD, 2014, forthcoming). They are less likely to remain unemployed, especially for a long time. They have suffered less from the global crisis (OECD, 2012a) and, unlike other categories of workers, employment for professionals and technicians, i.e. higher-skilled "non-managerial" occupations, showed signs of recovery between 2011 and 2012 (OECD, 2013a). Higher education is thus a factor in employability and lifelong learning.

Nonetheless, skills allocation in the labour market is not always optimal, as reflected in university graduates' employment rates (Figure 8.4). These are affected by the mismatch between labour supply and demand, levels of unemployment, which can be temporary or lasting, and the degree of disengagement of workers from the labour force. While university graduates enjoy close to full employment in Iceland, Norway or Sweden, their employment rates are substantially lower in Greece and Turkey. Employment rates also show that females are underrepresented in skilled employment, although they often account for a higher share of tertiary studies. This is a common issue in all countries; the gender gap is particularly striking in Japan, Korea and Turkey. In addition they are more likely to work part-time (OECD, 2014, forthcoming). The unbalanced participation of minorities in scientific and technological (S&T) occupations has also been widely documented (NSB, 2014) (see also the policy profile on "Innovation for social challenges").

While many countries are concerned by potential skills shortages in science and engineering, there is conflicting evidence from firms on the extent of "shortages" or of "overqualified" graduates in jobs that require lower level of expertise. Recent international survey data show for instance that between 10% and 40% of OECD doctorate holders do not work in research and many are in jobs unrelated to their doctoral degree, especially after a few years of their working life (Auriol et al., 2013).

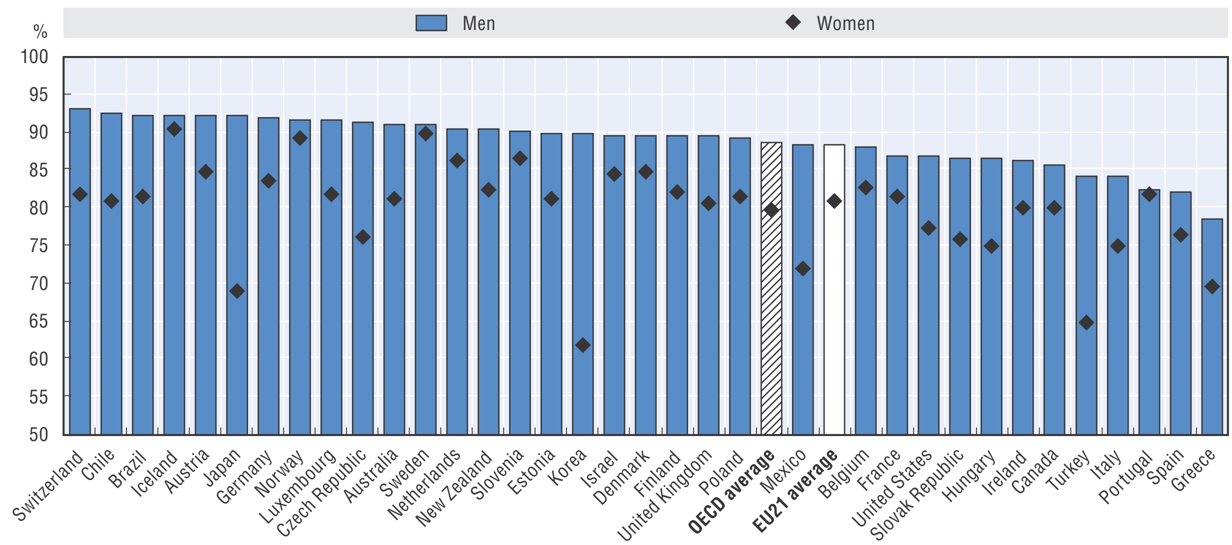
The under-employment or mis-employment of the highly skilled, whether women or minorities or not, raises several issues related to the loss of competences for the market, the risk of skills erosion in the long run, and low return on public and private investments on education.

While education policies affect education systems and mainly support the supply of skills for innovation (see the policy profile on "Strengthening education and skills for innovation"), labour policies aim to raise the level of knowledge and skills effectively used by the labour force. Labour and employment policies address issues concerning both the demand for and supply of labour. Governments pull demand by supporting businesses that recruit highly skilled workers, especially the small firms that typically face difficulties for attracting skills. They can help improve the attractiveness of STI careers and steer supply by attracting foreign talent and boosting enrolment in science, technology, engineering and mathematics (STEM) studies. Labour policies encompass vocational training and mobility schemes and also ensure skills upgrading after schooling or university.

The demand for skills differs in different economies. First, the range of skills for innovation ranges from S&T capabilities to the so-called "soft skills" (e.g. management, communication, entrepreneurship). Second, the type of skills required varies widely across

Figure 8.4. **Employment rate of university graduates by gender, 2012**

Number of university graduates in employment as a % of the population of university graduates aged 25 to 64



Note: University graduates include graduates at tertiary-level A and from advanced research programmes, according to the International Standard Classification of Education (ISCED 1997). Tertiary-type A programmes (ISCED 5A) are largely theory-based and are designed to provide qualifications for entry to advanced research programmes and professions with high skill requirements, such as medicine, dentistry or architecture. They have a minimum cumulative theoretical duration of three years' full-time equivalent, although they typically last four or more years. Advanced Research Qualifications (ISCED 6) refer to tertiary programmes that lead directly to the award of an advanced research qualification, e.g. Ph.D. The theoretical duration of these programmes is three years full-time in most countries, although the actual enrolment time is typically longer. The programmes are devoted to advanced study and original research.

EU21 includes Austria, Belgium, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, the Netherlands, Poland, Portugal, the Slovak Republic, Slovenia, Spain, Sweden and the United Kingdom. Data for Chile refer to 2011.

Source: OECD (2014), *Education at a Glance 2014: OECD Indicators*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/eag-2014-en*; UNESCO Institute for Statistics (UIS), *Education Database*, May 2014, *http://data.uis.unesco.org/Index.aspx?DataSetCode=EDULIT_DS* for Argentina, China, Colombia, India, Indonesia and South Africa; Eurostat, *Education and Training (ETR) Databases*, June 2014, *http://epp.eurostat.ec.europa.eu/portal/page/portal/education/data/database* for Latvia.

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industries and firm size (Toner, 2009). Third, the optimal mix of skills is not static and varies over time. In some countries, moderately skilled jobs (as defined by wages) have declined owing to computerisation or the offshoring of routine and repetitive tasks, but growth employment has been strong in professions that require more abstract, cognitive skills (OECD, 2010a). Governments have a role to play in monitoring potential skills shortages and helping labour markets and the skills-formation system align objectives and capacities.

Major aspects

Demand-side employment policies help to reduce the costs for firms of hiring highly skilled workers (e.g. tax incentives for R&D expenditure, including wages, or payroll withholding tax for the highly skilled) (see the policy profile on "Tax incentives for R&D and innovation"). They may also cover the recruitment of young researchers (e.g. industrial PhD grants, postdoc fellowships). Other initiatives promote innovation in workplaces (e.g. adoption of new technologies and working methods) to help employers make the most of available skills.

Academia and public administration are major destinations of the highly skilled. The creation of research chairs in academia or high-level positions in public administration help steer demand for talent and support public-sector research and innovation processes, while generating good career opportunities.

Table 8.1. **Typology of labour policies for the highly skilled and some country examples**

Key policy features		Key policy instruments	Some country examples
Demand-pull	**Targeting firms***	Tax incentives (e.g. tax relief on social contributions for researchers and new hired PhD holders), industrial PhD programmes, workplace development projects, learning networks.	Belgium (tax credit for R&D wages), Canada (Industrial Research Assistance Program), Spain (tax credit for R&D wages and payroll witholding tax deduction)
	Targeting academia and public administration	Job creation (e.g through the establishment of new academic chairs or special positions at universities), new Centres of Excellence.	Colombia (Labor Placement programme), Mexico (CONACYT's Chairs Initiative), South Africa (South African Research Chairs Initiative)
Supply-push	**Improving training and life-long learning opportunities**	Financial support (e.g. scholarship, freeze tuition fees), development of national qualifications framework, etc.	The Netherlands (Reform of training programmes at secondary vocational education institutes), Turkey (Turkish Qualifications Framework), UK (Higher Apprenticeship scheme)
	Encouraging mobility (sectoral and/or international)	Regulatory reforms to allow pension portability, research grants portability, etc.; creation of job positions in secondment / fiscal incentives for the recruitment of secondees, development of national qualifications framework, etc. Reform of immigration laws, reform of universities and public employment law, fiscal incentives, mobility support services (e.g. housing).	Colombia (Highly Recognized Diaspora Program), Germany (Qualified Professional Initiative), Poland (Mobility Plus), South Africa (Exceptional Skills Work Permit), Spain (Entrepreneur Act)
	Targeting researchers*	Financial incentives (e.g. tax incentives on personal income, new scholarships, etc.), improved working and research conditions (e.g. administrative and/or research support, research facilities/labs, research autonomy/freedom, etc.), work-family balance (e.g. parental leave, part-time arrangements, etc.), reform of public employment law (e.g. tenure track, recuitment and promotion systems).	Australia (Discovery Early Career Researcher Award, Future Fellowships), Austria (Collective agreements between university representatives and the union of public employees), Denmark (personal income tax exemption for highly skilled), New Zealand (Rutherford Discovery Fellowships)
	Targeting inactive/ underrepresented population (e.g. women, minorities etc.)	Targeted measures to reduce gender/minorities gap, e.g. aiming to increase their presence and visibility in doctoral studies, academia or research councils (e.g. senior positions, role models, mentorship, peer reviews panels), networking programmes, financial incentives (e.g. special awards, fellowships) etc.	Austria (Talente programme), Norway (Gender Balance in Senior Positions and Research Management - BALANSE), Slovenia (National Committee for Women in Science)
Matching demand and supply	**Monitoring and forecasting gaps**	Data collection and surveys on current and forecasted market needs and education enrolment and graduation trends.	France (Regular public reports on scientific employment, since 2006), New Zealand (Project for the collection of career prospects information, 2013), United Kingdom (Commission for Employment and Skills)
	Information system and skills frameworks (connecting labour markets and skills-formation system)	Information plaftorms on job opportunities, provision of guidance to job seekers/ firms, development of national qualifications framework, recognition of informal and on-the-job learning in national qualifications frameworks etc.	Japan (JREC-IN), Italy (Professions, employment and needs website), EU (EURAXESS portal)
	Skills policy governance	Joint participation in the design of skills policy agenda, and the implementation of STI policy (e.g. business participation in universities' boards).	UK Employer Ownership Initiative

* See also the policy profiles on "Strengthening education and skills for innovation", "Public research missions and orientation", "Commercialisation of public research results" and "Tax incentives for R&D and innovation".

Source: Based on country responses to the OECD STI Outlook policy questionnaire 2014.

Other employment policies aim to develop and upgrade the supply of skills. Acquisition of skills is an on-going process; it does not end with formal education (OECD, 2010a). Various financial instruments (e.g. frozen tuition fees, scholarships) or working arrangements (e.g. sabbaticals) promote adult education and on-the-job training. Some incentives are directed to firms (e.g. regulations and taxation for professional training).

Mobility during one's career also provides learning opportunities. Measures to encourage intersectoral mobility aim to reduce regulatory barriers between institutions (e.g. portability of pensions or research grants) and to create opportunities for interaction between industry and science (see the policy profiles on "Public research missions and orientation" and "Commercialisation of public research results"). Policy initiatives to encourage international mobility include changes in laws on immigration or public employment (e.g. at universities), simplification of residence and work permit procedures, financial incentives to attract foreign or national highly skilled workers from abroad (e.g. stipends, tax incentives for highly skilled foreign workers, social security net), or provision of mobility services and networking facilities (e.g. one-stop shop, website, housing assistance).

Labour policies for innovation target researchers in particular. They aim to improve the attractiveness of research careers by increasing remuneration (e.g. new research funding, premiums on research output, including publications, academic spin-offs, teaching), improving employment conditions (e.g. reforms of recruitment and promotion systems, tenure career paths, work-family balance arrangements including parental leave and part-time work), and improving research conditions (e.g. increased autonomy for research, support staff, world-class research facilities). Targeted measures may support researchers at different stages of their careers.

Women and minorities are an untapped or underexploited talent pool that has attracted particular policy attention. There are initiatives to enhance their presence and visibility in senior positions (e.g. appointment to executive boards or peer-review panels) or to serve as role models in schools and higher education institutions. Financial incentives (e.g. targeted awards or research grants) encourage them to pursue S&T careers and conduct research. Targeted research grants can also help offset the obstacles they may encounter in obtaining research funding through general competitive processes.

Matching demand for and supply of skills requires maintaining an information system to monitor changes in labour demand and education capacities (e.g. firm surveys, forecasting analysis), providing job seekers and firms with platforms to meet, and establishing a skills or qualification framework to support recruitment and enable mobility and lifelong learning (e.g. recognition of informal learning). Co-ordination exercises between government, the business sector and education providers are essential, as is the participation of business-sector representatives in the design of the skills policy agenda (e.g. consultative processes), and the delivery of skills policy (e.g. executive boards at institutional level).

Recent policy trends

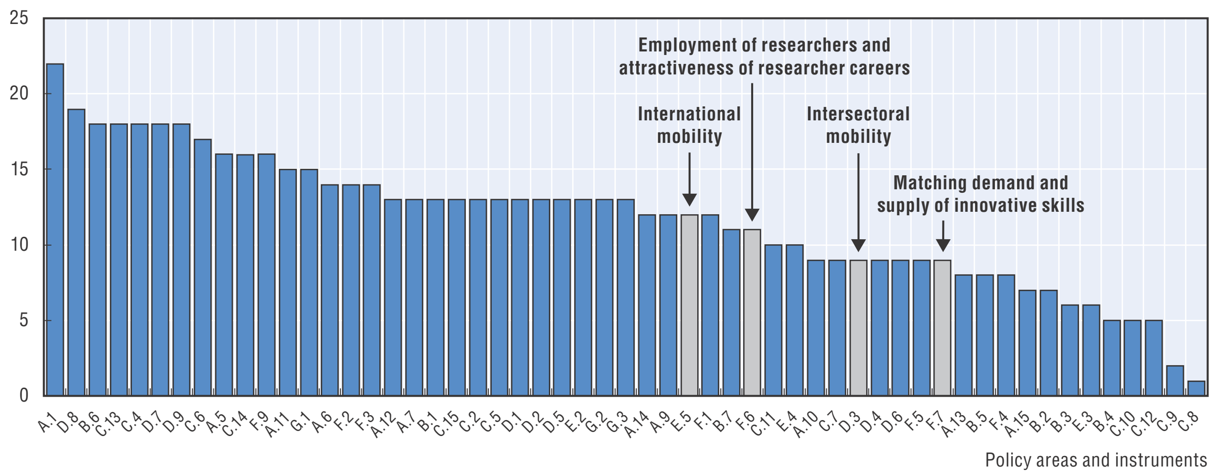
The OECD Innovation Strategy pointed to the need to empower people to innovate as an issue deserving consideration (OECD, 2010b). A number of OECD countries and emerging economies identified in their responses to the OECD STI Outlook policy questionnaire 2014 the strengthening of skills for innovation as one of their major national innovation policy priorities (see the policy profile on "National strategies for science, technology and industry").

Labour policies for the highly skilled have changed less than other STI policy areas in recent years (Figure 8.5). Policy attention has focused on improving researchers' career prospects, especially for junior researchers and women, attracting new talent from abroad, and building national frameworks and information systems to help better match demand for and supply of skills.

Improving the attractiveness of S&T careers is high on STI policy agendas both in OECD and non-member countries. Governments aim to strengthen job opportunities, especially in science and for young researchers and women.

Figure 8.5. **Labour policy initiatives for the highly skilled among other areas of STI policy change, 2012-14**

Countries reporting a substantial change in the policy area, compared with other STI policy areas



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 2014 questionnaire). The y-axis shows the number of countries reporting that the situation has substantially changed in each policy area. Simple counts do not account for the magnitude and impact of policy changes. Responses are provided by Delegates to the OECD Committee for Scientific and Technological Policy.

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

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New R&D jobs will be created in Belgium, France and Japan. Belgium (federal government) has increased public support for business R&D by raising the tax concession on payroll withholding for R&D wages to 80% (formerly 75%) as of 2013 and by fence-ringing the related tax budget against future budget cuts. France has planned to create 1 000 jobs in higher-education and public-sector research between 2012 and 2016, in a context of overall public employment decline. Japan's New Growth Strategy (2009-20) aims to create over 4 million new jobs in life innovation and green innovation to provide young researchers with career prospects and ensure full employment of S&T doctorate holders.

Many recent policy initiatives have targeted young researchers by providing them with better terms of remuneration, new research funding, and new research and job opportunities in industry.

- Estonia introduced a new research career model for PhD students in 2012 that extends social security coverage and increases remuneration in order to reduce dropouts during doctoral studies.

- Italy established the Scientific Independence of Young Researchers programme in 2014 to fund research projects of young researchers. The CONACYT Chairs Initiative (2013) aims to create new positions for young researchers in Mexico on a competitive basis. Russia's Federal Targeted Programme allocates new resources over 2014-16 to support researcher mobility, strengthen career development opportunities for recent PhD graduates and encourage researcher training abroad. Slovenia issued a public call in 2013 for research projects carried out by postdoctoral researchers in public research institutes and co-financed by industry in areas of strategic importance.
- Under its Economic Action Plan 2014 Canada plans to expand the Mitacs Elevate programme, which currently provides postdoctoral fellows with industry-relevant research experience and training. Support will be provided for up to 3 000 new full-time internships for post-secondary graduates in fields of high demand over 2014-16. Korea has initiatives to reduce the gap between supply of and demand for young scientists and engineers in small and medium-sized enterprises. Measures include improving the industrial working environment, establishing a one-stop information network for jobs, encouraging pre-employment while studying, and attracting engineers from abroad.

Women's participation in science remains an area of STI policy attention. The Initiative on Gender Balance in Senior Positions and Research Management (BALANSE) (2013-17) seeks to promote gender balance at the senior level in Norwegian research by financing female researchers' projects and supporting research on gender issues. France has been implementing a series of actions to improve the number and visibility of women in science over the past years and in 2013 signed an agreement with four women's associations to promote gender balance in scientific professions. Korea includes gender issues among the orientations of its 3rd S&T Basic Plan (2013-17).

Tapping into the global talent pool to enrich the national supply of skills has become crucial. Canada, Denmark, Germany and the United Kingdom have recently launched national strategies or action plans for the internationalisation of higher education. These include components of branding, inward and outward mobility of students and academics, and improving the learning environment (see Chapter 1 and the policy profile on "Internationalisation of public research"). Germany launched the Qualified Professional Initiative in 2012 to encourage STEM graduates with foreign academic degrees to pursue a career in Germany. The Czech Republic's NAVRAT-Return programme (2012-19) aims to reverse a situation of brain drain by re-integrating outstanding national scientists working abroad.

Efforts have been made to build knowledge around future skills needs and to strengthen institutional capacity to monitor skills shortages:

- New Zealand commissioned a project to assess ten-year career prospects in key occupations in order to inform students and education providers. Norway developed two forecasting models (one for the supply side and one for the demand side) to identify future skills needs. Korea conducted a National Forecasting for S&T Workforce (2013-22) and Ireland implemented in collaboration with industry the 2012 ICT Action Plan to increase the supply of high-level graduates in information and communication technology.
- The Colombian Intersectoral Commission for Human Resources Management has been established to identify potential skills imbalances.

The governance of skills policy has also undergone changes, with new evaluation exercises, new strategic policy setting, and improved co-ordination of various public and private stakeholders.

- New Zealand has conducted a stocktaking of post-PhD opportunities and post-doctoral positions to assess the efficiency of current policy settings.
- Turkey adopted a new National Qualifications Framework in 2014. National qualifications frameworks are also being prepared in Colombia and Finland. In 2014-15 the Dutch Qualifications Framework will be simplified and made more transparent to meet private demand better and be more useful for vocational training institutes.
- Several initiatives are under way in the United Kingdom, with a focus on strengthening vocational education and training. A 2013 UK publication, *Rigour and Responsiveness in Skills*, sets out the government's vision of human resources and skills development policies and proposes a roadmap for reform, including of the vocational education system. The Higher Apprenticeship Scheme is being expanded to offer a new work-based route to high-level professions in industry that were traditionally restricted to graduates. The Employer Ownership initiative involves employers in the formulation of the skills policy agenda and enables them to deliver solutions for training their own workforce.

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BUILDING A SCIENCE AND INNOVATION CULTURE

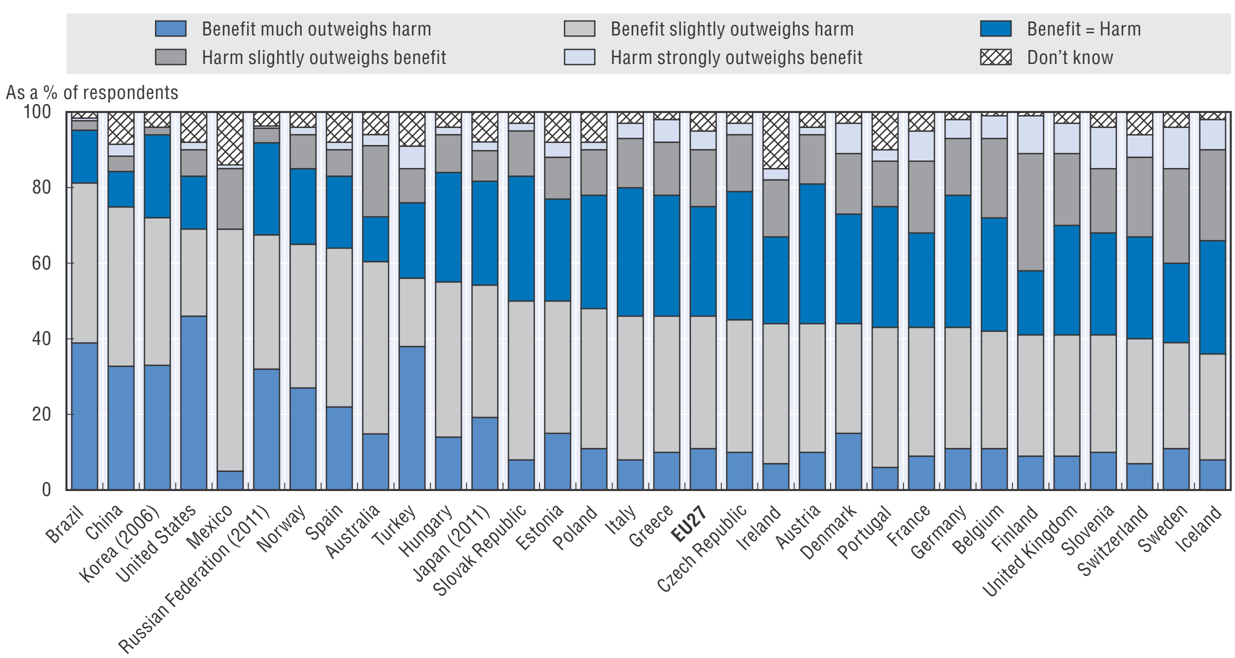
Rationale and objectives

Innovation requires developing and mobilising a broad range of skills throughout workplaces and society (Hanel, 2007; OECD, 2010; Toner, 2011). Skills for innovation span a wide range of personal attributes, including relevant subject knowledge (from theoretical to practical expertise and know-how), creative thinking (such as analytical and critical capabilities), and behavioural and social traits (e.g. self-confidence, risk taking, leadership, teamwork, attitudes towards change). Innovation can be influenced by the social and cultural values, norms and behaviours that can create an "innovation culture", in which public perceptions of science, technology and entrepreneurship play a very important role.

While the importance of innovation for sustaining economic growth and driving improvements in living standards is generally acknowledged, there is also widespread evidence of significant attitudinal and knowledge "gaps". Public perception surveys in a large number of countries indicate that, although most people have a positive view of the impact of science and technology (S&T) on their personal well-being, a significant proportion have mixed or negative opinions about the effects of scientific research (Figure 8.6) (OECD, 2013a). It can be difficult to make survey results internationally comparable (Bauer, 2012) but they do

Figure 8.6. **Public perception of scientific research benefits, 2010**

Responses to the question: "Have the benefits of scientific research outweighed the harmful results?"



Note: International comparability may be limited. Results are based on surveys conducted by means of face-to-face interviews. For Japan, Korea, the Russian Federation and the United States, respondents were invited to choose among the following options: "Benefits are much greater than harm, Benefits are slightly greater than harm, Benefits and harm are about equal, Harm is slightly greater than benefits, Harm is much greater than benefits, and Don't know". For Brazil, respondents were asked to choose among the following options: "Only benefits, More benefits than harm, Both benefit and harm, More harm than benefits, Only harm, and Don't know". For Australia, EU countries and China, the question invited respondents to express their (dis)agreement with the statement, "The benefits of science are greater than any harmful effects it may have", by choosing among the following: "Totally agree, Tend to agree, Neither agree nor disagree, Tend to disagree, Totally disagree, Don't know". In Mexico, respondents were asked to choose among: 'Strongly agree, Agree, Disagree, Strongly disagree and Don't know".
For Japan and the Russian Federation, data refer to 2011. For Korea, data refer to 2006.
Source: OECD, based on OECD (2013), *OECD Science, Technology and Industry Scoreboard 2013: Innovation for Growth*, OECD Publishing, Paris, *http://dx.doi.org/ 10.1787/sti_scoreboard-2013-en*, and on EU and national sources.

StatLink http://dx.doi.org/10.1787/888933151983

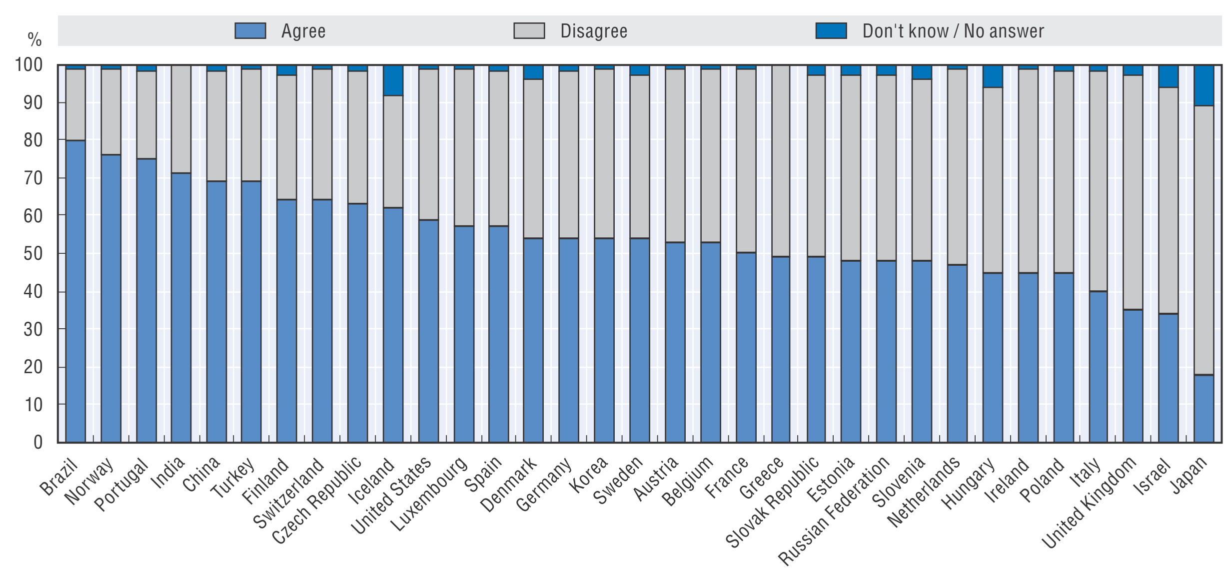
point to significant differences across regions. From the perspective of the adoption of new goods and services, a European poll found that nearly half of the EU25 population was significantly hostile to new innovations or very reluctant to try new products or services or pay a premium for them (European Commission, 2005).

There is significant policy interest in the attitude towards innovation of individuals in different age groups. More recent youth cohorts have shown less interest in science and innovation than was hoped for, and governments are concerned about how to motivate individuals to pursue science and innovation careers. The ageing of the population and labour force in most OECD countries also means that individuals in the middle of their careers and later need to deal with the challenges and opportunities created by technology developments and innovations. Governments can play a role in unleashing talent, fostering vocations, providing youth with the skills to participate in rapidly changing knowledge-based economies, and allowing the elderly to adopt solutions that can help them remain active and independent.

Policy makers will need to identify and monitor systematically skills and attitudes of relevance to science and innovation in order to improve them. Individual and collective attitudes are complex and constantly evolving phenomena, although some changes only occur over generations. At the same time, some social and environmental challenges require more immediate action in terms of consumption behaviour and social habits, for instance (see Chapter 1). Efforts to promote a science and innovation culture can be undermined not only by high-profile incidents and crises of confidence (e.g. Fukushima), but also by a less apparent erosion of trust in the decision-making process and in its use of science and evidence. This has triggered some serious rethinking about the impacts of S&T on the economy and society and a reassessment of the appropriate policy responses.

Figure 8.7. **School helped to develop a sense of initiative and a sort of entrepreneurial attitude, 2012**

Percentage of respondents, by degree of agreement with the proposed statement



Note: Results are based on sample surveys conducted by means of phone interviews. The survey was co-ordinated by the European Commission (EC), Directorate-General Enterprise and Industry, between 15 June and 8 August 2012 and targeted the population aged 15 years and over. The statement presented to respondents was: "My school education is helping me/has helped me to develop my sense of initiative and a sort of entrepreneurial attitude". Respondents indicate whether they totally agree, tend to agree, disagree or totally disagree.

Source: OECD (2013), *Entrepreneurship at a Glance*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/888932829438*, based on EC (2012), *Entrepreneurship in the EU and Beyond*, Flashbarometer No. 354, June 2012, Brussels, *http://ec.europa.eu/public_opinion/flash/fl_354_en.pdf*.

StatLink *http://dx.doi.org/10.1787/888933151996*

Major aspects

Policy measures directed to civil society, schools, universities and workplaces have sought to develop a science and innovation culture in view of the fact that innovation is science-, business-, practitioner- and user-driven (Vincent-Lancrin, 2012) and pervades many spheres of human activity (Table 8.2).

Such policy measures seek to improve public access to information on the future of science, technology and innovation and to promote society's participation in policy design. The OECD Declaration on Future Policies for Science and Technology underscored the importance of raising awareness of S&T and recommended public participation in the definition of major technological orientations (OECD, 1981).

Other policy measures aim to raise awareness of and interest in S&T, especially among youth. Traditionally this has meant broad dissemination of scientific information, via the mass media, promotion of science events and other initiatives and support for the activities

Table 8.2. **Typology of policy measures for enhancing a science and innovation culture**

Spheres	Main target populations	Key policy instruments	Some country examples
Civil society	**Adult population and citizens**	Public dialogue (awareness workshops, conferences, standards)	France's Observatory of Biology
		Participation to STI policy design (public consultation)	Finland's national stakeholder confrerie, Great New Zealand Science Project
	Youth	Science communication (science centre/museum, science weeks/fairs/years/exhibitions), science media (TV, radio, broadcasts, website and social medias), outreach programme by scientists)	Australia Questacon, Canada Science.gc.ca, Chile VA!, Korea Science Festival and Idea Festival, Start-up Expo and Start-up Fair, Germany BIOTechnikum truck,
Classrooms and education systems	**Students at all educational levels**	Awards/prizes and competitions in science and innovation	China innovation and entrepreneurship race, New Zealand's Future Scientist prize, Slovak Republic's Innovative Deed of the Year (design)
		Formal education initiatives (lecture courses, new curricula)*	Danish Foundation for Entrepreneurship-Young Enterprise, Norway's Action Plan for Entrepreneurship in Education, Sweden's compulsory teaching of entrepreneurship
		New pedagogical practices and networking activities (hands-on exercises, experiment labs, participatory learning, role models and mentorship)*	Austria Young Science, Germany Little Scientists' House, Norway's IPRs educational scheme, Slovak Republic Scientific Patisserie
	Teachers	Capacity building for teaching, including the design of innovative teaching methods and materials	Austria's new teaching methods, Ireland's Project Maths
		Training opportunities, awareness conferences and workshops, financial incentives	Estonia's Training of academic teachers on entrepreneurship, New Zealand's fellowships for S&T teachers, Young Enterprise Norway
Workplaces	**Academia (researchers, doctorate students and postdocs)**	Training opportunities (e.g. IPRs, start ups etc.), awareness conferences and workshops	Technology Transfer Offices in many countries
		Support for commercialisation of public research results and industry-science linkages (remuneration schemes, performance criteria and promotion, industrial PhD)*	Innova Chile CORFO, Germany's VIP and EXIST grants, New Zealand's Callaghan Innovation's R&D Student Grants
	Firms	Support to industry-science linkages, and technical assistance to firms (innovation vouchers, experts detachment, industrial PhDs, extension programmes)*	Technology Transfer Offices in many countries, Colombia's pilot program for training and advice in innovation management
		Training opportunities, seminars and information workshops and support, visibility	Costa Rica's CATI (IPRs) and National Portal of Innovation, New Zealand's Entrepreneurship Development Programme, South Africa's Science awareness awards, United Kingdom's Business Link

* See also the policy profiles on "Strengthening education and skills for innovation", "Start-ups and innovative entrepreneurship", "Commercialisation of public research results", and "Financing business R&D and innovation".

Source: Based on country responses to the STI Outlook policy questionnaire 2014.

of science museums. The development and use of information and communication technologies (ICTs), the increasing access to digital infrastructures and the Internet, and greater interactive online communication – e.g. social media – have helped engage the public but have also reduced reliance on traditional sources. For example, it is common for individuals to consult health or technical information on Internet sites, the quality of which may vary. Some initiatives focus on specific fields: Germany's BIOTechnikum double-decker truck travels around the country to spread information on biotechnology and related career prospects; the Slovak Republic has an annual "Innovative Deed of the Year" competition to select the best young designer; Germany has competition on solar-energy-driven model cars.

Promotion of science and innovation among youth largely takes place in classrooms. However, the evidence suggests that individuals in many countries think that schools do not make a substantial contribution to promoting entrepreneurial competencies and attitudes (Figure 8.7). Major reforms of education systems seek to add new disciplines and new learning practices to curricula. They have concerned all levels of education, from primary schools to higher education institutions and have required building capacity in teaching and infrastructure (see the policy profile on "Strengthening education and skills for innovation" and on "Start-ups and innovative entrepreneurship").

Policy initiatives to build a science and innovation culture also target workplaces. They encourage a new research and innovation culture to help universities fulfil their "third" mission of transferring and co-creating relevant knowledge with the rest of society. Training, information workshops and revised remuneration and promotion frameworks seek to raise awareness of intellectual property rights (IPRs) and interest in the commercialisation of public research results in the research community. Researchers, especially early in their careers, are helped to launch start-ups (see the policy profile on "Commercialisation of public research results"). Firms receive technical assistance through financial and non-financial channels such as innovation vouchers, extension programmes and seconding of experts.

Recent policy trends

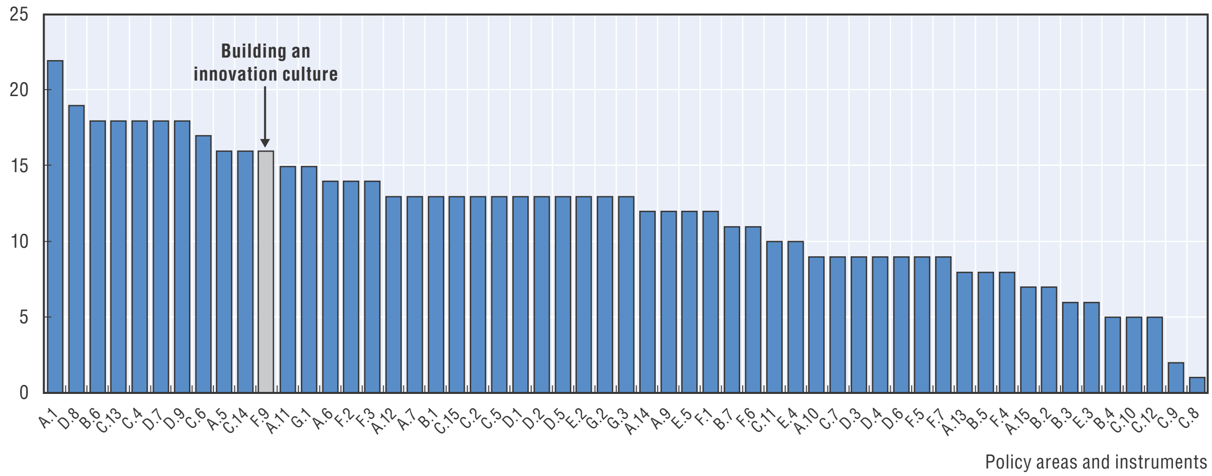
In recent years, policy efforts aimed at strengthening a science and innovation culture have also attempted to go beyond science and technology, narrowly defined, to reflect the broader and changing nature of innovation. Policy initiatives similar to those previously implemented to nurture a scientific culture now aim to nurture an entrepreneurial spirit and broader forms of creativity and to promote the exploitation of links between them.

Recently, several countries have implemented new policy initiatives to build a science and innovation culture (Figure 8.8). Among the countries reporting new policy initiatives, this has been one of the most active policy areas in the overall policy mix for innovation and the most active on for human resources and education related policies. Most of these initiatives are large public events (e.g. Australia's national science week, Greece's research night, Korea Science Festival, Start-up Expo and Start-up Fair), promotion campaigns (e.g. Chile's Year of Innovation and Imagine Chile initiative), competitions or awards (e.g. Australia's Innovation Challenge, Canada's new awards for entrepreneurial culture, China's innovation and entrepreneurship race, Costa Rica's Innovation Champions publication, Turkey's Entrepreneurship Competitions).

Several countries have included developing a science and innovation culture in their strategic STI agenda (see the policy profile on "National strategies for STI"). In middle-income economies such as Colombia, Chile and Costa Rica, building an innovation culture is a key

Figure 8.8. **Initiatives to build an innovation culture among other areas of STI policy change, 2012-14**

Countries reporting a substantial change in the policy area, compared with other STI policy areas



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 2014 questionnaire). The y-axis shows the number of countries reporting that the situation has substantially changed in each policy area. Simple counts do not account for the magnitude and impact of policy changes. Responses are provided by Delegates to the OECD Committee for Scientific and Technological Policy.

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

StatLink http://dx.doi.org/10.1787/888933152000

component of their national STI strategy. Malaysia has identified this as one of its five main STI policy priorities for 2014. The same is true of more advanced economies with a traditionally high level of performance on STI indicators. Finland is broadening the scope of its Action Plan for Research and Innovation Policy (2012) to encourage experimentation and risk taking through longer-term basic research funding. The 4th Japanese S&T Basic Plan (2011-15) is based on the concept of "science in society, science for society" and promotes a wide range of S&T communication activities. Likewise, Korea has adopted a "Creative Economy" initiative to foster creativity, imagination, challenges and start-ups and has developed a new S&T culture programme.

Some countries are adapting their governance structures and building capacity in this area although it sometimes remains insufficient (European Commission, 2013). Following the USD 117 million PPP (EUR 100 million) allocated by the Investment for the Future Programme to develop projects of S&T culture, France recently established the National Council for Scientific, Technical and Industrial Culture. A comprehensive evidence-based strategy is also being prepared. In Finland a working group is examining the current state of national science education in order to formulate policy recommendations for new national curricula, learning materials, teaching methods, qualifications and training for the early childhood and pre-primary levels. The Russian Federation is devoting USD 164 million PPP (RUR 3.3 billion) over 2014-20 to finance activities to develop researchers' communication channels and popularisation of science: organisation of S&T communications events, museum creation, and creation and maintenance of Internet resources and mass medias. An additional USD 135 million PPP (RUR 2.7 billion) is granted in the form of subsidies to target youth at schools through information infrastructure, competitive incentives for science and education personnel, and traditional S&T communication channels.

The European Innovation Union has noted the need to strengthen links between universities and businesses and to create knowledge alliances that foster combining scientific, entrepreneurial and creative skills. New Zealand's Science and Society project is a joint education-science plan to increase engagement and achievement in science, technology, engineering and maths and improve the understanding, skills and adoption of S&T in society.

Austria introduced a new teacher training model for pupils in primary and secondary schools in 2013 and the Federal Framework Law created the legal foundations of its implementation.

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PART III

Assessing STI performance

PART III

Chapter 9

STI country profiles

STI country profiles reader's guide

The country profiles (CPs) in the 2014 *OECD STI Outlook* (STIO) are designed to provide a concise overview of science, technology and innovation (STI) policy and performance in OECD members and selected non-OECD economies. Each country profile is based on information gathered from the country's response to the OECD STIO policy questionnaires 2012 and 2014, as well as various additional OECD and non-OECD sources.

Headings in the country profiles are linked to the STIO policy profiles, which examine the main global STI policy trends across countries. Issues featuring in both the policy and country profiles are: *i)* innovation policy governance; *ii)* new sources of growth; *iii)* new challenges; *iv)* universities and public research; *v)* innovation in firms; *vi)* innovative entrepreneurship; *vii)* technology transfer and commercialisation; *viii)* clusters and smart specialisation; *ix)* globalisation; and *x)* skills for innovation.

The table of key figures presents indicators on the country's economic performance (labour productivity), environmental performance (green productivity and demand), the size of its R&D system as measured by gross domestic expenditure on R&D (GERD), the degree of public commitment to S&T as measured by the share of GERD that is publicly financed, and the changes in these indicators over the past five years. 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.

Panel 1 contains a double figure that sheds light on the strengths and weaknesses of the country's STI performance. It uses indicators on the country's national innovation system 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 benchmarks, and may fall out of the range indicated in the figure (e.g. below the lowest OECD country). All indicators are normalised (by GDP and population cohorts) to take account of the size of the economy and the relevant population cohorts, and are presented as indices (OECD median = 100) for benchmarking purposes.

Panel 2 shows the structural composition of business expenditure on R&D (BERD) in terms of performance of the main industry sectors, firm size and firms' national affiliation. It reflects the country's industry structure and its business innovation efforts. Panel 3 presents the country's revealed technological advantage (RTA), as measured by international patent applications filed under the Patent Cooperation Treaty (PCT) in three key technology fields (bio- and nano-technology, ICTs, and environment-related technologies). It also shows the number of patents filed by universities and public research institutions in these fields.

Panel 4 gives an overview of the country's policy mix for public R&D, i.e. the orientation and funding modes of public research. It also illustrates changes in the policy mix for R&D over the past five years. Finally, Panel 5, a new feature in STIO 2014, reflects the balance and relative importance of various government measures to support business R&D and innovation. It is based on the country's self-assessment in its reply to the OECD STIO 2014 policy questionnaire.

Further details on the methodology, data sources and descriptions of indicators used in the country profile are provided in Annex 9.A. Data, metadata as well as the original sources and databases of the indicators used in the STIO 2014 are accessible at the statistical portal IPP.Stat (cut-off date: 8 July 2014).

Abbreviations used in the country profiles

BERD: Business expenditure on research and development

EU: European Union

FDI: Foreign direct investment

GDP: Gross domestic product

GERD: Gross expenditure on research and development

HEIs: Higher education institutions

IPRs: Intellectual property rights

MNEs: Multinational enterprises

PRIs: Public research institutes

R&D: Research and development

S&E: Science and engineering

SSS: Smart specialisation strategy (also known as 3S)

STI: Science, technology and innovation

S&T: Science and technology

3S: See SSS

STEM: Science, technology, engineering and mathematics

USD: United States dollars
(converted using the purchasing power parities of the relevant year)

VC: Venture capital

Synthetic table

Table 9.1. **Comparative performance of national science and innovation systems, 2014**

Country relative position: in the top 5 OECD or above (★), in the middle range on par or above OECD median (▲), in the middle range below OECD median (∆) and in the bottom 5 OECD or below (○)

		Competences and capacity to innovate									
		Universities and public research			R&D and innovation in firms				Innovative entrepreneurship		
		Public R&D expenditure (per GDP)	Top 500 universities (per GDP)	Publications in the top-quartile journals (per GDP)	Business R&D expenditure (per GDP)	Top 500 corporate R&D investors (per GDP)	Triadic patent families (per GDP)	Trademarks (per GDP)	Venture capital (per GDP)	Young patenting firms (per GDP)	Ease of entrepreneurship index
		PUB_XGDP	UNI500_GDP	PUB25_GDP	BE_XGDP	CORPRD500_GDP	PTRIAD_GDP	TRDMRK_GDP	VC_XGDP	PTYG_GDP	EASE_I
		(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
Argentina	ARG	∆	∆	○	○	○	○	○			
Australia	AUS	▲	▲	▲	▲	∆	∆	▲	∆		▲
Austria	AUT	▲	★	▲	▲	▲	▲	∆	∆	★	▲
Belgium	BEL	∆	▲	▲	▲	∆	▲	∆	▲	∆	∆
Brazil	BRA		∆	○		∆	○	○			∆
Canada	CAN	▲	▲	▲	∆	∆	▲	★	★	○	▲
Chile	CHL	○	∆	○	○	○	○	∆			∆
China	CHN	∆	∆	○	▲	∆	∆	○			○
Colombia	COL	○	○	○	○						
Costa Rica	CRI	○	○	○	○	○					
Czech Republic	CZE	▲	∆	∆	∆	∆	∆	∆	○		∆
Denmark	DNK	★	▲	★	▲	★	▲	▲	▲		▲
Estonia	EST	▲		▲	▲	○	∆	∆	▲		▲
Finland	FIN	★	★	▲	★	★	★	▲	★	★	▲
France	FRA	▲	∆	∆	▲	▲	▲	▲	▲	∆	▲
Germany	DEU	★	▲	∆	▲	▲	★	▲	▲	★	▲
Greece	GRC	○	∆	∆	○	∆	○	○	○		∆
Hungary	HUN	○	∆	∆	∆	∆	∆	○	∆		∆
Iceland	ISL	★	○	★	▲	▲	∆	★			∆
India	IND	∆	○	○	○	○	∆	○			○
Indonesia	IDN		○	○	○		○	○			∆
Ireland	IRL	∆	▲	▲	∆	▲	▲	▲	★	○	∆
Israel	ISR	∆	★	▲	★	▲	▲	▲	★		○
Italy	ITA	∆	∆	∆	∆	∆	∆	∆	○	▲	★
Japan	JPN	▲	∆	○	★	▲	★	∆	∆	○	▲
Korea	KOR	▲	∆	∆	★	▲	▲	▲	▲		∆
Latvia	LVA	∆	○	○	○		∆				
Lithuania	LTU	∆	○	○	○		∆				
Luxembourg	LUX	○	○	∆	∆	★	▲	★	∆		∆
Malaysia	MYS	∆	∆	○	∆	∆					
Mexico	MEX	○	○	○	○	○	○	∆			○
Netherlands	NLD	▲	▲	★	▲	▲	▲	▲	▲	▲	★
New Zealand	NZL	∆	★	▲	∆	∆	∆	★	∆		★
Norway	NOR	▲	▲	∆	∆	▲	∆	∆	∆	▲	∆
Poland	POL	∆	∆	∆	○	○	∆	○	○		○
Portugal	PRT	∆	▲	▲	∆	∆	∆	∆	∆		▲
Russian Federation	RUS	∆	○	○	∆	∆	○	○	∆		∆
Slovak Republic	SVK	∆	○	○	○	○	○	○			★
Slovenia	SVN	∆	▲	▲	▲	∆	∆	∆	∆		∆
South Africa	ZAF	○	∆	○	∆	∆	∆	∆	∆		○
Spain	ESP	∆	∆	∆	∆	∆	∆	∆	○	○	○
Sweden	SWE	★	★	★	★	★	★	▲	▲	★	∆
Switzerland	CHE	▲	▲	★	▲	★	★	★	▲	★	▲
Turkey	TUR	∆	○	○	∆	∆	○	○			○
United Kingdom	GBR	∆	▲	▲	∆	▲	▲	▲	▲	∆	▲
United States	USA	▲	∆	∆	▲	▲	▲	▲	★	○	★
EU28	EU28	▲	▲	★	▲	∆	▲	∆	▲	▲	

Table 9.1. **Comparative performance of national science and innovation systems, 2014** *(cont.)*

Country relative position: in the top 5 OECD or above (★), in the middle range on par or above OECD median (▲), in the middle range below OECD median (Δ) and in the bottom 5 OECD or below (○)

		Interactions and skills for innovation												
		ICT and Internet infrastructures				Networks, clusters and transfers				Skills for innovation				
		ICT investment (per GDP)	Fixed broadband subscribers (per population)	Wireless broadband subscribers (per population)	E-government readiness index	Industry financed public R&D expenditure (per GDP)	Patents filed by universities and public labs (per GDP)	International co-authorship (%)	International co-invention (%)	Tertiary education expenditure (per GDP)	Adult population at tertiary education level (%)	Top adult performers in technology problem solving (%)	Top 15 year-old performers in science (%)	Doctoral graduate rate in science and engineering (%)
		ICTINV_XGDP	FBBAND_HAB	WBBAND_HAB	EGOV_I	PUB_BEF_XGDP	PATPRI_XGDP	INTCOA_XSA	COPAT_XPCT	TER_XGDP	ADTERPOP_XT	TOPAD_PST_XAD	TOP15_SCI_XT	PHDR_SCIENG_XCOH
		(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)	(s)	(t)	(u)	(v)	(w)
Argentina	ARG		○	○	○	○		Δ	★	▲	○		○	○
Australia	AUS	▲	Δ	★	▲	▲	▲	Δ	Δ	▲	▲	▲	★	▲
Austria	AUT	▲	Δ	▲	Δ	▲	Δ	★	▲	Δ	Δ	Δ	Δ	▲
Belgium	BEL	▲	▲	Δ	Δ	▲	▲	★	★	Δ	▲		▲	▲
Brazil	BRA		○	Δ	○		Δ	○	Δ	○	○		○	○
Canada	CAN	Δ	▲	Δ	▲	▲	▲	Δ	▲	★	★	▲	▲	▲
Chile	CHL		○	○	Δ	○	Δ	▲	Δ	★	○		○	○
China	CHN		○	○	○	▲	Δ	○	○		○			○
Colombia	COL		○	○	Δ			▲	Δ	★	Δ		○	
Costa Rica	CRI		○	○	○			★	★		Δ		○	
Czech Republic	CZE	Δ	Δ	Δ	○	Δ	Δ	Δ	▲	Δ	Δ	Δ	Δ	Δ
Denmark	DNK	★	★	★	★	Δ	★	▲	▲	▲	Δ	★	Δ	▲
Estonia	EST		Δ	▲	Δ	Δ		▲	★	▲	▲	○	★	Δ
Finland	FIN	Δ	▲	★	▲	★	▲	▲	Δ	★	▲	★	★	★
France	FRA	Δ	★	Δ	▲	Δ	★	▲	Δ	▲	Δ		▲	▲
Germany	DEU	Δ	▲	Δ	▲	★	▲	Δ	Δ	Δ	Δ	▲	▲	★
Greece	GRC	○	Δ	Δ	Δ	Δ	○	Δ	▲	▲	Δ		○	Δ
Hungary	HUN		Δ	○	Δ	▲	○	▲	▲	○	Δ		Δ	○
Iceland	ISL		▲	▲	Δ	★		★	▲	○	▲		Δ	Δ
India	IND		○	○	○		Δ	○	▲	○				
Indonesia	IDN		○	○	○			▲	★	○	○		○	○
Ireland	IRL	○	Δ	▲	Δ	○	★	▲	▲	▲	▲	○	▲	▲
Israel	ISR		Δ	Δ	▲	▲	★	Δ	Δ	▲	★		Δ	▲
Italy	ITA	Δ	Δ	Δ	Δ	○	Δ	Δ	○	○	○		Δ	Δ
Japan	JPN	★	▲	▲	▲	Δ	▲	○	○	▲	★	▲	★	Δ
Korea	KOR	▲	★	★	★	▲	★	○	○	★	★	○	▲	Δ
Latvia	LVA		Δ	Δ	Δ	▲		Δ	★	▲	Δ		○	Δ
Lithuania	LTU		Δ	○	Δ	★		Δ	Δ		▲		Δ	
Luxembourg	LUX	○	▲	▲	▲	Δ	Δ	★	★	○	▲		▲	
Malaysia	MYS		○	○	Δ			Δ	Δ	★	○		○	
Mexico	MEX	○	○	○	○	○	○	Δ	▲	Δ	○		○	○
Netherlands	NLD	▲	★	▲	★	★	▲	▲	Δ	▲	Δ	★	▲	Δ
New Zealand	NZL	★	▲	▲	▲	★	Δ	▲	Δ	▲	▲		★	▲
Norway	NOR		▲	▲	▲	▲	Δ	▲	Δ	▲	▲	★	Δ	▲
Poland	POL		○	▲	○	Δ	Δ	○	★	Δ	Δ	○	▲	○
Portugal	PRT	▲	Δ	○	Δ	○	Δ	▲	▲	Δ	○		○	Δ
Russian Federation	RUS		○	Δ	Δ	★	○	○	Δ	Δ	★		○	○
Slovak Republic	SVK	○	○	Δ	○	Δ		Δ	▲	○	Δ	○	Δ	▲
Slovenia	SVN	Δ	Δ	Δ	Δ	▲	Δ	Δ	Δ	Δ	Δ		▲	▲
South Africa	ZAF		○	○	○	Δ	Δ	Δ	Δ	○	○			○
Spain	ESP	Δ	Δ	Δ	Δ	▲	▲	Δ	Δ	Δ	Δ		Δ	Δ
Sweden	SWE	★	▲	★	▲	▲	○	▲	Δ	▲	▲	★	Δ	★
Switzerland	CHE	★	★	Δ	▲		▲	★	★	Δ	▲		▲	★
Turkey	TUR		○	○	○	▲	○	○	○	Δ	○		○	○
United Kingdom	GBR	▲	▲	▲	★	Δ	▲	Δ	▲	Δ	▲		▲	★
United States	USA	▲	▲	▲	★	Δ	▲	○	○	★	★	Δ	Δ	Δ
EU28	EU28	Δ	▲	▲		Δ	▲	▲	▲		Δ		Δ	▲

Note: Non-OECD countries are also compared to OECD countries and may therefore be out of range (e.g. lower than the lowest OECD country). They appear in this table with top five and bottom five OECD values

Israel: "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: See references and methodological annex of the OECD STI Outlook 2014 country profiles.

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ARGENTINA

The Argentinian government recognises that innovation is a key source of growth and currently concentrates its efforts in several areas.

Hot issue 1: Innovating to address social challenges (including inclusiveness). Argentina focuses on resolving the challenges of social 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. In 2009, MINCYT created Argentinian Sectoral Fund (FONARSEC), a fund mainly financed by grants from the World Bank and the Inter-American Development Bank, which also supports innovation initiatives that foster social inclusion.

Hot issue 2: Improving co-ordination of and participation in governance. Many public bodies are involved in Argentina's STI system. MINCYT, with a budget of USD 1 443 million (ARS 4 994 million) in 2013, has a central role in managing innovation investments and R&D institutions. 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. The Evaluation and Quality Assurance Unit (UEAC) of the National Agency for the Promotion of Science and Technology and the National Directorate of Programmes and Projects of the Undersecretary of Institutional Evaluation conduct evaluations with a view to quality assurance. To improve co-ordination, 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 MINCYT's allocation of resources. In March 2013, 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 issue 3: Targeting priority areas/sectors. Sectoral funds constitute the backbone of Argentina's S&T policy. 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 development of target technologies (e.g. bio- and nano-technology) and sectors (e.g. energy, health and agro-industry).

Hot issue 4: Increasing overall human resources, skills and capacity building. Argentina spent 1.47% of GDP on tertiary education in 2011, a level close to the OECD median (Panel 1[S]). However, performance of 15-year-olds in science is well below the OECD median (Panel 1[V]) and points to shortcomings in the quality of education. The share of doctoral graduates in S&E is also well below the OECD median (Panel 1[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. Since its inception in 2004, more than 1 000 scientists had returned to Argentina as part of the RAICES programme as of 2013. These efforts have led to an increased supply of younger researchers, with the share of researchers under 40 rising from 41% in 2003 to nearly 48% in 2011. Furthermore, to improve the performance of Argentina 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 addressing pressing socio-economic challenges.

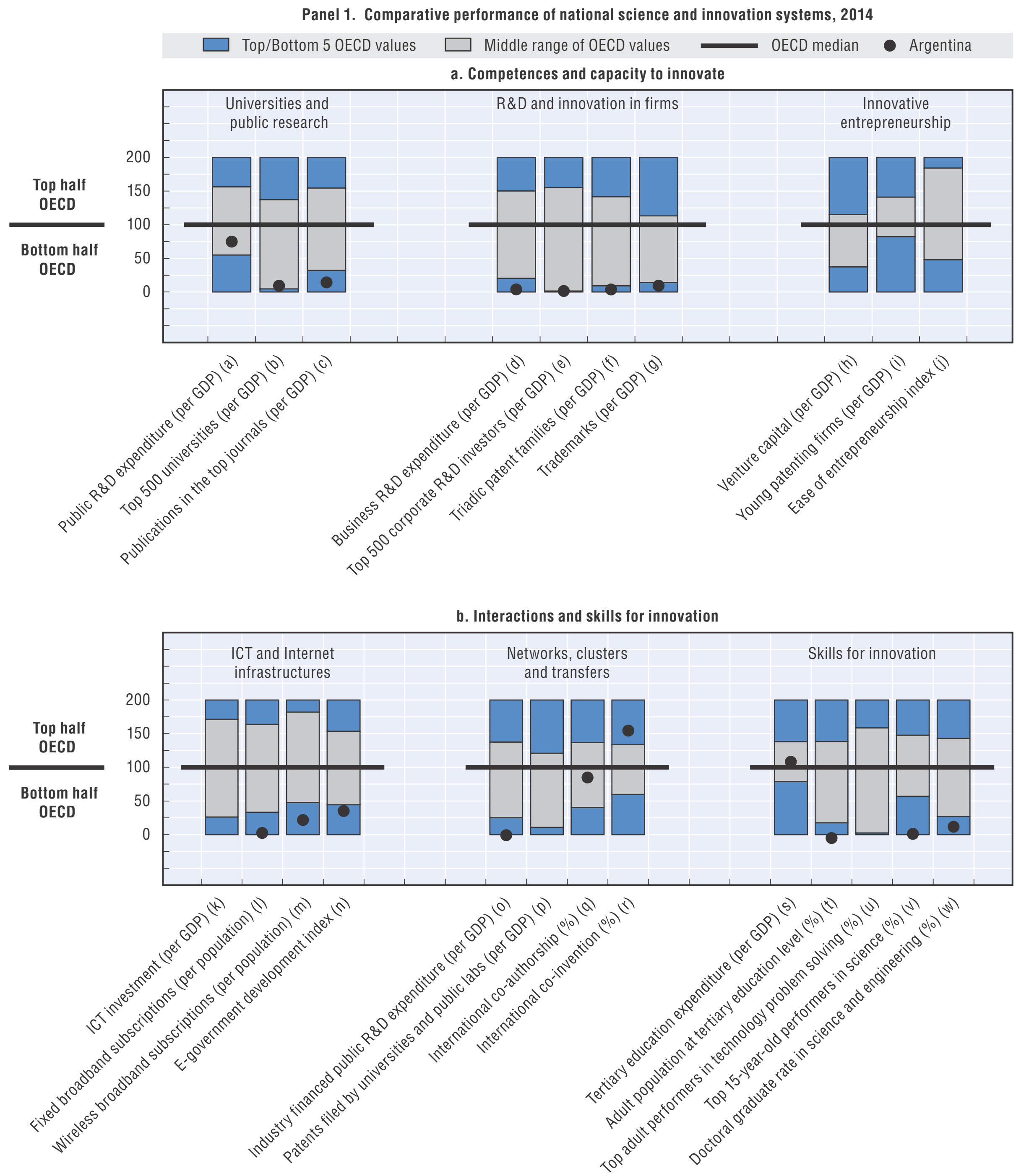
Highlights of the Argentinian STI system

Universities and public research: In addition to efforts to improve the skills base described above, MINCyT has invested in the country's R&D infrastructure needs. In 2013, as part of its Work Plan for Science and Technology, four

Key figures, 2013

Economic and environmental performance	ARG	OECD	Gross domestic expenditure on R&D	ARG	OECD
Labour productivity			**GERD**		
GDP per hour worked, USD PPP, 2013	n.a.	47.7	Million USD PPP, 2012	5 447	1 107 398
(annual growth rate, 2008-13)	n.a.	(+0.8)	As a % of total OECD, 2012	0.5	100
Green productivity			**GERD intensity and growth**		
GDP per unit of CO_2 emitted, USD, 2011	3.4	3.0	As a % of GDP, 2012	0.74	2.40
(annual growth rate, 2007-11)	(+3.8)	(+1.8)	(annual growth rate, 2007-12)	(+13.7)	(+2.0)
Green demand			**GERD publicly financed**		
NNI per unit of CO_2 emitted, USD, 2011	n.a.	3.0	As a % of GDP, 2011	0.48	0.77
(annual growth rate, 2007-11)	n.a.	(+1.6)	(annual growth rate, 2007-11)	(+15.2)	(+2.8)

Figure 9.1. **Science and innovation in Argentina**



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

new buildings of a total 11 122 square metres of R&D infrastructure, including the new headquarters for the national DNA databank and nanotechnology offices and laboratories, were completed. This represents a 17% increase in R&D surface compared to 2007.

Innovation in firms: With BERD of 0.16% of GDP in 2012, well below the OECD median (Panel 1[d]), Argentina lags far behind the OECD in innovation performance, triadic patents (Panel 1[f]) and trademark registrations (Panel 1[g]). To improve innovation performance, government programmes target key knowledge areas and sectors to improve the quality of human capital for research and innovation and the articulation between public research and industry.

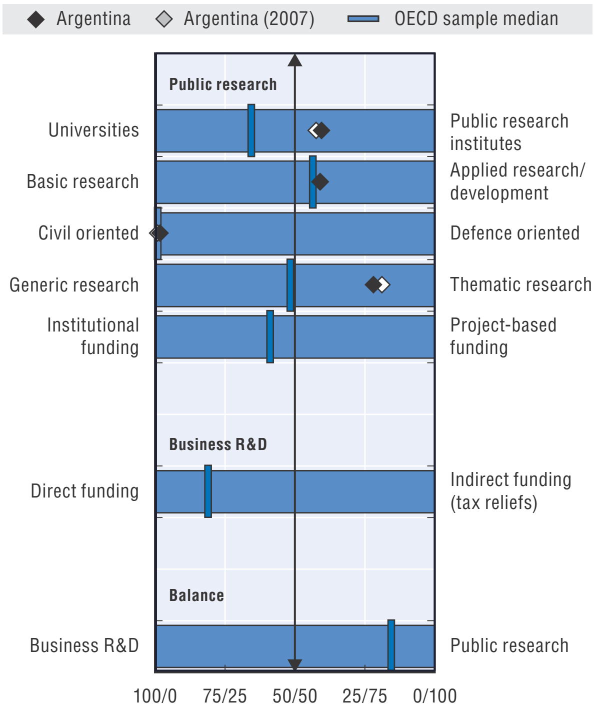
ICT and Internet infrastructures: Argentina's Internet infrastructure and use is below OECD levels (Panel 1[l, m, n]). Some 10.9% of Argentinians had a fixed broadband subscription, a higher share than in Brazil (9.2%) but below that of Chile (12.4%). About 21% of Argentina's inhabitants are wireless broadband subscribers, leading Mexico (10.8%), but trailing Brazil (37.3%). Argentina's e-government development index is still low with respect to the OECD median.

Clusters and smart specialisation: The government aims to reduce the regional gap in STI capacity by increasing share of GERD performed by the 19 least R&D-intensive provinces from 28% in 2011 to 37% in 2020. COFECYT disbursed USD 38 million (ARS 113 million) in 2012 to work towards this goal.

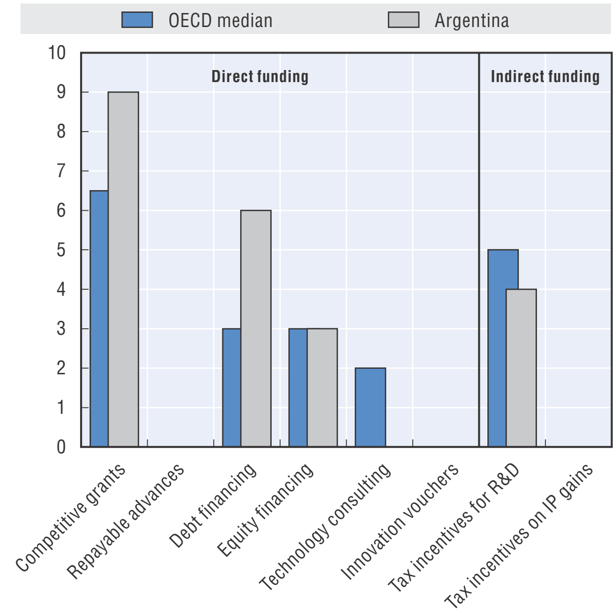
Globalisation: International co-authorship of scientific publications is close to the OECD median (Panel 1[q]). International co-patenting (Panel 1[r]) is considerably above the OECD median. More generally, the government seeks to foster international co-operation in S&T. To this end, it has established partnerships and recently increased the number of co-operative projects and programmes with Brazil, Chile, Mexico, the United States and Canada as well as France, Belgium, the United Kingdom, Germany, the Netherlands and Italy.

Recent developments in STI expenditures: Argentina spent 0.74% of GDP on R&D in 2012, considerably below the OECD median. The government finances the majority of GERD (0.48% of GDP), and its contribution grew by 15.2% a year over 2007-12, marginally faster than the overall annual growth of GERD (14.6%) over the same period. While low compared to the OECD median, Argentina's public R&D spending at 0.57% of GDP (Panel 1[a]) is higher than that of Chile (0.14%) or Mexico (0.25%). BERD stood at 0.16% of GDP and grew moderately compared to 2004 (0.14%). MINCyT is currently evaluating the means of measuring private R&D; preliminary results indicate that BERD may have been somewhat underestimated.

Panel 2. Allocation of public funds to R&D, by sector, type and mode of funding, 2012



Panel 3. Most relevant instruments of public funding of business R&D, 2014



Note: Policy information comes from country responses to the OECD STI Outlook policy questionnaires 2014 and 2012. Argentina's responses are available in the *OECD STI Outlook Policy Database*, edition 2014 at *http://qdd.oecd.org/Table.aspx?Query=7534DEC8-6D3D-4D19-B320-69E375B75D82*.
Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888933152019

AUSTRALIA

Australia's economy has been one of the world's most resilient during the global economic crisis and has benefited greatly from a global commodities boom. Following the 2013 general election, the Australian government is implementing "Our Plan – Real Solutions for all Australians" to build a stronger, more productive and diverse economy, with more efficient government and more productive businesses.

Hot issue 1: Encouraging innovation in firms including SMEs and supporting entrepreneurship. Australia's economy relies relatively heavily on primary and resource-based industries. In line with its industrial structure, BERD is at the OECD median at 1.23% of GDP (2011); the share of high-technology manufacturing is considerably below the OECD median (Panel 2). Innovation output, as measured by triadic patents, is also below the median (Panel 1[f]) while trademark registrations are slightly above (Panel 1[g]). The government encourages innovation and entrepreneurship in firms of all sizes and in all sectors of the economy. The R&D tax incentive, introduced in 2011 to replace the R&D tax concession, offers preferential conditions for SMEs. In 2014, the Australian government announced it would invest USD 329 million (AUD 484.2 million) in a new Entrepreneurs' Infrastructure Programme with AusIndustry being the single business service to deliver it. The new programme will encourage entrepreneurship and equip businesses to undertake changes and expansion and commercialise new ideas.

Hot issue 2: Improving framework conditions for innovation. Australia has a reasonably favourable business environment (Panel 1[j]). However, availability of venture capital is below the OECD median (Panel 1[h]). The new government aims to improve productivity and job growth by cutting the costs of red tape for business and community groups by USD 680 million (AUD 1 billion) a year. This includes abolishing the carbon tax introduced by the previous government and lowering the company tax rate.

Hot issue 3: Improving the return on and impact of science. Australia has a relatively strong science base with high public expenditure on R&D, world-class universities, and high-quality scientific publications (Panel 1[a, b, c]). Industry-financed public R&D expenditure is above the OECD median (Panel 1[o]), as a result of government tax incentives that are designed to improve academic-industry linkages. The government aims to ensure that the science sector continues to deliver economic and social benefits to all Australians. To increase co-operation between public science and industry, the Industrial Transformation Research Programme, administered by the Australian Research Council, funds research partnership between Australian universities and industry. CSIRO, Australia's national science and technology agency, has incorporated impact-led decision making into all science areas to help plan, monitor and evaluate the impact of its research programmes.

Hot issue 4: Targeting priority areas and sectors. The government aims to achieve a world-class "five-pillar economy" by building on the country's strengths. Five industry growth sectors and related services are targeted: *i)* manufacturing innovation, *ii)* advanced services, *iii)* agricultural exports, *iv)* world-class education and research, and *v)* mining exports. It is considering policy initiatives that target priority areas and sectors. The Australian government is currently considering mechanisms to provide greater focus to its investment in science and research, including the development of science and research priorities to drive investment in areas of immediate and critical importance to Australia and its place in the world.

Hot issue 5: Innovation to contribute to structural adjustment. The Australian government is supporting investment in industries and maintaining industry capabilities through the Growth Fund and the Manufacturing Transition Grants Programme. In addition, its Industry Investment and Competitiveness Agenda will focus on initiatives to promote national competitiveness and productivity, including economy-wide measures to boost the competitiveness of Australian manufacturing and lower the costs of doing business.

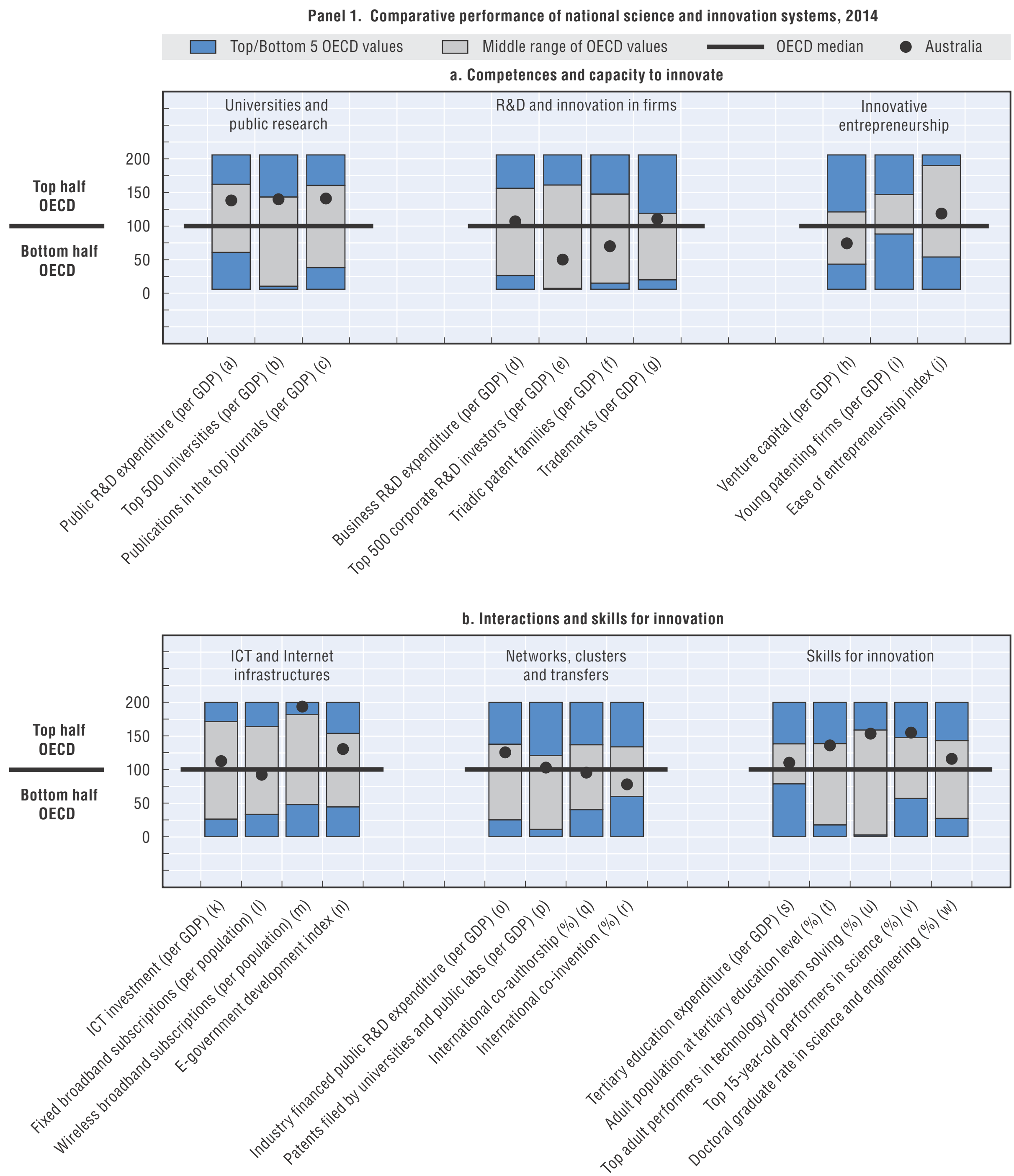
Highlights of the Australian STI system

STI policy governance: As a result of the change in government, the Department of Industry and Department of Education were established in November 2013. The Department

Key figures, 2013

Economic and environmental performance	AUS	OECD	Gross domestic expenditure on R&D	AUS	OECD
Labour productivity			**GERD**		
GDP per hour worked, USD PPP, 2013	55.5	47.7	Million USD PPP, 2010	20 469	1 107 398
(annual growth rate, 2008-13)	(+1.7)	(+0.8)	As a % of total OECD, 2010	2.1	100
Green productivity			**GERD intensity and growth**		
GDP per unit of CO_2 emitted, USD, 2011	2.1	3.0	As a % of GDP, 2010	2.19	2.40
(annual growth rate, 2007-11)	(+2.0)	(+1.8)	(annual growth rate, 2008-10)	(+0.8)	(+2.0)
Green demand			**GERD publicly financed**		
NNI per unit of CO_2 emitted, USD, 2011	2.0	3.0	As a % of GDP, 2008	0.78	0.77
(annual growth rate, 2007-11)	(+2.5)	(+1.6)	(annual growth rate, 2006-08)	(+4.4)	(+2.8)

Figure 9.2. **Science and innovation in Australia**



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

of Industry's vision is to enable growth and productivity for globally competitive industries, by building skills and capability, supporting science and innovation, promoting investment, and improving regulation. The Department of Education is responsible for promoting a rise in economic productivity and social well-being through access to quality higher education, international education and international quality research. The Australian government is considering whole-of-government co-ordination mechanisms for science, research and innovation with a view to providing strategic advice on all aspects of the system.

Universities and public research: Excellence in Research for Australia (ERA) evaluates the quality of the research undertaken in Australian universities against national and international benchmarks. The outcomes are determined and moderated by committees of distinguished researchers, drawn from Australia and overseas. The unit of evaluation is broadly defined as the Field of Research (FoR) within an institution based on the Australia and New Zealand Standard Classification (ANZSRC). The indicators used in ERA include a range of metrics such as citation profiles which are common to disciplines in the natural sciences, and peer review of a sample of research outputs which is common in the humanities and social sciences. ERA is a comprehensive collection. The data submitted by universities covers all eligible researchers and their research outputs. The precise set of indicators used has been developed in close consultation with the research community. This approach ensures that the indicators used are both appropriate and necessary, which minimises the resourcing burden of ERA for Government and universities and ensures that ERA results are both robust and broadly accepted. The first full round of ERA occurred in 2010 and the results were published in early 2011. This was the first time a nationwide stocktake of discipline strengths and areas for development had ever been conducted in Australia. The second round of ERA was completed with the publication of the ERA 2012 National Report on 6 December 2012. The next ERA round will occur in 2015 and preparations are currently under way. Subsequent rounds will occur every three years.

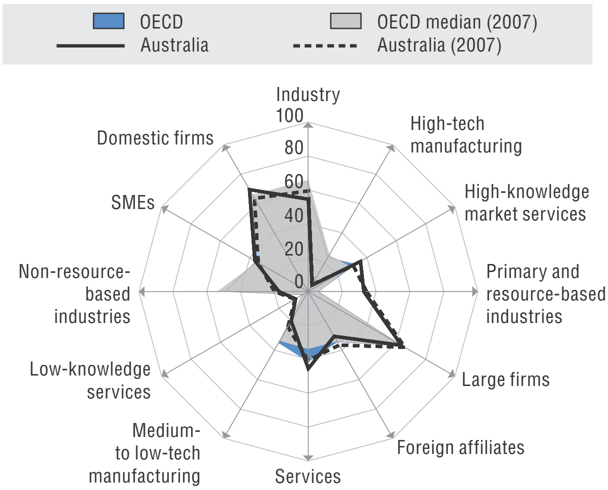
The National Collaborative Research Infrastructure Strategy (NCRIS), administered by the Department of Education, supports major research infrastructures in order to encourage collaboration between the research sector, industry and government on world-class research. NCRIS is designed to provide Australia's research sector with ongoing access to high-quality, operational research infrastructure facilities to ensure that Australian research continues to be competitive and rank highly on an international scale. The Australian government is providing USD 102 million (AUD 150 million) in 2014-15 to secure Australian researchers' access to current major research facilities and the supporting infrastructure and networks necessary to undertake world-class research.

Globalisation: The Department of Industry has a partnership agreement with the Australian Trade Commission, which affirms strong mutual interests in jointly developing Australia's economic interests through industry policy, international trade and productive FDI. One outcome of this collaboration has been the development and promotion of a common narrative and a consistent message to international audiences on opportunities for investment and collaboration on innovation. The current agreed priorities between the organisations are: resources and energy investment; skills; global value chains [mining, equipment, technology services (METS), oil and gas, food processing, and advanced manufacturing in medical technology and aerospace]; advanced services and technologies investment; and improving the co-ordination of delivery.

Skills for innovation: Australia performs well on skills indicators: as demonstrated e.g. by its fourth highest PISA scores in science for 15-year-olds in the OECD area and the adult tertiary education attainment level (Panel 1[v, t]). To help ensure the quality of future skill supplies, the Australian Curriculum Programme seeks to strengthen overall education, especially in maths and science skills. Australia's vision for 2020 is a strong and productive Australian research workforce, with the scale, breadth and depth of skills required to support innovation, education of the next generation of Australians, and ultimately productivity improvements across the economy.

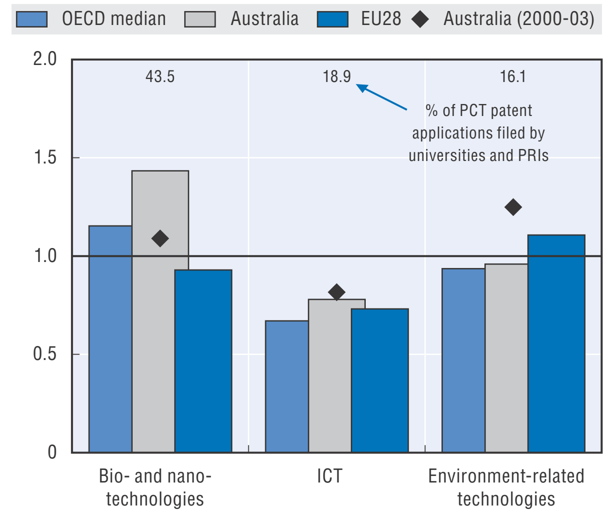
Panel 2. Structural composition of BERD, 2011

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

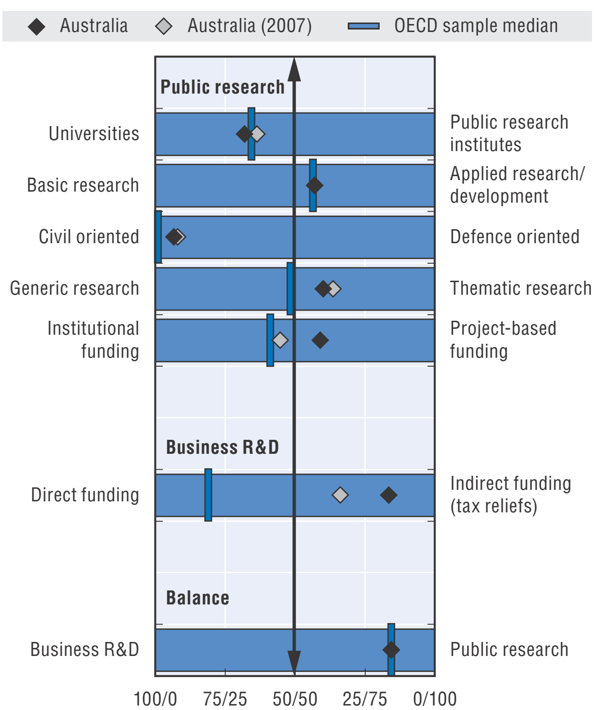


Panel 3. Revealed technology advantage in selected fields, 2009-11

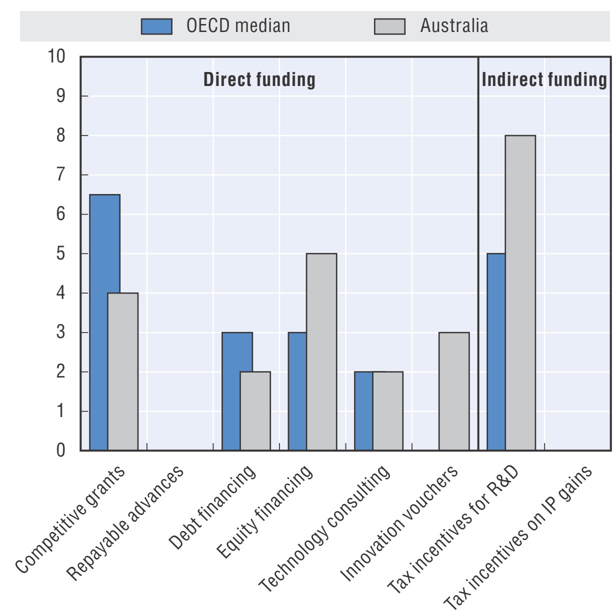
Index based on PCT patent applications



Panel 4. Allocation of public funds to R&D, by sector, type and mode of funding, 2012



Panel 5. Most relevant instruments of public funding of business R&D, 2014



Note: Policy information comes from country responses to the OECD STI Outlook policy questionnaires 2014 and 2012. Australia's responses are available in the *OECD STI Outlook Policy Database*, edition 2014 at *http://qdd.oecd.org/Table.aspx?Query=BD5FF3D2-640B-473B-BE5F-136DF7A79D18*.

Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888933152021

AUSTRIA

Austria is a small and open advanced European economy which had seen rapid progress in its research and innovation system. Keeping up the dynamic development of the Austrian innovation system is an important task. After nearly two decades of sustained growth, the expansion of R&D expenditure has slowed in the aftermath of the financial crisis, and constraints on public R&D expenditure are tight in current budgets. The main challenge is to increase the efficiency of current spending and to continue structural and institutional reforms in research organisations and public administration while launching new initiatives to address some of the main bottlenecks perceived in the research, technology and innovation system. In March 2011, the Austrian Council of Ministers announced a new Research, Technology and Innovation (RTI) Strategy for 2011-20: Becoming an Innovation Leader.

Hot issue 1: Strengthening science – industry linkages, including knowledge transfer. Industry-science linkages have improved in recent years, with an average share of public research funded by industry (Panel 1[o]). Longstanding initiatives to promote strategic science-industry collaboration include the competence centres for excellent technologies (COMET), co-operation and innovation networks (COIN-Net), as well as the Christian Doppler (CD) Laboratories. The Josef Ressel Centres programme (started in 2012) applies the principles of the CD Labs in local contexts. The Laura Bassi centres of expertise support a forum for skilled female and male researchers from academia and the private sector to work together. Recent initiatives include the Knowledge Transfer Centres and IPR Commercialisation Programme (2014-18) and new rules and guidelines for the ownership and licensing of publicly funded research results and IPR licensing support for PRIs.

Hot issue 2: Reforming the education system. Against the backdrop of increased international competition, Austria is preparing for a potential lack of human resources for STI. To ensure the required supply, education is a key part of the RTI Strategy. The New Secondary School initiative is a major educational reform and the MINT Programme aims to improve education in mathematics, IT, natural science and technology. *Forschungskompetenzen für die Wirtschaft* is an initiative to build R&D skills, while the Lifelong Learning Strategy and the Lifelong Guidance Strategy aim to increase human capital at all levels. Joint ministerial programmes such as *Jugend innovativ*, Sparkling Science and Innovation Generation aim to stimulate interest in and skills for STI in young people.

Hot issue 3: Using innovation to address social challenges. Like other advanced countries, Austria faces social challenges related to ageing, health and climate change, which the government intends to address through STI. A number of inter-ministerial working groups on societal challenges have been created in recent years, and Austria has joined seven out of ten EU Joint Programming Initiatives (JPIs). In one of the JPIs, Urban Europe, Austria plays a leading role in its governance.

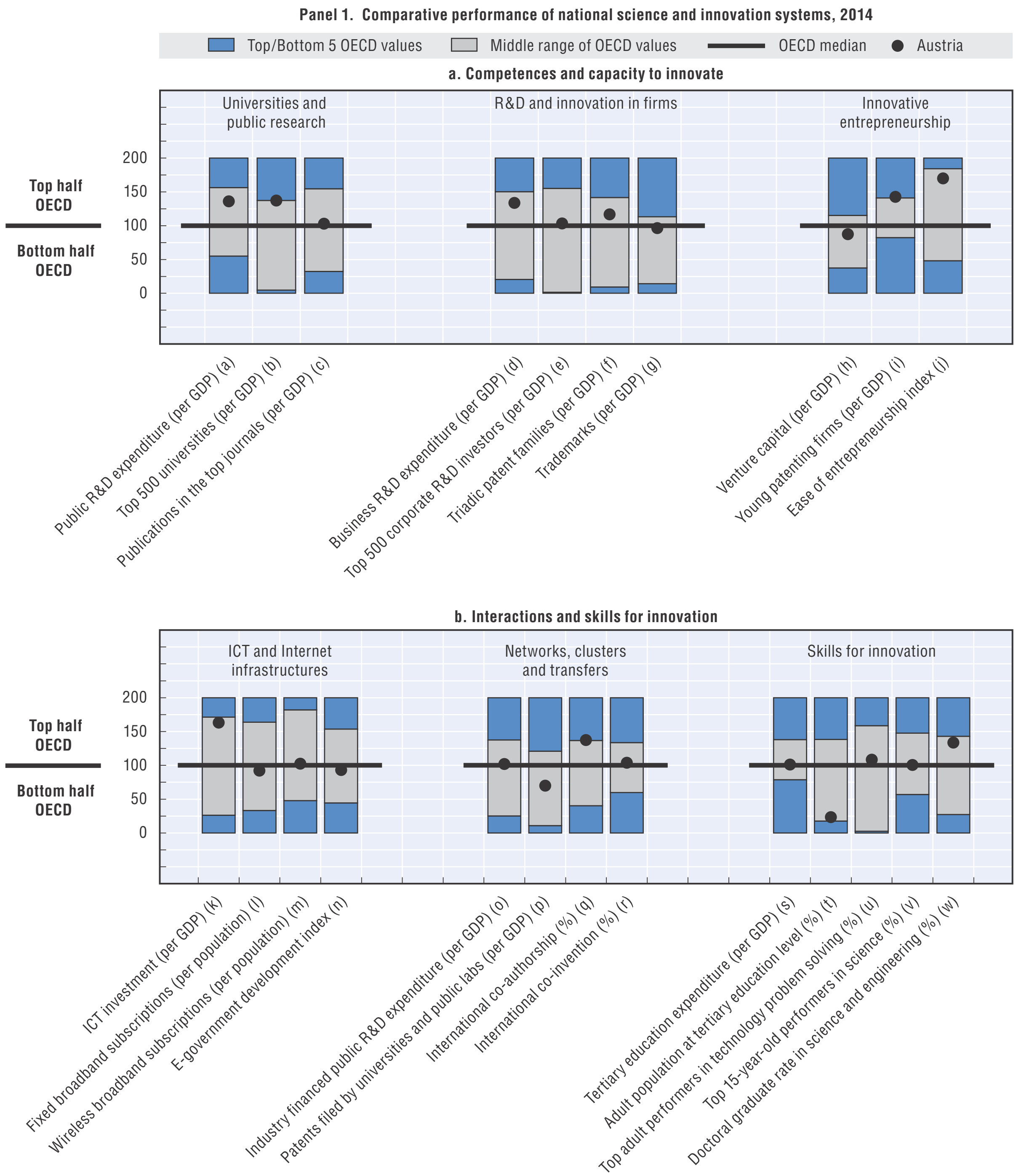
Hot issue 4: Strengthening public R&D capacity and infrastructure. Austria has been reinforcing its science base with relatively high public-sector R&D expenditure (Panel 1[a]). Its share of top 500 universities is in the upper middle OECD range and international publications are in line with the OECD median (Panel 1[b, c]). Maintaining healthy funding or university research, especially competitive project-based funding, is essential to their future performance. New performance contracts were concluded between the state and public universities and the Academy of Sciences in 2012 and 2013, respectively. To improve its research infrastructure, Austria takes an active part in the European Strategy Forum on Research Infrastructures (ESFRI) and is involved in several initiatives of the European Research Infrastructure Consortium (ERIC). Austria co-ordinates the ERIC on Biobanking and Biomolecular Resources Research Infrastructure (BBMRI). Universities are encouraged to collaborate on R&D infrastructure investment and use.

Hot issue 5: Increasing the innovation potential of SMEs. Austria's number of global corporate investors in R&D (Panel 1[e]) is at the OECD median, and foreign MNEs are the main force in R&D performed by large companies (Panel 2). However, many innovative, R&D-performing SMEs (Panel 2) are competitive in niche export markets and a noteworthy strength. Public support has shifted towards indirect support measures and moved slightly towards business R&D (Panel 4). The RTI Strategy seeks to increase research-intensive firms (particularly SMEs) by 3% a year and firms conducting R&D

Key figures, 2013

Economic and environmental performance	AUT	OECD	Gross domestic expenditure on R&D	AUT	OECD
Labour productivity			**GERD**		
GDP per hour worked, USD PPP, 2013	55.1	47.7	Million USD PPP, 2013	10 817	1 107 398
(annual growth rate, 2008-13)	(+0.8)	(+0.8)	As a % of total OECD, 2012	1.0	100
Green productivity			**GERD intensity and growth**		
GDP per unit of CO_2 emitted, USD, 2011	4.3	3.0	As a % of GDP, 2013	2.86	2.40
(annual growth rate, 2007-11)	(+1.7)	(+1.8)	(annual growth rate, 2007-12)	(+3.1)	(+2.0)
Green demand			**GERD publicly financed**		
NNI per unit of CO_2 emitted, USD, 2011	4.4	3.0	As a % of GDP, 2011	1.01	0.77
(annual growth rate, 2007-11)	(+2.2)	(+1.6)	(annual growth rate, 2007-12)	(+7.4)	(+2.8)

Figure 9.3. **Science and innovation in Austria**



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

by 25% by 2020. To this end, the system of fiscal incentives was simplified in 2011, and the remaining instrument, the R&D premium, was raised from 8% to 10% to reach USD 691 million (EUR 547 million) in 2012. New initiatives include a package of measures (*Jungunternehmer-Offensive*) introduced in 2012 to support young entrepreneurs and the Frontrunner Initiative for leading innovative firms. A new voucher scheme for innovation in creative industries was introduced in 2013, and the Loan Initiatives for innovative start-ups as well as the AWS PreSeed and AWS Seed Financing schemes for high-technology companies were broadened and expanded.

Highlights of the Austrian STI system

STI policy governance: With the adoption of the RTI Strategy in 2011, a task force comprising all relevant ministries was established to oversee its implementation, and issued a comprehensive plan in November 2013. A concept for innovation-related public procurement was adopted in 2012, with the Ministry of Science, Research and Economy and the Ministry for Transport, Innovation and Technology jointly overseeing its implementation.

***New sources of growth*:** A "manufacturing of the future" initiative has a budget of USD 70-80 million to strengthen Austrian manufacturing through research on future technologies and processes. Austria does not currently have a technology advantage in biotechnology and ICT (Panel 3). The Biotechnology Action Plan bundles existing initiatives with new measures to promote the development of biotechnology with a budget of USD 60 million (2013-15). ICT of the Future is a new funding programme to support technology development and innovation in ICT applications linked to societal challenges.

***New challenges*:** Austria's technology advantage in environment-related technologies has increased in the past years (Panel 3). The new Energy Research Initiative (ERI) based on the 2010 Energy Strategy will support technology development for the production of renewable energy sources and the storage of CO_2. The Cleantech Initiative provides risk capital for innovative enterprises in energy and environmental technologies. The government-owned AWS Bank's capital injection of USD 8.3 million (EUR 6.9 million) is expected to leverage around USD 42 million (EUR 35 million) in funding. E-Mobility is an initiative to develop a more sustainable and efficient transport system.

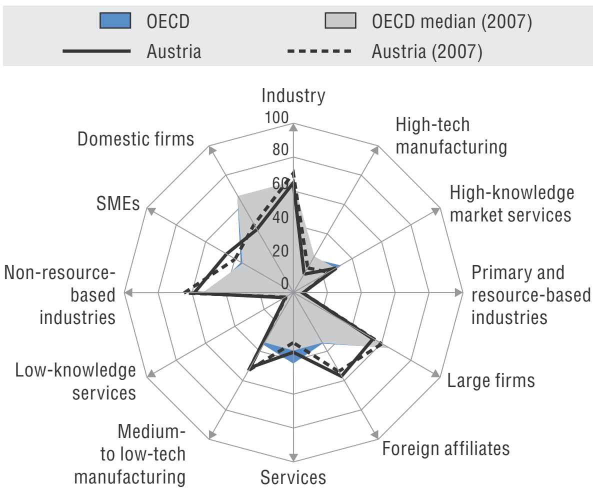
Clusters and smart specialisation: With the Automotive Cluster Styria, founded in 1995, Austria was an "early mover" in cluster policy. Almost every federal state (*Land*) runs cluster initiatives or incubators to link companies and research institutions around thematic priorities. Nationwide, there are more than 100 innovation infrastructure sites (*Impulszentren*). A national platform for clusters was established in 2008 to create a structured and co-operative forum for regional and national clusters. Around 55 cluster initiatives with around 10 000 partners and 20 technology parks participate in the platform. In 2014 the focus will be on enabling technologies and societal challenges.

Globalisation: The Go-International programme of the Austrian Chamber of Commerce encourages internationalisation, including of innovative firms. The export cheque for technology-oriented enterprises, for example, co-finances various activities of these businesses abroad. Austria is actively involved in EU activities, such as ERA-NET, Joint Programming Initiatives or Joint Technology Initiatives, and the government is working on the implementation of its STI internationalisation strategy "Beyond Europe" to strengthen collaboration outside the EU. The Austrian R&D funding schemes are generally receptive to co-funding and partnerships from abroad.

Recent developments in STI expenditures: GERD was 2.86% of GDP in 2013 (Key Figures) and is estimated to stay in this range in 2014 (Austrian Report on Research and Technology 2014). This puts Austria well ahead of the EU28 and OECD averages. Austrian growth of GERD – the fastest among EU countries during 2007-12 – has slowed recently due to budgetary constraints. The recent Work Programme for the Austrian Government 2013-18 endorses the objective to spend 2% of GDP on higher education by 2020. The government also supports the ambition to raise GERD to 3.76% of GDP by 2020, with up to 70% funded by business.

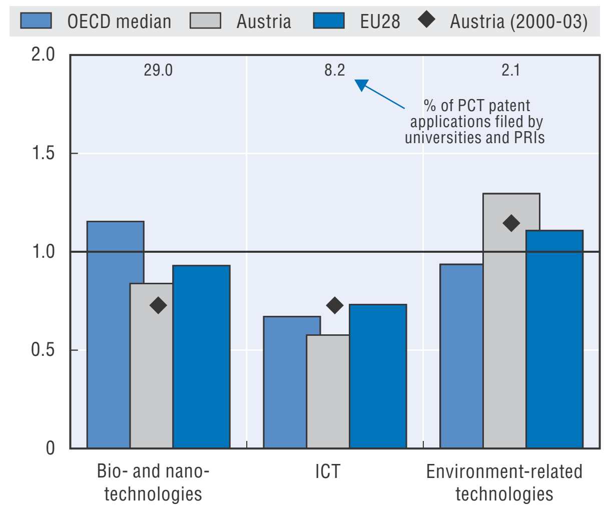
Panel 2. Structural composition of BERD, 2011

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

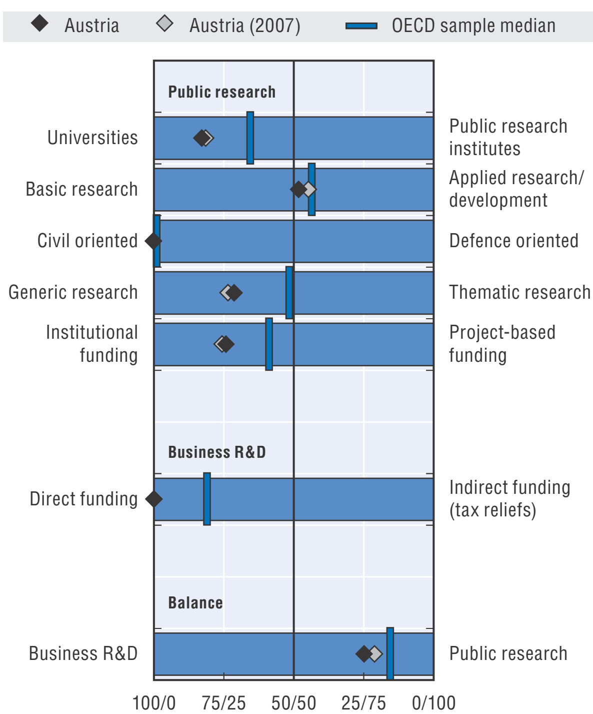


Panel 3. Revealed technology advantage in selected fields, 2009-11

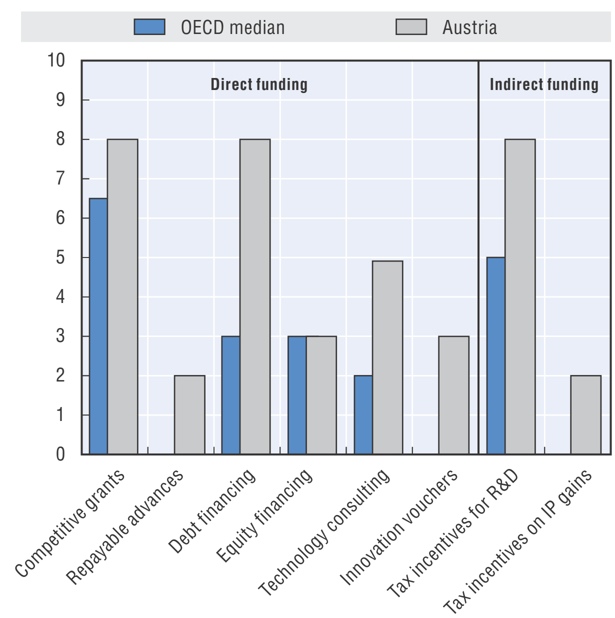
Index based on PCT patent applications



Panel 4. Allocation of public funds to R&D, by sector, type and mode of funding, 2012



Panel 5. Most relevant instruments of public funding of business R&D, 2014



Note: Policy information comes from country responses to the OECD STI Outlook policy questionnaires 2014 and 2012. Austria's responses are available in the *OECD STI Outlook Policy Database*, edition 2014 at *http://qdd.oecd.org/Table.aspx?Query=5367B9C7-2138-4A86-854D-B839D9ECB390*.

Source: See reader's guide and methodological annex.

StatLink *http://dx.doi.org/10.1787/888933152036*

BELGIUM

Belgium is a small EU economy and is very open to international trade and FDI. Its economy is strongly service-oriented and it has some internationally competitive technology sectors (e.g. pharmaceuticals and chemicals).

Hot issue 1: Improving overall human resources, skills and capacity building. While Belgium's labour-force skills are reasonably strong (Panel 1[s, t, v, w]), the demand for engineers exceeds the number of graduates in certain areas. The federal government offers tax deductions to increase the employment of researchers, and it raised the deduction on the withholding tax on researchers' salaries from 75% to 80% in July 2013. This tax incentive amounted to USD 759 million (EUR 630 million) in 2012, up from USD 675 million (EUR 560 million) in 2011. In 2012, Flanders launched the STEM Action Plan in combination with a science communication plan to increase the number of secondary and higher education students in STEM. Wallonia's Beware Fellowships support researcher mobility and promote awareness of S&T among youth by supporting actors in the field.

Hot issue 2: Improving the returns to and impact of science. Belgium has a sound science base and seven of the world's top 500 universities. Universities and PRIs publish and patent actively (Panel 1[b, c, p]). Industry-science relations are good and the business sector finances a relatively high share of public R&D (Panel 1[o]). Transfer of knowledge is a major concern at all government levels. Commercialisation of research is a key part of the federal government's strategy and resulted in USD 258 million (EUR 219 million) in tax deductions on revenues from commercialisation of patented inventions in 2010. The Brussels Capital Region (BCR) supports the creation of university spin-offs through financing and technology transfer offices. The Flanders Holding Company manages the Transformation and Innovation Acceleration Fund (TINA), with a budget of USD 235 million (EUR 200 million) in 2010. It provides risk capital financing for innovation projects and acts as "entrepreneur" and facilitator. Since 2012 the Spin-off Financiering instrument supports the setting up of spin-off companies from research results. Wallonia supports the technology transfer offices co-ordinated by the Agency for Technology Promotion. Its Technological Innovation Partnership encourages collaborative research, with new mechanisms (e.g. collective research calls) to improve collaboration by SMEs and research centres. It is launching a new Green Impulse Fund for young innovative companies.

Hot issue 3: Addressing the challenges of STI globalisation and increasing international co-operation. Belgium seeks to create a favourable environment for business innovation and to attract foreign investment in R&D and innovation. It has a well-developed and productive science base and a strong international reputation in R&D in certain technological fields and in patenting (Panel 1[f]). Belgian STI activities are well integrated internationally (Panel 1[q, r]) and foreign affiliates account for more than half of BERD (Panel 2). Attracting inward FDI continues to be a major priority of the Belgian governments. To this end, they support national research infrastructures, active participation in international scientific and industrial research initiatives, and the integration of Belgian scientists in the European Research Area.

Hot issue 4: Targeting priority areas/sectors. Each region has identified its own priority areas. There is some overlap. The BCR focuses on certain sectoral niches and on R&D and innovation to meet societal challenges. The priority sectors identified in the new BCR Innovation Plan are ICT, health care and the environment. Funding schemes have been prepared along with a cluster initiative to foster a growth ecosystem and critical mass in the priority sectors. The Flanders Policy Note 2009/2014 on Scientific Research and Innovation identifies similar priorities, and the Flanders 2011 Concept Note on Innovation Centre stresses the role of innovation in addressing grand societal challenges through thematic "innovation hubs". Initiatives include the setting up of living labs and thematic initiatives (e.g. Energyville, ICleantech, a call for social innovation, the establishment of the Centre for Medical Innovation).

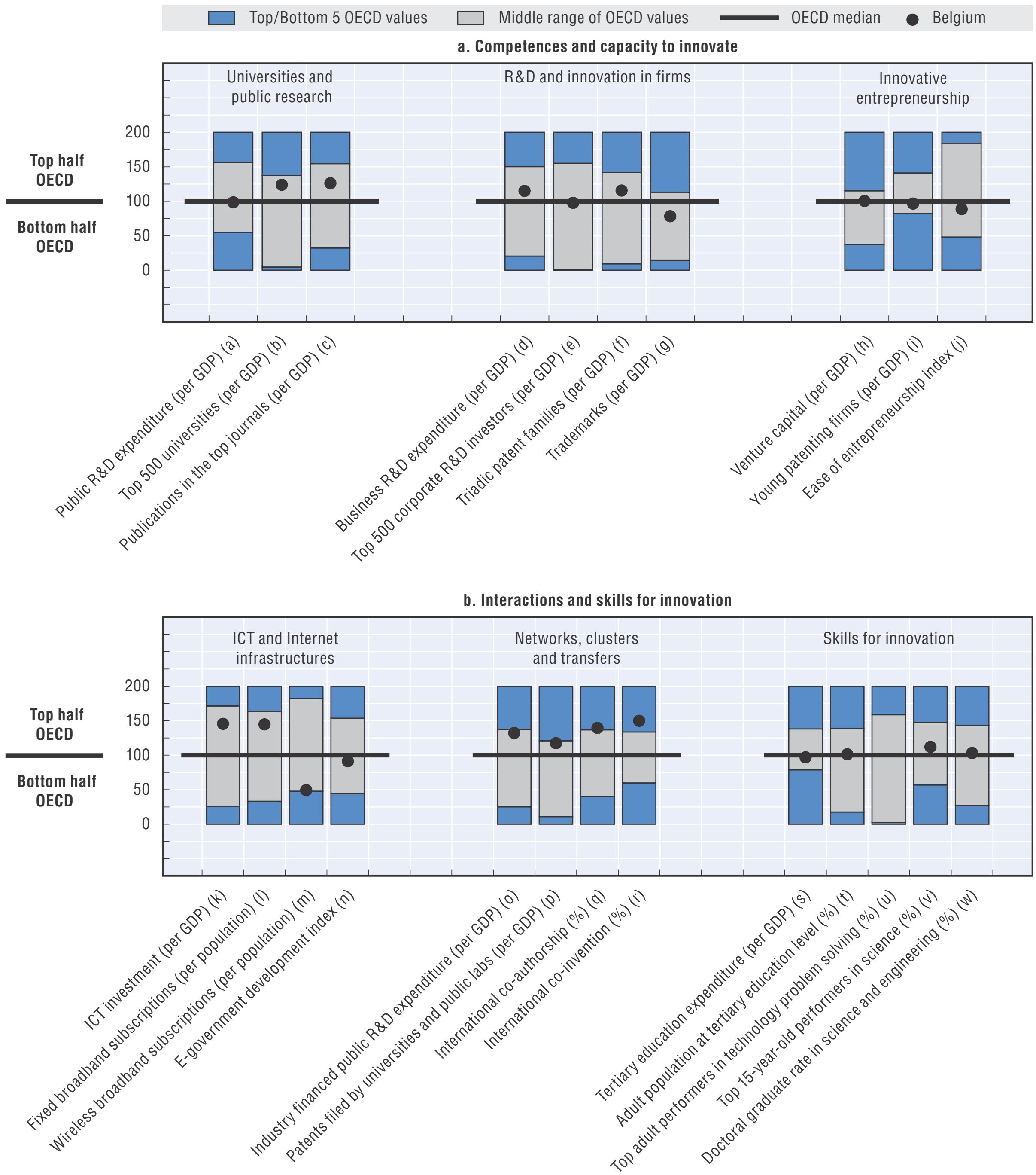
Wallonia's Research Strategy 2011-15 identifies priorities linked to societal needs; six sector-oriented clusters *(pôles de compétitivité)* were created with government support as part of the Marshall plan, updated to Marshall Plan 2 Green, to help raise competitiveness and stimulate innovation

Key figures, 2013

Economic and environmental performance	BEL	OECD	Gross domestic expenditure on R&D	BEL	OECD
Labour productivity			**GERD**		
GDP per hour worked, USD PPP, 2013	64.3	47.7	Million USD PPP, 2012	10 095	1 107 398
(annual growth rate, 2008-13)	(0.0)	(+0.8)	As a % of total OECD, 2012	0.9	100
Green productivity			**GERD intensity and growth**		
GDP per unit of CO_2 emitted, USD, 2011	3.3	3.0	As a % of GDP, 2012	2.24	2.40
(annual growth rate, 2007-11)	(+1.3)	(+1.8)	(annual growth rate, 2007-12)	(+3.8)	(+2.0)
Green demand			**GERD publicly financed**		
NNI per unit of CO_2 emitted, USD, 2011	3.3	3.0	As a % of GDP, 2011	0.58	0.77
(annual growth rate, 2007-11)	(+1.0)	(+1.6)	(annual growth rate, 2007-11)	(+6.0)	(+2.8)

Figure 9.4. **Science and innovation in Belgium**

Panel 1. Comparative performance of national science and innovation systems, 2014



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

with initiatives for green technologies, health, energy and social innovation. Wallonia also has specialised life science and sustainable development funds. The federal level mainly targets the space sector; more than USD 240 million (EUR 200 million) a year go to the European Space Agency.

Hot issue 5: Improving framework conditions for innovation (including competitiveness). Belgium's business environment and financing for entrepreneurship are at or slightly below the OECD median (Panel 1[h, j]). Innovative entrepreneurship has been integrated in the BCR's research and innovation system. The BCR's BRUSTART II fund targets small innovative companies, and its new VC fund supports "pre-commercial" research. BCR's funding agency IMPULSE also provides support to young innovative companies for business planning, technical-economic monitoring, legal and financial matters, and search for partners. In Flanders, in addition to the TINA fund, the Vinnof fund invests in innovative growing companies and the ARKimedes fund invests in start-ups and fast-growing SMEs with innovation mezzanine, seed and early-stage funding. In Wallonia the public investment companies (Invests, Novallia) invest in spin-offs and start-ups. The Creative Wallonia Action Plan launched in 2011 aims to stimulate the creative economy and to support an innovation culture throughout the economy.

Highlights of the Belgian STI system

STI policy governance: Belgium is a federal country composed of three Communities (Flemish, French and German-speaking) and three regions (Brussels-Capital Region, Flanders and Wallonia). STI competences are distributed across all of these. The Communities are the main source of scientific research support, and the regions of innovation and business R&D support. Since 2010, greater intergovernmental co-operation on R&D and innovation has been discussed among all relevant policy actors and governments.

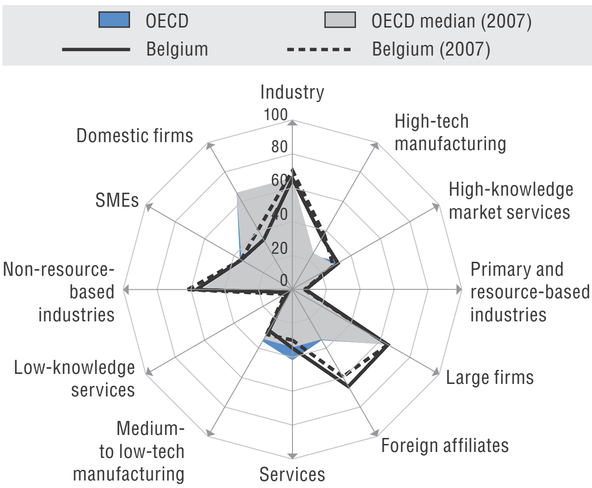
New challenges: Many initiatives address global and societal challenges. In 2014 the BCR is developing Smart City Mobility in conjunction with innovative public procurement for transport. The Walloon Marshall Plan 2 Green emphasises environmental issues and industrial ecology, and in 2011 Wallonia launched a competitiveness cluster for green technologies, which supports several energy research programmes and launched the Employment-Environment Alliance to promote sustainable construction. Flanders' two major measures are the Flemish Climate Policy Plan 2013-20 and the Flemish Second Energy Efficiency Action Plan (2011-16), which has adopted new energy standards, especially in construction and housing, aimed at building energy-neutral buildings by 2021. The federal level has focused on societal challenges by launching BRAIN, an important research programme.

Innovative entrepreneurship: The development of research and innovation in SMEs is a policy priority at the federal as well as the regional level. SMEs have received a wide range of support for improving their innovation capabilities (training, consultancy, funding, business angels, etc.). The federal government has increased the reduction on the advance tax payment for all research and technical staff in young innovative companies from 50% to 75%. In addition to instruments for SMEs such as the SME Wallet and the innovation voucher, BCR has developed new instruments in conjunction with EU initiatives aimed at SMEs. In Flanders, support for innovation in SMEs reached a record 58% of total direct innovation support for businesses in 2013. Recent initiatives include Sprint projects, which target large companies that conduct middle-large development projects, or VIS-trajecten IV aimed at "innovation-follower" companies. The Walloon government's overall budget for direct support of business R&D and innovation increased by more than 70% over the last five years to USD 144 million (EUR 120 million) in 2013. Novallia is a USD 53 million (EUR 46 million) scheme that promotes SMEs' innovation projects via loans at fixed interest rates. Wallonia has also developed several schemes to promote research and innovation in SMEs through the Walloon Small Business Act and Creative Wallonia Plan.

Clusters and smart specialisation: Discussions were launched in all regions in 2011 on a "smart specialisation strategy" to reshape innovation policy instruments and governance. The BCR innovation plan (2013-20) is aligned both with the EU's Strategy 2020 and with the region's smart specialisation strategy. The Flemish government launched several calls in 2012-13 to stimulate demand-driven initiatives, such as proposals for key enabling technologies, for testing the trajectories of a cluster-oriented policy, and for projects from co-operating businesses to develop a roadmap for a new industrial entrepreneurship. Cluster policy is the backbone of Wallonia's smart specialisation strategy, which focuses on innovation and creativity, greening, internationalisation, and SMEs.

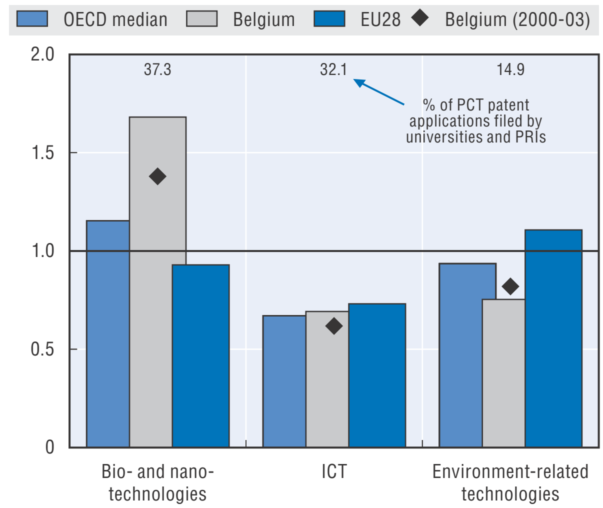
Panel 2. Structural composition of BERD, 2011

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



Panel 3. Revealed technology advantage in selected fields, 2009-11

Index based on PCT patent applications



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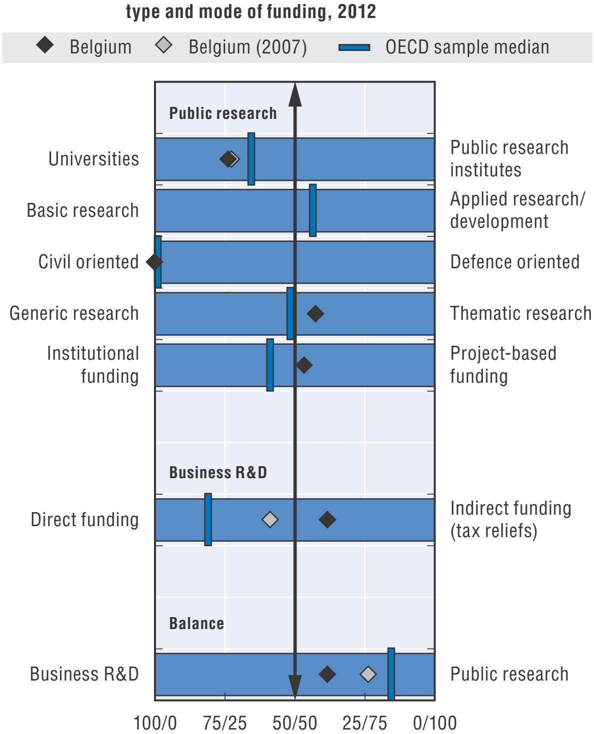

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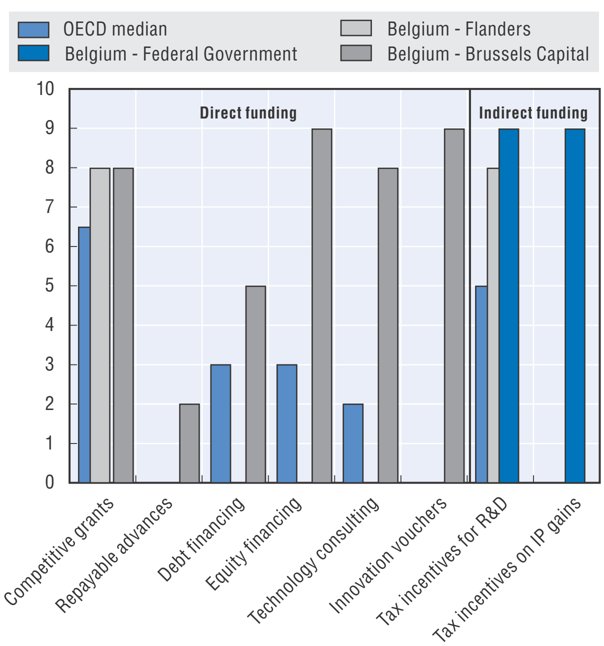

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Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888933152044

BRAZIL

An emerging economy, Brazil has the world's seventh largest economy. It weathered the global economic downturn well, but growth has slowed over the last two years. To boost economic performance, the Greater Brazil Plan 2011-14, adopted in 2011, gives innovation a central role and includes proposals for significant changes in legislative frameworks.

Hot issue 1: Innovation to contribute to structural adjustment and to a new approach to growth. The National Strategy for Science, Technology and Innovation (ENCTI) 2012-15 aims to: *i)* close the technological gap with developed economies; *ii)* support Brazil's leadership in areas of the knowledge economy that take advantage of the country's rich natural resources, such as green innovation, agro-business and other natural-resource-based activities; *iii)* strengthen the internationalisation of the national research system; *iv)* foster the development of a green economy; and *v)* address the country's substantial social and regional inequalities. To achieve these objectives, the government targets GERD of 1.8% of GDP in 2014, up from 1.16% in 2010. Compared to other major emerging economies, Brazil's 2010 R&D intensity is second to China's (1.76% of GDP), ahead of India's (0.76%, 2007) and South Africa's (0.76%), and well ahead of Chile's (0.33%) and Mexico's (0.45%) of the same year.

Hot issue 2: Promoting innovation in firms, entrepreneurship and SMEs. Brazil is home to a few of the world's largest R&D-investing firms (Panel 1[e]). It is also at the forefront of high-technology fields such as deep-water oil extraction. This leadership in innovation, however, has not spilled over to the Brazilian economy; the country's overall innovation performance on non-technological innovation such as trademark registration is very weak (Panel 1[g]). To address this challenge, the ENCTI aims to increase BERD from 0.56% of GDP in 2010 to 0.9% in 2014. Difficult framework conditions for innovation are also responsible for weak STI performance, although barriers to entrepreneurship are lower in Brazil than in China or India (Panel 1[j]).

To promote business innovation, Brazil's innovation policy has progressively shifted from a strong focus on support for science to stronger support for business R&D. Several changes have been made in the legislative framework: the Innovation Law (*Lei da Inovação* 2004), the Goodwill Law (*Lei do Bem*, 2005), and a 2007 modification of tax exemption rules to permit direct funding and to provide more incentives for businesses to engage in innovation. On 14 March 2013, the federal government launched the Innovate Company Plan (*Plano Inova Empresa*) to: raise the level of R&D in companies; encourage projects with greater technological risk; combine finance (credit) with non-refundable grants and equity financing; maximise the use of the state's purchasing power; decentralise policy implementation to reach microenterprises and SMEs and reduce administrative bureaucracy. Between 2013 and 2014, it allocated USD 21.6 billion (BRL 32.9 billion) for companies' investment in product and processes innovation.

Hot issue 3: Supporting innovation to address social challenges (inclusiveness). Funding agencies provide support for developing low-cost, easy-to-use applications that address social challenges. For example, HABITARE, an initiative with a budget of USD 14 million (BRL 22 million) for 2009-10, supports innovations in housing technology including for social housing. The programmes and measures to support entrepreneurship and start-ups described above can also help make innovation more inclusive, and measures for higher school enrolment rates (see below) also aim to reduce social exclusion.

Highlights of the Brazilian STI system

STI policy governance: Brazil's STI policy governance has not changed significantly in recent years. Developments are underway to increase the decentralisation of instruments and strengthen the co-ordination of federal, state and private resources for innovation in the process of programmes implementation. The National Council for Industrial Development was redesigned in August 2011 to improve co-ordination and involvement of stakeholders. Ministries, the president of the National Bank for Economic and Social Development (BNDES), private businesses, and industry and labour union representatives participate in the Council.

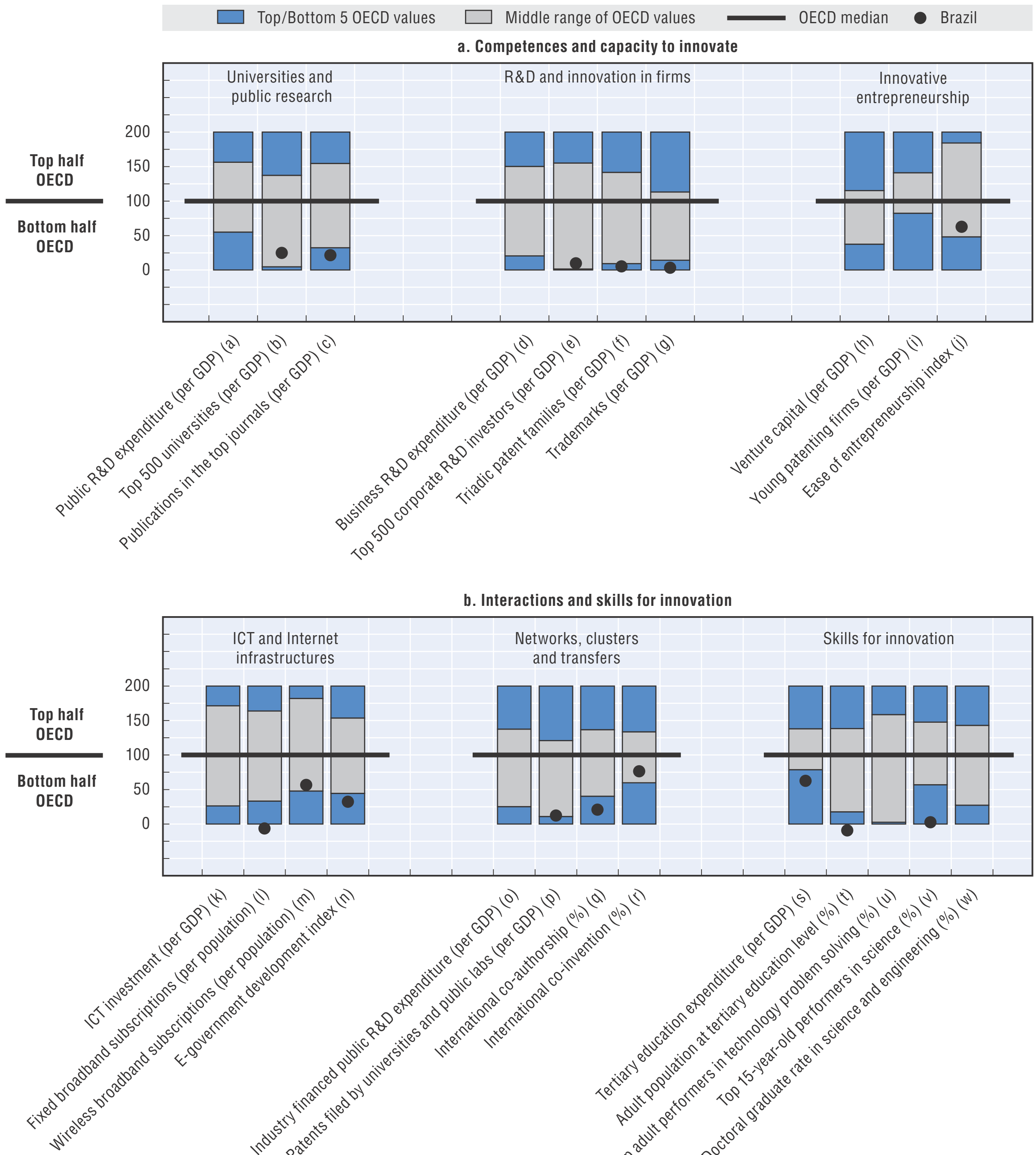
New sources of growth: Brazil's STI strategy seeks to strengthen its comparative advantage in the "green" economy. In environmental technologies, Brazil has an RTA above

Key figures, 2013

Economic and environmental performance	BRA	OECD	Gross domestic expenditure on R&D	BRA	OECD
Labour productivity			**GERD**		
GDP per hour worked, USD PPP, 2013	n.a.	47.7	Million USD PPP, 2010	25 292	1 107 398
(annual growth rate, 2008-13)	n.a.	(+0.8)	As a % of total OECD, 2010	2.5	100
Green productivity			**GERD intensity and growth**		
GDP per unit of CO_2 emitted, USD, 2011	5.0	3.0	As a % of GDP, 2010	1.16	2.40
(annual growth rate, 2007-11)	(0.0)	(+1.8)	(annual growth rate, 2007-10)	(+6.1)	(+2.0)
Green demand			**GERD publicly financed**		
NNI per unit of CO_2 emitted, USD, 2011	n.a.	3.0	As a % of GDP, 2010	0.63	0.77
(annual growth rate, 2007-11)	n.a.	(+1.6)	(annual growth rate, 2007-10)	(+6.2)	(+2.8)

Figure 9.5. **Science and innovation in Brazil**

Panel 1. Comparative performance of national science and innovation systems, 2014



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

the BRIICS average, but below the OECD median; In bio- and nano-technologies, Brazil displays an advantage with respect to both the OECD and the EU28 (Panel 2). Support programmes include sectoral funds (CT-Energy, CT-Petro). In February 2012, a new Climate Fund under BNDES was announced to finance projects that help reduce greenhouse gas emissions.

Universities and public research: Brazil has relatively few universities among the world's top 500 (Panel 1[b]). Performance, measured by science and engineering publications in top-quartile scientific journals (Panel 1[c]) is weak by OECD standards, although Brazilian S&E articles increased on average by 6.4% a year between 2001 and 2011, according to the US National Science Foundation. The increase was, however, less than that of other major emerging economies: China (15.6%) but also India (7.6%).

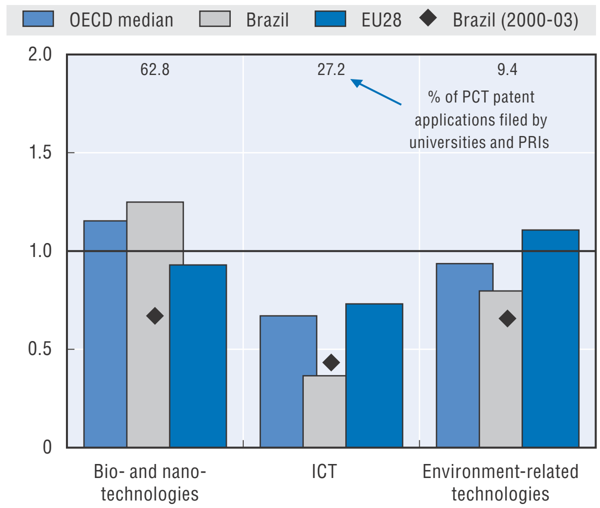
Innovative entrepreneurship: Many Brazilian SMEs innovate little. Several government initiatives therefore support start-ups and provide funding support mainly in the form of grants. For example, PRIME, the *Primeira Empresa Inovadora* programme, supported 1 381 enterprises with USD 104 million (BRL 166 million) between 2009 and 2011. As part of the decentralisation of financing for microenterprises and SMEs, the Brazilian Innovation Agency's (FINEP) Inovacred programme, established in September 2012, aims to improve funding support by decentralising financing operations through development banks, public research promotion agencies and state commercial banks. From 2012 to 2018, the programme plans to certify 20 financial agents and to fund approximately 2 000 firms with a total of USD 788 million (BRL 1.2 billion). In addition, the *Pró-Inova* programme, introduced in 2005, encourages business innovation and entrepreneurship by diffusing information about the available tools, facilities and mechanisms.

Technology transfer and commercialisation: The government has strongly emphasised supporting the commercialisation of technological innovations. On 10 July 2013, FINEP issued a new USD 420 million (BRL 640 million) call to support incubators and technological parks as well as their resident companies. Public support will be provided to incubators and technological parks through loans to and equity investments in the resident companies as well as to firms having graduated in less than two years. Brazil also has several programmes to encourage cross-sector mobility of researchers (e.g. PAPPE, the Programme for Support of Research in Enterprise, and SEBRAE, the Brazilian Support Service for Small Enterprises) to facilitate knowledge flows between universities and PRIs and the business sector.

Skills for innovation: Human capital is a major innovation system bottleneck in Brazil. The share of the adult population with tertiary education is very small (Panel 1[t]). The education system needs improvement, and the performance of 15-year-olds in science is very poor (Panel 1[v]), although there were marked improvements in the OECD Pisa scores over 2003-12. Efforts have been made to increase the quality of education at all levels, including the introduction of entrance examinations for teachers. To support higher enrolment rates, funding for basic and professional education has increased and conditions for student loans have eased.

Panel 2. Revealed technology advantage in selected fields, 2009-11

Index based on PCT patent applications



Note: Policy information comes from country responses to the OECD STI Outlook policy questionnaires 2014 and 2012. Brazil's responses are available in the *OECD STI Outlook Policy Database*, edition 2014 at *http://qdd.oecd.org/Table.aspx?Query=4C6D0A7D-252B-47C9-9BB8-2B3B1DFC7275*.

Source: See reader's guide and methodological annex.

StatLink *http://dx.doi.org/10.1787/888933152054*

CANADA

Canada is the world's ninth largest economy, and its export-led growth is projected to strengthen in 2014-15. The STI system is well developed, though weaknesses and challenges remain.

Hot issue 1: Encouraging innovation in firms and supporting entrepreneurship and SMEs. Canadian BERD decreased steadily from 1.26% of GDP in 2001 to 0.88% in 2012, well below the OECD median (Panel 1[d]). This occurred despite the generous Scientific Research and Experimental Development (SR&ED) tax incentive, which amounted to USD 2.7 billion (CAD 3.3 billion) in 2012 and to 80% of overall public support for business R&D. New measures have been announced to streamline and improve the predictability and enforcement of the SR&ED tax incentive programme. Owing to the importance of natural resources industries in the economy, large firms account for a smaller share of Canadian BERD than the OECD average (Panel 2) and Canadian firms fall below the OECD median in terms of top 500 corporate R&D investors (Panel 1[e]). The 2013 federal budget introduced new measures to promote business innovation: USD 325 million (CAD 400 million) to support a Venture Capital Action Plan over the next seven to ten years; USD 98.4 million (CAD 121 million) over two years through the National Research Council to help the growth of innovative businesses; USD 48.8 million (CAD 60 million) over five years to help outstanding, high-potential incubator and accelerator organisations expand their services to entrepreneurs, with an additional USD 32.5 million (CAD 40 million) provided to the Canada Accelerator and Incubator Programme in the 2014 budget; USD 81.3 million (CAD 100 million) through the Business Development Bank of Canada to invest in firms graduating from business accelerators; USD 16 million (CAD 20 million) over three years for the Business Innovation Access Programme (an innovation voucher programme); and USD 15 million (CAD 18 million) over two years to the Canadian Youth Business Foundation to help young entrepreneurs grow their firms.

Hot issue 2: Strengthening R&D capacity and infrastructure. Canada has a strong university-centred research system (Panel 4), which performs above the OECD average (Panel 1[a, b, c]), and has a healthy link to industry funding (Panel 1[o]). The 2014 budget proposes to create the Canada First Research Excellence Fund with an additional USD 1.2 billion (CAD 1.5 billion) to advance Canada's global research leadership over the next decade. New and on-going initiatives to support industry-science linkages include: new funding of USD 30 million (CAD 37 million) in 2013-14 and on-going funding through the federal research granting councils for partnered research. The Canada Foundation for Innovation (CFI) received USD 403 million (CAD 500 million) in the 2012 budget to sustain its core investment in modern research infrastructures. A further USD 183 million (CAD 225 million) was allocated to CFI in the 2013 budget to enrich the next Leading Edge/New Initiatives Fund competition, to support cyber-infrastructure, etc. In keeping with global trends on open access, the Natural Sciences and Engineering Research Council and the Social Sciences and Humanities Research Council are considering a policy that would require federally funded peer-reviewed journal publications to be made freely available within one year of publication, as is currently the case for research funded by the Canadian Institutes of Health Research.

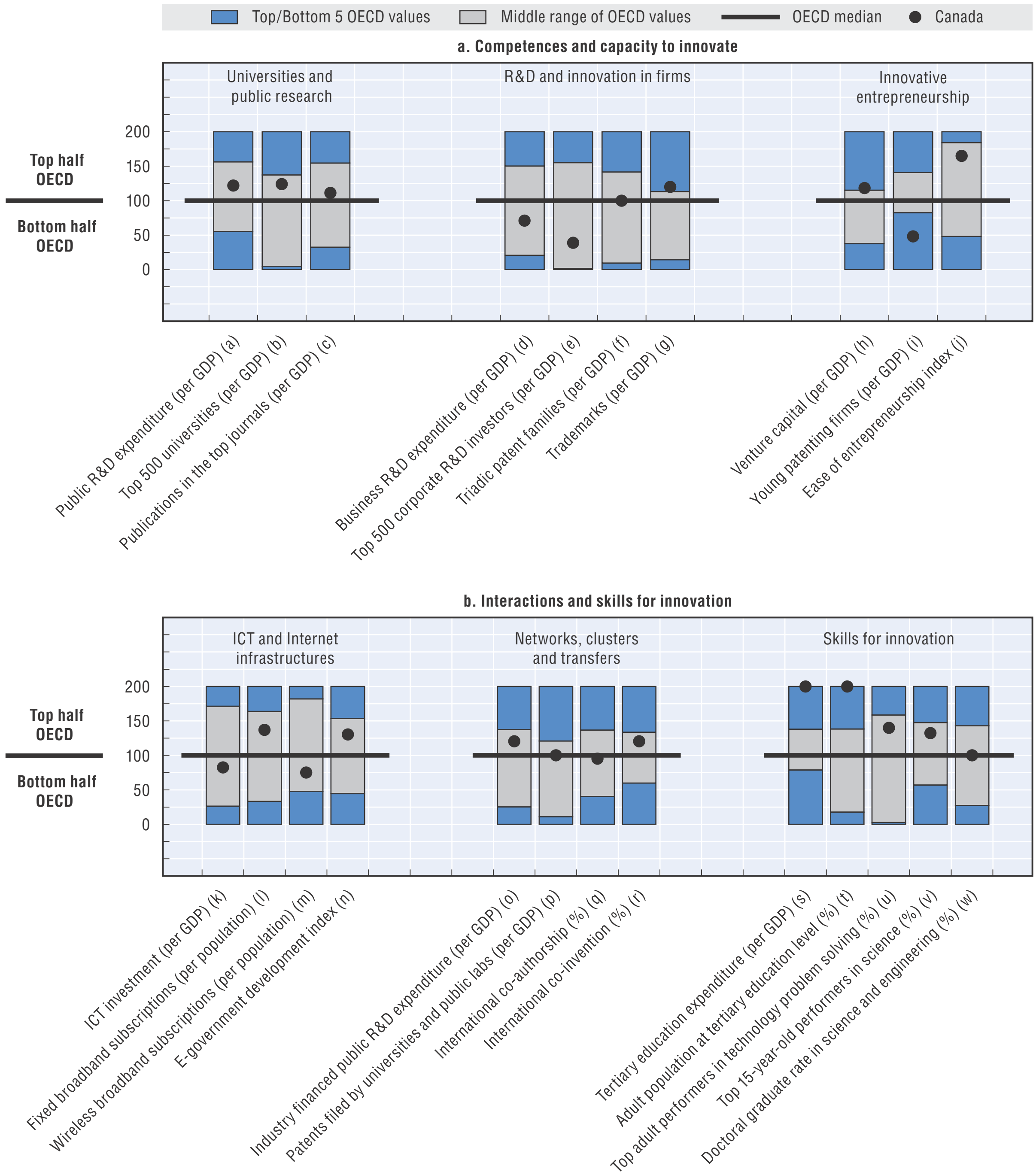
Hot issue 3: Targeting priority areas/sectors. Canada has a strong RTA in the three technological areas covered in Panel 3, but its RTA in environment-related technologies decreased in past years. To support the development and demonstration of new, clean technologies, the government appropriated USD 264 million (CAD 325 million) in its 2013 budget over eight years to Sustainable Development Technology Canada. Also in the 2013 budget, Canada's manufacturing and processing sector received USD 1.1 billion (CAD 1.4 billion) in tax relief for the 2014-18 period. The government will also provide stable funding of close to USD 813 million (CAD 1 billion) over five years for the permanent Strategic Aerospace and Defence Initiative, some of which is directed to an Aerospace Technology Demonstration Programme, in addition to new funding for the latter. On 7 February 2014, the framework for Canada's future in space was unveiled and will serve as a guide for Canada's strategic activities, including R&D, in space. In the 2014 budget, strategic investments in the automotive and forestry sector include: USD 406 million (CAD 500 million) in additional funding for the Automotive Innovation Fund over

Key figures, 2013

Economic and environmental performance	CAN	OECD	Gross domestic expenditure on R&D	CAN	OECD
Labour productivity			**GERD**		
GDP per hour worked, USD PPP, 2013	49.2	47.7	Million USD PPP, 2012	24 801	1 107 398
(annual growth rate, 2008-13)	(+0.8)	(+0.8)	As a % of total OECD, 2012	2.2	100
Green productivity			**GERD intensity and growth**		
GDP per unit of CO_2 emitted, USD, 2011	2.3	3.0	As a % of GDP, 2012	1.69	2.40
(annual growth rate, 2007-11)	(+1.4)	(+1.8)	(annual growth rate, 2007-12)	(-1.4)	(+2.0)
Green demand			**GERD publicly financed**		
NNI per unit of CO_2 emitted, USD, 2011	2.1	3.0	As a % of GDP, 2012	0.71	0.77
(annual growth rate, 2007-11)	(+0.7)	(+1.6)	(annual growth rate, 2007-12)	(+0.4)	(+2.8)

Figure 9.6. **Science and innovation in Canada**

Panel 1. Comparative performance of national science and innovation systems, 2014



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

the next two years and USD 73.5 million (CAD 90.4 million) over four years to renew the Investments in Forest Industry Transformation programme.

Highlights of the Canadian STI system

STI policy governance: The Canadian government will release an updated STI strategy in 2014. The new strategy draws on the results of a broad public consultation on three policy areas: business innovation; developing innovative and entrepreneurial people; and excellence in public and post-secondary R&D. In May 2013, the National Research Council (NRC) announced that it would become a national research and technology organisation inspired by the German Fraunhofer institutes. It was reorganised into three divisions: engineering, life sciences and emerging technologies and chose areas of strategic importance in which to stimulate business investments in critical R&D. The NRC also put in place a Concierge Service, a single access point for SMEs looking for innovation-related assistance.

New sources of growth: The NRC partnered with the provinces and the private sector to fund several research initiatives in 2013 and stimulate industrial R&D activity in key technologies: printable electronics: USD 33 million (CAD 40 million); industrial biomaterials: USD 44.7 million (CAD 55 million); the Algal Carbon Conversion Pilot Project: USD 15 million (CAD 19 million); and the Canadian Wheat Alliance: USD 79 million (CAD 97 million). A new Advanced Manufacturing Fund of USD 163 million (CAD 200 million) was announced in the 2013 budget.

New challenges: The government addresses the global health challenge through a contribution of USD 183 million (CAD 225 million) to Grand Challenges Canada (GCC) through 2016. USD 12 million (CAD 15 million) a year will support expansion of the Strategy for Patient-Oriented Research, the creation of the Canadian Consortium on Neurodegeneration in Ageing, and other health research priorities.

ICT and Internet infrastructure: In April 2014, the Canadian government released Digital Canada 150, a plan to take full advantage of the digital economy. It includes new investments to help SMEs adopt digital technologies and to provide digital companies with access to venture capital. It also promotes digital technologies and open data. The federal government is a primary funder of a number of organisations that are key stakeholders in the advanced digital research ecosystem: Compute Canada, a national platform of supercomputing resources; CANARIE, Canada's Advanced Network for Innovation and Research, which provides a "national backbone" high-speed network to meet the needs of researchers working with high volumes of complex data; and Canada's research granting councils, which fund academic research and research infrastructure and cover data collection, development, analysis (computing), storage and networking aspects of research; and universities across Canada.

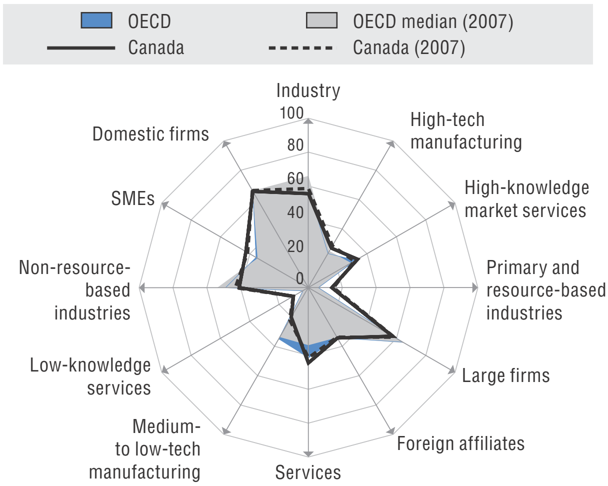
Clusters and smart specialisation: Over the next five years, to help Canada capture the commercial opportunities presented by open data, the Atlantic Canada Opportunities Agency will provide USD 366 million (CAD 450 million) to support innovation and commercialisation. The Federal Economic Development Agency for Southern Ontario will establish an Open Data Institute in Waterloo, Ontario. The Institute for Quantum Computing, at the University of Waterloo, is a leading Canadian research facility. It received USD 12 million (CAD 15 million) over three years, starting in 2014-15, to carry out and commercialise leading-edge research in quantum technologies. The 2014 government budget announced a total of USD 180 million (CAD 222 million) over five years for TRIUMF, Canada's premiere physics laboratory and home to the world's largest cyclotron particle accelerator in British Columbia.

Globalisation: In November 2013, Canada released a Global Markets Action Plan. A key objective is linkages to international business partners, international research, venture capital and entrepreneurial services that help high-potential Canadian businesses maximise access to opportunities. In January 2014, a new International Education Strategy was launched to maintain and enhance Canada's global position in higher education by attracting more international researchers and deepening research links between Canadian and foreign educational institutions. Several initiatives also facilitate the international mobility of the highly skilled and entrepreneurs.

Skills for innovation: Canada spends the highest share of GDP on higher education in the OECD area, and has a strong skills base in science and innovation (Panel 1[s, t, u, v]). The government has made strategic investments to strengthen S&E education, including information campaigns about fields of study, funding for internships in high-demand fields via the Career Focus programme, and enhanced support for First Nations and Inuit students.

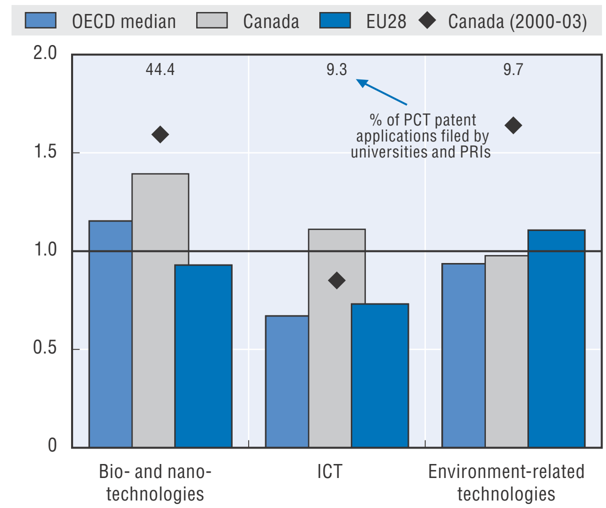
Panel 2. Structural composition of BERD, 2011

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

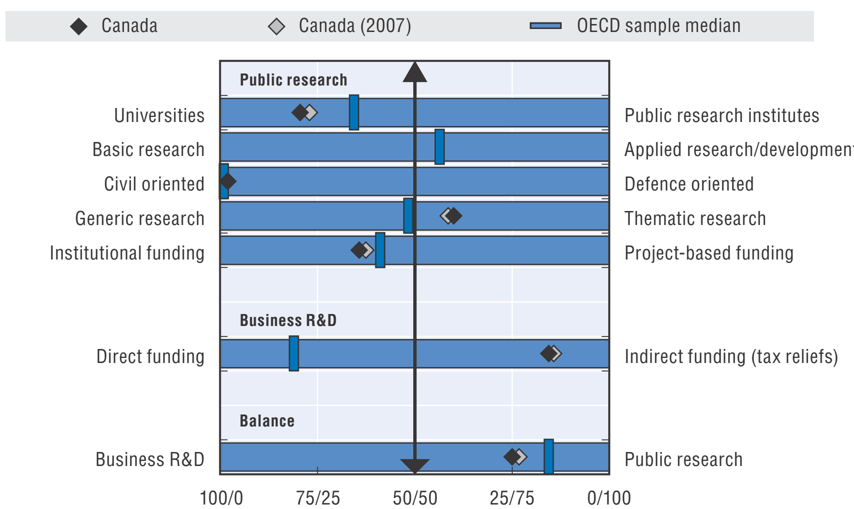


Panel 3. Revealed technology advantage in selected fields, 2009-11

Index based on PCT patent applications



Panel 4. Allocation of public funds to R&D, by sector, type and mode of funding, 2012



Note: Policy information comes from country responses to the OECD STI Outlook policy questionnaires 2014 and 2012. Canada's responses are available in the *OECD STI Outlook Policy Database*, edition 2014 at *http://qdd.oecd.org/Table.aspx?Query=72CBF532-BA6B-4BFC-90E9-02EBF397362D*.

Source: See reader's guide and methodological annex.

StatLink *http://dx.doi.org/10.1787/888933152069*

CHILE

Over 2008-13, Chile's productivity growth exceeded that of most OECD economies. While Chile's STI system lags in many respects, it is catching up in some areas.

Hot issue 1: Improving the framework conditions for innovation (including competitiveness). While BERD as a share of GDP lags the OECD median (Panel 1[d]), it grew by 10% in 2009-12; 7.8% of BERD is publicly financed in 2012, down from 18.3 % in 2009, and close to the OECD average (7.6%). In March 2012, to encourage further private investment in R&D, the government modified its R&D tax credit framework: the eligibility requirements for collaboration with external research centres and the requirement to invest at least 15% of the company's gross annual revenue were abolished.

Hot issue 2: Increasing returns and impact of science. Chile's public research system has a small budget; few of its universities are among the world's leading institutions and there are few international publications relative to GDP by OECD standards (Panel 1[a, b, c]). However, the 35.3% of Chilean GERD performed by HEIs in 2012 was well above the OECD average (18.1%), owing to the importance of HEIs in the innovation system. To capitalise on the returns from a rather limited science base, several initiatives to encourage and step up the commercialisation of public research were introduced during 2012-14 (see below).

Hot issue 3: Encouraging innovation in firms and supporting entrepreneurship and SMEs. Chile's business innovation performance is well below the OECD medians (Panel 1[d, f, g]), particularly among SMEs. To address this challenge, the government supports entrepreneurship through several funding schemes, including seed, angel and venture capital programmes that also provide financial, legal and managerial advice. Triadic patent applications as a share of GDP (Panel 1[f]) indicate that Chile currently has a weak international technological presence. In 2012 the Ministry of Foreign Affairs created CONTACTChile to support the internationalisation of Chilean businesses. CONTACTChile targets technology-intensive companies (primarily SMEs) with a strong export potential. Each beneficiary is supported with up to USD 20 000. It focuses on ICT, environment and biotechnology sectors and on firms that address social challenges.

Hot issue 4: Improving the governance of innovation. In January 2013, the government created an S&T advisory committee (STAC) to improve the governance of the innovation system. In its report, "Institutional Modernisation for STI", the committee identified several obstacles that are hard to address under the current governance framework. A key objective is to optimise the use of the public budget for innovation. Public R&D expenditure is managed by different agencies; they respond to different ministries and do not necessarily adhere to an integrated, common, long-term vision for STI policy. The STAC suggested creating an institutional body to co-ordinate the agencies involved. Also, to strengthen collaboration of HEIs with the business sector, the STAC proposed creating a ministry in charge of formulating co-ordinated policies for STI and higher education.

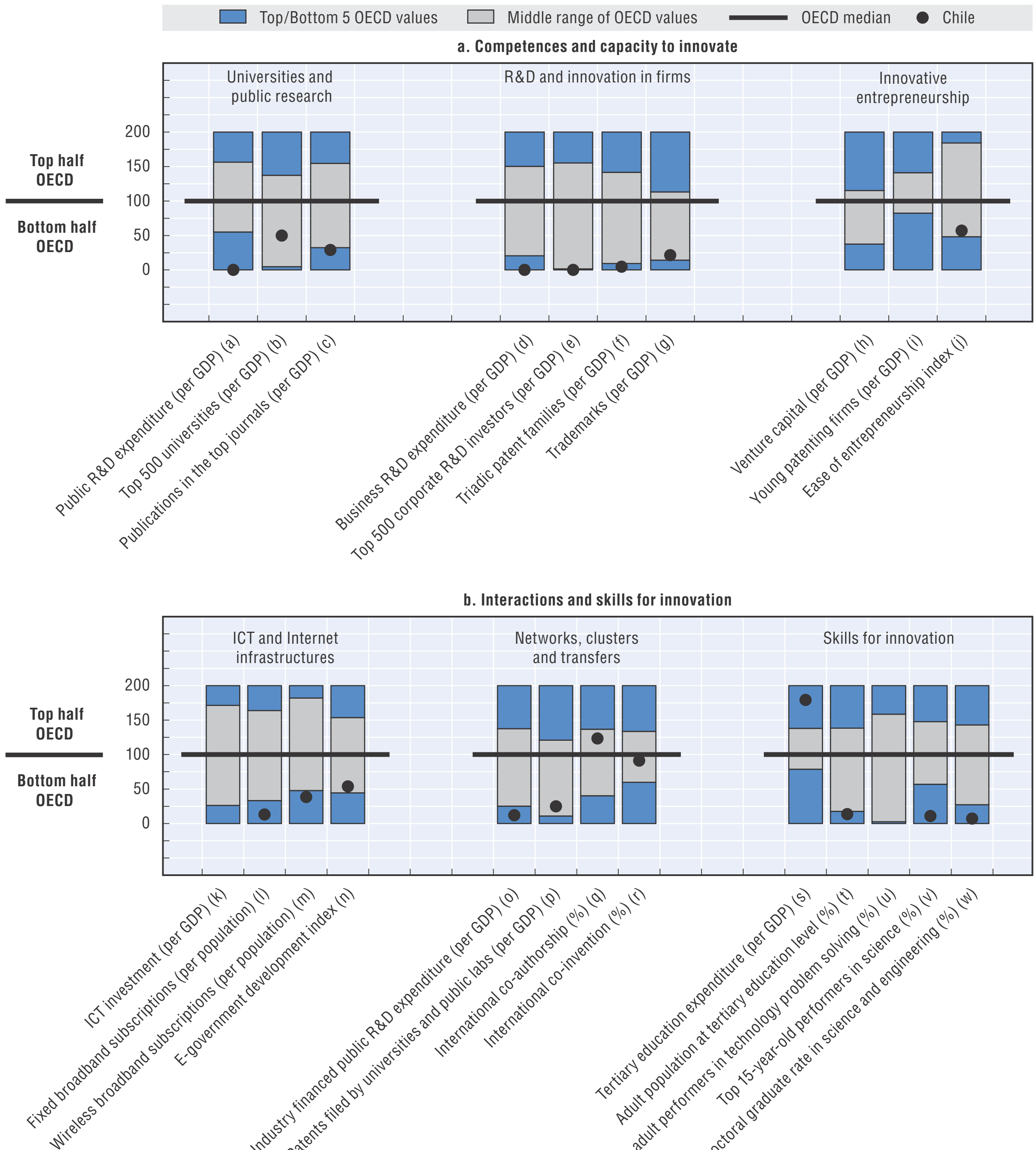
Hot issue 5: Enhancing high-end HRST and the supply of researchers. Chile spends 2.61% of GDP on higher education (Panel 1[s]), just behind Canada and the United States, and 29% of the Chilean population has tertiary education (Panel 1[t]), a share comparable to that of the EU28 (27%). Yet in 2012, Chile had only one researcher per thousand employees, compared to the EU28 average of seven. Also, quality indicators only place Chile at the OECD bottom (Panel 1[v]). To improve the supply of high-end HRST, the government is expanding its *Becas Chile* scholarship programme. Its budget of USD 151 million (CLP 52 588 million) for 2013 provides full financial support for international postgraduate studies on condition that students return to Chile upon completion of their studies. In addition, a national scholarship programme, with USD 113 million (CLP 39 238 million) in 2013, funds postgraduate studies in Chilean universities.

Key figures, 2013

Economic and environmental performance	CHL	OECD	Gross domestic expenditure on R&D	CHL	OECD
Labour productivity			**GERD**		
GDP per hour worked, USD PPP, 2013	26.7	47.7	Million USD PPP, 2012	1 312	1 107 398
(annual growth rate, 2008-13)	(+2.4)	(+0.8)	As a % of total OECD, 2012	0.1	100
Green productivity			**GERD intensity and growth**		
GDP per unit of CO_2 emitted, USD, 2011	3.4	3.0	As a % of GDP, 2012	0.35	2.40
(annual growth rate, 2007-11)	(-1.4)	(+1.8)	(annual growth rate, 2007-12)	(+6.4)	(+2.0)
Green demand			**GERD publicly financed**		
NNI per unit of CO_2 emitted, USD, 2011	4.4	3.0	As a % of GDP, 2011	0.16	0.77
(annual growth rate, 2007-11)	(+0.2)	(+1.6)	(annual growth rate, 2007-10)	(+8.4)	(+2.8)

Figure 9.7. **Science and innovation in Chile**

Panel 1. Comparative performance of national science and innovation systems, 2014



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

Highlights of the Chilean STI system

New sources of growth: The National Innovation Council reviewed Chile's innovation strategy in August 2013 at the end of the President Piñera government. The review identified energy, biology and education as strategic business sectors. As part of its new STI strategy, Chile will also carry out a decadal survey on astronomy in 2014. The government expects to host more than two-thirds of the world's terrestrial observations in the next decade. In addition to providing policy guidelines, the review aims to create a public network of actors to co-ordinate scientific, technological and entrepreneurial efforts. Recently, the new government of President Bachelet launched the Growth, Innovation and Productive Agenda, which includes priority sectors for social and economic development.

Innovative entrepreneurship: Overall, Chile's Ease of Doing Business Index is below the OECD median (Panel 1[j]). The Chilean authorities have continued their efforts in this regard: a new law, introduced in May 2013, eases requirements for business registration and reduces the time required for registering a firm to one day.

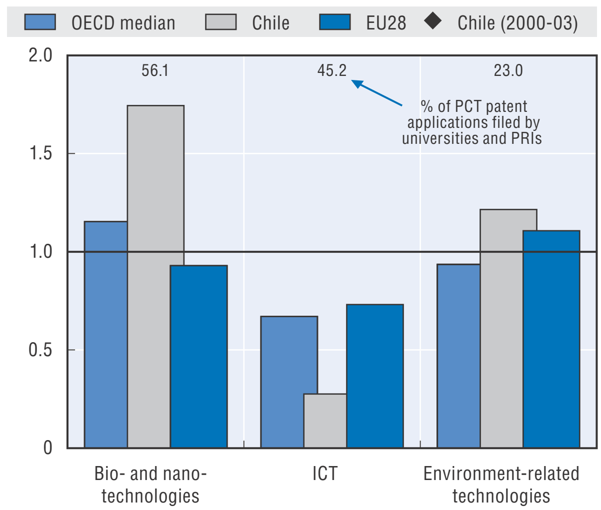
ICT and Internet infrastructures: Connectivity and use of the Internet continue to be a challenge for Chile. The country lags the OECD in fixed and wireless broadband subscribers per capita (Panel 1[l, m]). Its e-government development index has improved since 2012 but is still below the OECD median (Panel 1[n]).

Technology transfer and commercialisation: In order to strengthen the commercialisation of public research, the Transfer and Licensing Offices Programme (from the Chilean Economic Development Agency, CORFO) seeks to build competences for managing technology transfer and commercialising R&D. It also funds the training (in Chile and abroad) of professionals and technical staff in universities and research institutes. It also seeks to strengthen its IPR framework by improving procedures, protection and enforcement of IPR. The National Commission for Scientific and Technological Research (CONICYT) continues its efforts to facilitate access to research data generated by public funds.

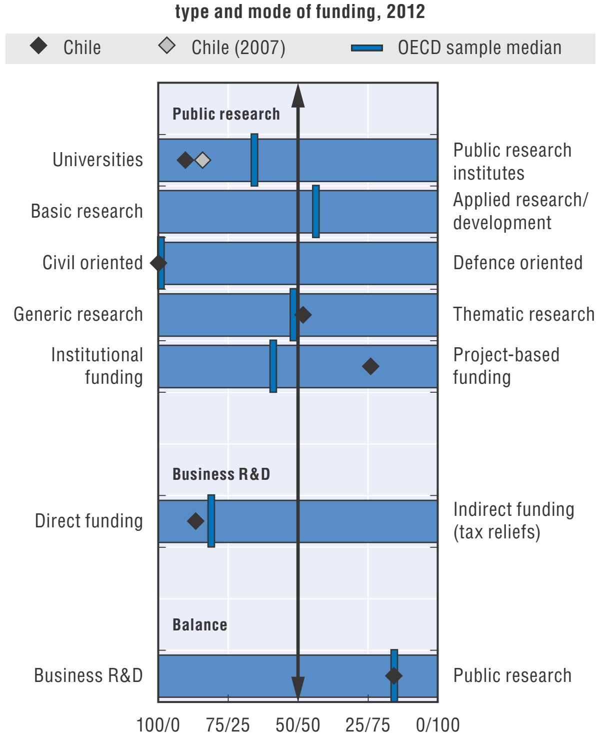
Globalisation: Over the past three years, Start-Up Chile, a seed capital programme, has supported more than 750 start-ups, whose founders come from over 70 countries. The programme seeks to attract overseas entrepreneurs by offering USD 40 000 in equity-free seed capital and a working visa to develop projects in Chile.

Panel 2. Revealed technology advantage in selected fields, 2009-11

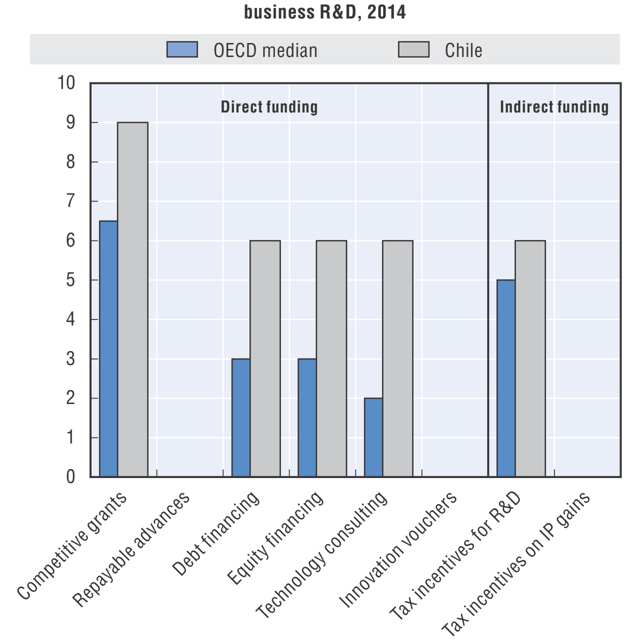
Index based on PCT patent applications



Panel 3. Allocation of public funds to R&D, by sector, type and mode of funding, 2012



Panel 4. Most relevant instruments of public funding of business R&D, 2014



Note: Policy information comes from country responses to the OECD STI Outlook policy questionnaires 2014 and 2012. Chile's responses are available in the *OECD STI Outlook Policy Database*, edition 2014 at *http://qdd.oecd.org/Table.aspx?Query=F0FDDDAB-9EE4-46BB-B88D-03B3CF196AED*.

Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888933152070

CHINA

China's growth pattern is currently changing, with a reduction in the rate of growth and an attempt to rebalance the economy from exports and investment towards private consumption. Innovation plays an increasing role, as illustrated by the fact that China spent 1.98% of GDP on R&D in 2012, closing the gap with the EU28.

Hot issue 1: Encouraging innovation in firms and supporting entrepreneurship and SMEs. The business sector accounts for 74% of GERD (1.51% of GDP, 2012), and Chinese firms are active both as R&D performers and contractors (Panel 1[d, o]). Although the number of patent applications by Chinese residents has soared in recent years, Chinese innovation output is still lagging in terms of international patenting and trademark registration (Panel 1[f, g]) by OECD standards. There is a lack of venture capital and the business environment is difficult for innovative start-ups. The dominance of state-owned enterprises (SOEs), especially in public utilities, tends to mitigate the pressures to innovate that normally arise from competition. Improving the business sector's innovation capability is therefore a key challenge. Various policy instruments foster an enterprise-centred innovation system and emphasise the indigenous innovation capacity of Chinese firms. The tax incentive was revised in 2013 to expand the range of eligible R&D costs and make not-for-profit R&D organisations eligible for tax allowances on imported R&D equipment. Tax incentives are granted to firms investing in education and training programmes. The corporate income tax and the value added tax have been reduced for high-technology enterprises, SMEs and ICT firms in order to support their development.

Hot issue 2: Innovating to address to social challenges. China faces serious social challenges in terms of food security, public health and ageing, all of which will require contributions from STI. The National S&T Major Projects therefore focus strongly on public health, ageing, food and drug safety, and disaster prevention. Energy and health are among the four sectoral focuses of the Innovation 2020 Programme of the Chinese Academy of Sciences. China has also promoted "inclusive innovation", i.e. innovation by and for low-income people. Existing initiatives include the Spark Programme, which promotes agricultural and rural developments by facilitating peasants' access to relevant technologies and related training and the S&T Programme for Public Wellbeing, which supports the commercialisation of technologies that can benefit social development, both implemented under the Ministry of S&T.

Hot issue 3: Innovating to contribute to sustainable and green growth. The main priority is to enhance the contribution of STI to China's transition to an ecologically sustainable mode of development. China's green productivity, at USD 1.3 (GDP per unit of CO_2 emitted, 2011), was much lower than EU27's at USD 4. At 4.1% a year, however, it grew faster than the OECD median at 1.8% over 2007-11. The government's 12th Five-Year Plan (2011-15) sets the target for green productivity growth at 17% over the five-year period. The present 12th Five-Year-Plan for S&T Development therefore focuses considerable attention on energy and climate change and has triggered a new wave of industrial policies in support of clean energy industries and related low-carbon technologies. Yet, China's RTA in biotechnology and green technologies has slipped considerably (Panel 3).

Hot issue 4: Strengthening public R&D capacity and infrastructures. Although many PRIs became corporate entities as part of the reform of the S&T system in the early 2000s, PRIs still dominate China's public research and are strongly oriented towards applied and experimental R&D (Panel 4). The government issued "Opinions on Deepening the Reform of the Scientific and Technological System and Speeding up the Building of a National Innovation System" in September 2012. The new round of PRI reforms aims to clarify the roles of the three types of PRI (commercial innovation, social welfare and basic research), and to establish appropriate governance, management and funding mechanisms to fulfil their missions.

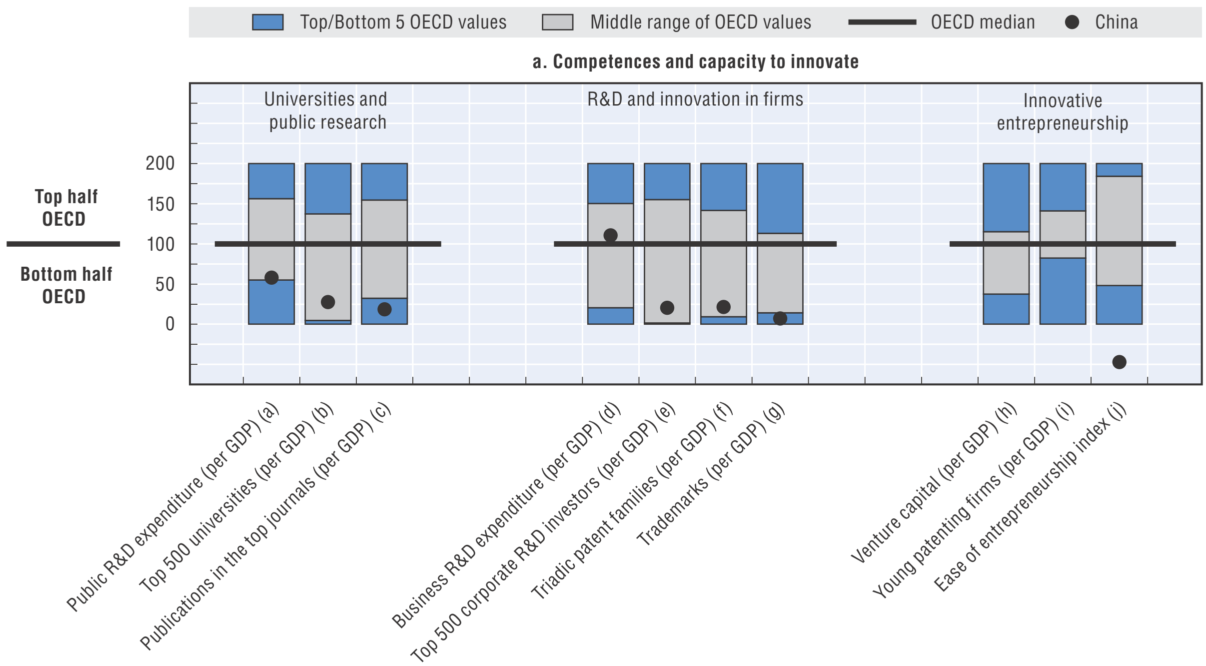
Hot issue 5: Fostering high-end human resources for S&T and research. Although China has the world's largest pool of human resources for S&T, the tertiary-qualified share of the population is still extremely low (Panel 1[t]). Furthermore, China lacks world-class researchers. Both the Thousand Talents Programme approved by the Organisation Department of the Chinese Communist Party and the 100 Talents of the Chinese Academy of Sciences aim to attract and retain top-tier academics, including from overseas. The

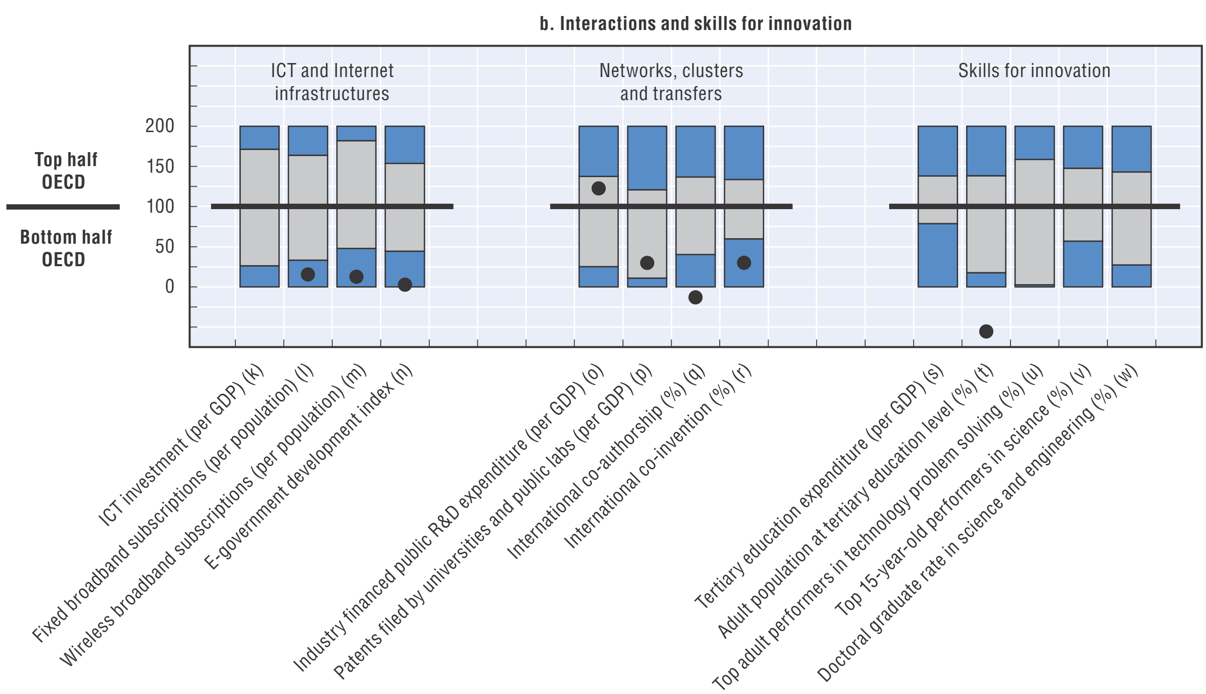
Key figures, 2013

Economic and environmental performance	CHN	OECD	Gross domestic expenditure on R&D	CHN	OECD
Labour productivity			**GERD**		
GDP per hour worked, USD PPP, 2013	n.a.	47.7	Million USD PPP, 2012	293 550	1 107 398
(annual growth rate, 2008-13)	n.a.	(+0.8)	As a % of total OECD, 2012	26.5	100
Green productivity			**GERD intensity and growth**		
GDP per unit of CO_2 emitted, USD, 2011	1.3	3.0	As a % of GDP, 2012	1.98	2.40
(annual growth rate, 2007-11)	(+4.1)	(+1.8)	(annual growth rate, 2007-12)	(+17.2)	(+2.0)
Green demand			**GERD publicly financed**		
NNI per unit of CO_2 emitted, USD, 2011	n.a.	3.0	As a % of GDP, 2011	n.a.	0.77
(annual growth rate, 2007-11)	n.a.	(+1.6)	(annual growth rate, 2007-12)	(+14.2)	(+2.8)

Figure 9.8. **Science and innovation in China**

Panel 1. Comparative performance of national science and innovation systems, 2014





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

National Plan for Science and Technology Talent Development (2010-20) addresses the business sector's need for innovative personnel, by supporting mobility of the highly skilled and by investing in innovation platforms and national key labs to cultivate talented, leading R&D personnel. Living allowances and funding for postdoctoral research in enterprises are provided as well.

Highlights of the Chinese STI system

STI policy governance: A leading group of the S&T system reform, involving some 20 ministries and national agencies was set up in 2012. A mid-term evaluation of the S&T Development Plan 2006-20 was launched in 2014, and the methods and standards for evaluating the Industry-Research Strategic Alliance for Technological Innovation were issued in 2012. The management of main S&T programmes have been revised to simplify the application process; scientists applying for projects funding run by MOST do not have to conduct the Q&A session in person, as most of the application and evaluation procedures can be done through the Internet, while the budget management system was improved by building the project library and S&T programme information system.

ICT and Internet infrastructures: While ICT infrastructures have developed rapidly in China, ICT use per capita and e-government readiness are still very low by OECD standards (Panel 1[l, m, n]). China has been investing in S&T infrastructures through the R&D Infrastructure and Facility Development Programme since 2005, with an estimated budget of USD 1.5 billion (CNY 5 billion).

Technology transfer and commercialisation: In 2013, the Legislative Affairs Office of the State Council started to revise the Law on Promoting the Transfer of Scientific and Technological Achievement. The number of Industry-Research Technology Strategic Alliances for Technological Innovation increased from four in 2007 to 146 in 2013.

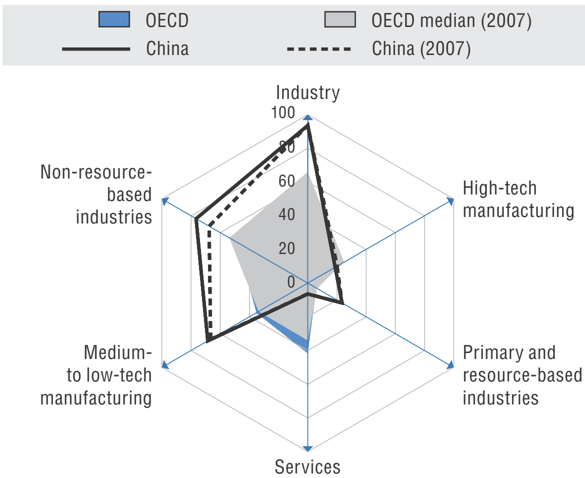
Clusters and smart specialisation: China's national innovation system features marked regional disparities. The government has used the innovation demonstration zones as an important policy instrument to spearhead innovation in regions with relatively advantageous innovation capabilities. So far three zones have been set up in Zhongguncun in Beijing, East Lake in Wuhan and Zhangjiang in Shanghai. Enterprises located in these zones enjoy preferential policies and public support for their innovative activities. Furthermore, the Framework for Development and Reform Planning for the Pearl River Delta Region (2008-20) aims to make the region an innovative centre in the Asia-Pacific area. By 2012, China had 105 high-technology zones, hosting about half of the national technology incubators, and 132 Economic and Technological Development Zones, which have in recent years expanded from the fast-growing coastal cities to other regions. To boost the development of the western region, the Great Western Exploration Strategy supports investments in research infrastructure, research collaboration and human resource mobility between the eastern and western regions.

Globalisation: China's science and innovation systems are weakly linked to global networks, as shown by its very low share of co-authorship and co-invention (Panel 1[q, r]). The government seeks to improve the openness of the STI system through continued government co-operation on S&T and diversification of the ways in which Chinese enterprises and PRIs interact with foreign counterparts. In recent years, China has also increased its participation in large-scale international collaborative projects, such as the EU 7th Framework Programme, and has engaged in annual bilateral dialogues with key partner countries, such as the United States and Germany, on STI co-operation.

Recent developments in STI expenditure: China's R&D intensity has tripled since 1998, reaching 1.98% of GDP in 2012, approaching the level of EU28 as a whole. BERD as a share of GERD rose to the top level of OECD countries and firm self-funded R&D reached 95% of BERD in 2012.

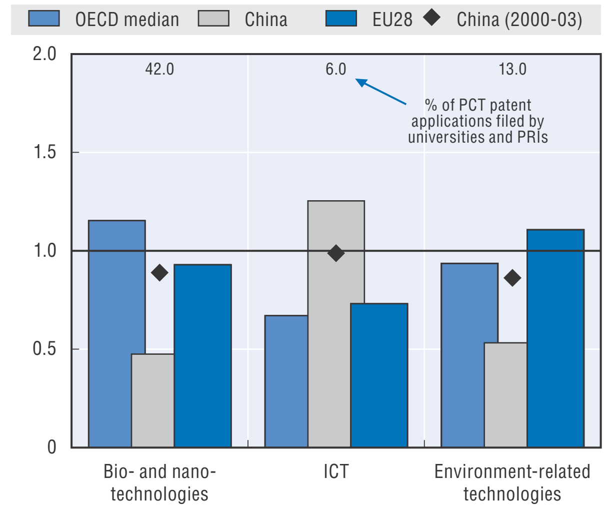
Panel 2. Structural composition of BERD, 2011

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

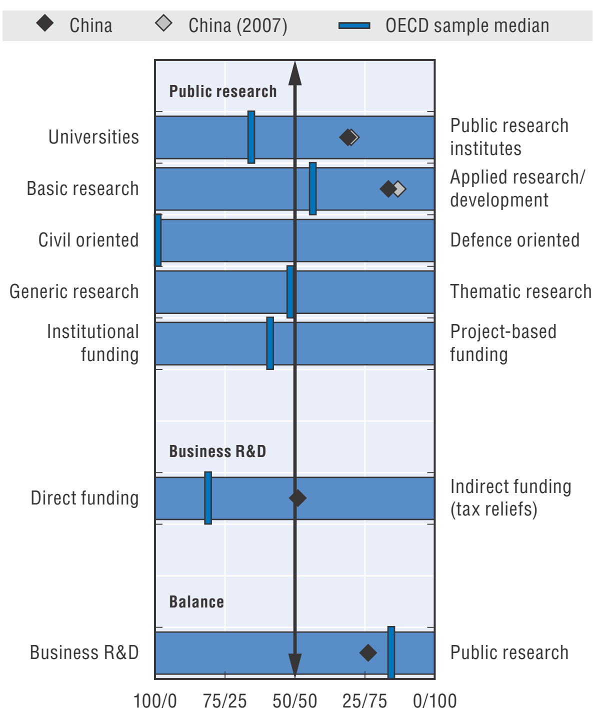


Panel 3. Revealed technology advantage in selected fields, 2009-11

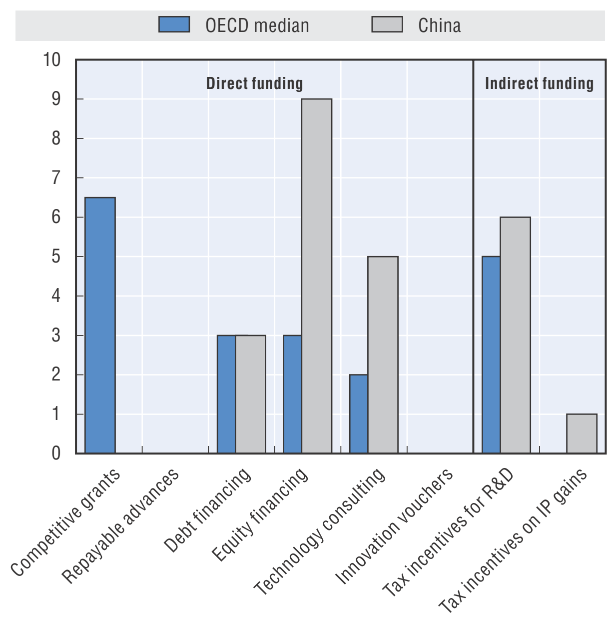
Index based on PCT patent applications



Panel 4. Allocation of public funds to R&D, by sector, type and mode of funding, 2012



Panel 5. Most relevant instruments of public funding of business R&D, 2014



Note: Policy information comes from country responses to the OECD STI Outlook policy questionnaires 2014 and 2012. China's responses are available in the *OECD STI Outlook Policy Database*, edition 2014 at *http://qdd.oecd.org/Table.aspx?Query=AF0BD43B-D359-4A89-BBF3-449C90AC037F*.

Source: See reader's guide and methodological annex.

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COLOMBIA

Colombia has achieved high economic growth during the past decade and shown resilience during the global financial crisis, although it faces still the challenges to boost productivity growth and diversify the economy. In this context, the government has established the following STI hot issues in its National Innovation Strategy (2010-14).

Hot issue 1: Innovation to contribute to addressing social challenges (including inclusiveness). Following the guidelines set out by the national STI strategic plan, several public bodies prioritise the allocation of resources in regions, sectors and knowledge areas considered strategic for social as well as economic development. In 2012, the Administrative Department of Science, Technology and Innovation (Colciencias) created the Ideas for Change programme to support innovative solutions that address societal and environmental challenges at low cost. In 2012, the programme focused on access to water in remote Colombian regions, funding 11 projects for USD 754 000 (COP 948.6 million). The programme currently focuses on the generation of clean and renewable energy in regions that are not connected to the central electrical grid.

In addition, Colciencias carried out in 2012 and 2013 a call for a dialogue on encouraging the development of research from an intercultural perspective. This should create opportunities for generating relevant knowledge in academic, ethnic, territorial and social communities, promote traditional community knowledge, recover the role of knowledge in constructing a social identity and diversify options for socio-economic development.

Moreover, Colombia is integrating its socially focused STI efforts in the design of a social innovation policy, the aim of which is to create a favourable environment for developing social innovation.

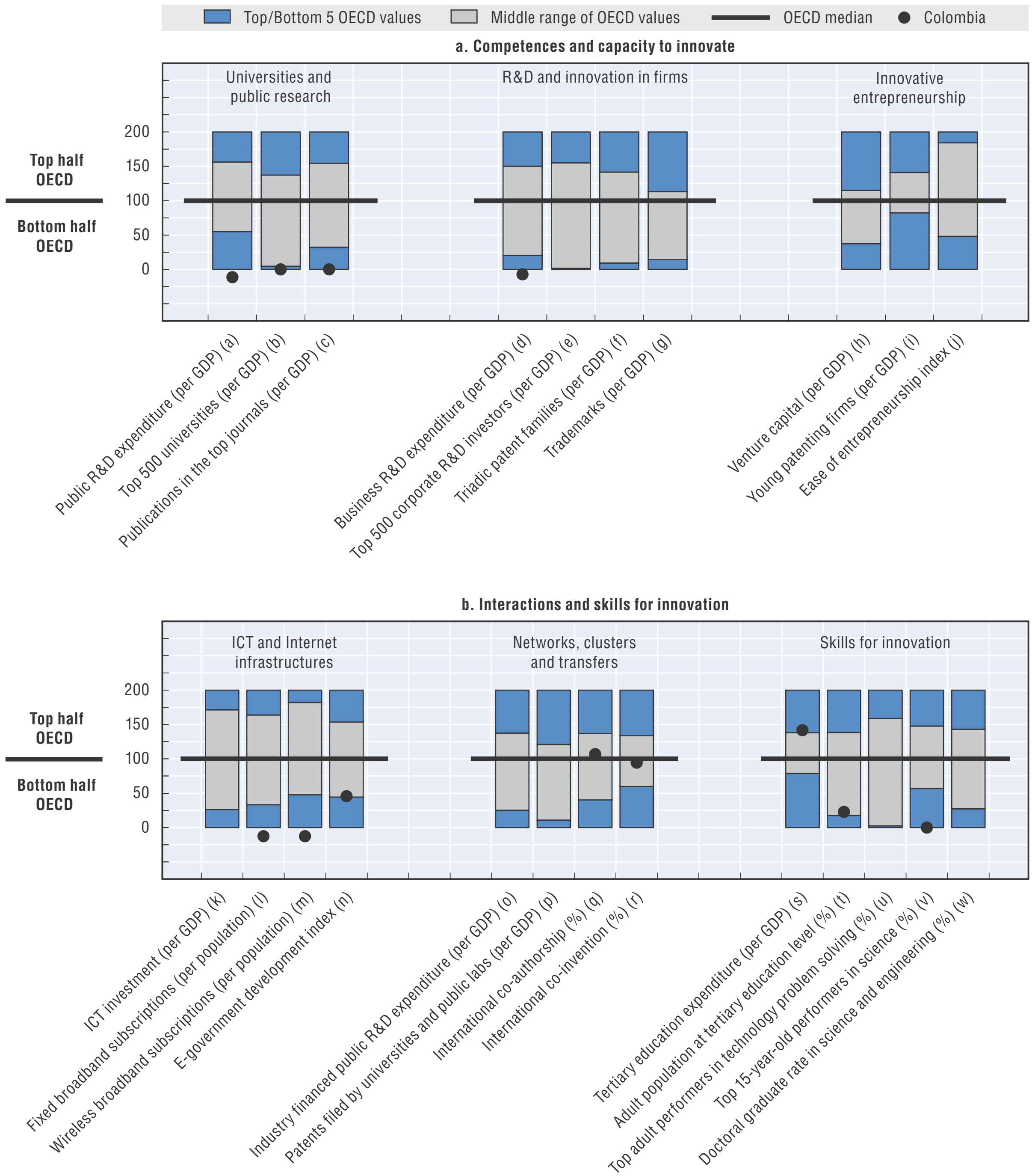
Hot Issue 2: Improving the governance of innovation system and policy. Colombia's innovation system is coordinated by the National Planning Department (DNP) and Colciencias which is an agency that encompasses the roles of science ministry, research council and innovation agency. These two bodies were responsible for Colombia's National Innovation Strategy for 2010-14. In response to the growing importance of innovation in the national development strategy, in 2012 the government created iNNpulsa Colombia, within the National Development Bank (Bancóldex) to promote high-growth innovative companies and to support competitiveness by a more integrated business support system and by interacting with other actors in Colombia's innovation and entrepreneurship ecosystems. Colciencias has adopted a new business model, using online tools to enhance transparency and effectiveness in managing calls for grants.

Key figures, 2013

Economic and environmental performance	COL	OECD	Gross domestic expenditure on R&D	COL	OECD
Labour productivity			**GERD**		
GDP per hour worked, USD PPP, 2013	n.a.	47.7	Million USD PPP, 2011	857	1 107 398
(annual growth rate, 2008-13)	n.a.	(+0.8)	As a % of total OECD, 2011	0.1	100
Green productivity			**GERD intensity and growth**		
GDP per unit of CO_2 emitted, USD, 2011	6.3	3.0	As a % of GDP, 2011	0.18	2.40
(annual growth rate, 2007-11)	(+1.2)	(+1.8)	(annual growth rate, 2007-11)	(+5.5)	(+2.0)
Green demand			**GERD publicly financed**		
NNI per unit of CO_2 emitted, USD, 2011	7.8	3.0	As a % of GDP, 2011	0.10	0.77
(annual growth rate, 2007-11)	(+1.0)	(+1.6)	(annual growth rate, 2007-11)	(+3.4)	(+2.8)

Figure 9.9. **Science and innovation in Colombia**

Panel 1. Comparative performance of national science and innovation systems, 2014



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

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Hot Issue 3: Strengthening public R&D capacity and infrastructure. Colombia's publicly funded GERD is only 0.08% of GDP (2011), well below the OECD median (Panel 1[a]) and that of other Latin American countries for instance Argentina (0.57%) and Chile (0.14%). Colombia's STI strategic plan for 2010-14 sets the goal to increase GERD to 0.5% of GDP. The government has allocated 10% of the royalties from the exploitation of non-renewable resources to an STI fund. Between 2012 and 2020, the fund aims to disburse up to USD 636 million (COP 800 billion) per year for S&T projects (including R&D activities). With regard to education, the Ministry of National Education aims to promote international exchange programmes and accreditations to Colombia's HEIs. By positioning Colombia's HEIs in an international context, the Ministry aims to improve the quality of higher education, increase international knowledge transfer and raise the mobility of researchers.

Colciencias has been strengthening the capacity and public infrastructure for R&D through strategic actions such as support for the standardisation and accreditation of testing and calibration laboratories, and the strengthening of research centres. Between 2010 and 2012, Colciencias supported 90 standardisation and accreditation projects with USD 14.5 million (COP 16 500 million) and between 2010 and 2013, it supported 74 projects targeted at strengthening research centres, with USD 51.8 million (COP 59 030 million).

Highlights of the Colombian STI system

New sources of growth: The Ministry of Information and Communication Technologies (MinCIT) has devoted USD 281 million (COP 320 billion) during 2010-13 in two programmes: *Vive Digital* and APPS.co. The former supports projects promoting regional innovation and technological development through ICTs, while the latter fosters the creation of ICT companies that aim to develop mobile applications, software and Internet content.

Innovation in firms: At 0.05% of GDP, BERD is not only below all of the OECD countries (Panel 1[d]), but also that of other Latin American countries such as Argentina (0.16%). To address this situation, the government uses three main mechanisms to support business R&D investments. First, at the guidance of Colciencias and other relevant government bodies, Bancóldex provides preferential credits at below market interest rates for innovation projects. Secondly, a tax incentive scheme offers tax exemptions of up to 175% of R&D investments made during the taxable period. Thirdly, a variety of government agencies provide subsidies for firms' STI activities. iNNpulsa provides non-refundable grants of up to USD 278 000 (COP 350 million) per beneficiary. Colciencias recently expanded its Innovation Management programme to further support the development of innovative capabilities in Colombian firms. In 2013, it allocated around USD 19 million (COP 21.4 billion) to fund knowledge-intensive business services from international entities specialising in business innovation.

Innovative entrepreneurship: With a budget of USD 138 million (COP 174 billion) for 2012-13, iNNpulsa Colombia seeks to promote business growth and to build an innovation culture in the Colombian society. 70% of Colciencias' Innovation Management programme, with a budget of USD 20 million (COP 22.4 billion) in 2013, was directed to micro and SMEs, while Colombia's business environment has improved in recent years.

ICT and Internet infrastructures: While the numbers of fixed and wireless broadband subscriptions remain well below the OECD level (Panel 1[l, m]), much progress has been made in this area in recent years. MinCIT is on its way to meet the target of quadrupling connections across all regions between 2010 and 2014. In addition, a broadband infrastructure is being deployed throughout the country. Under this initiative, the number of connected municipalities grew from about 200 in 2010 to 777 by mid-2013.

Technology transfer and commercialisation: Colciencias organises regional Innovation Business Conferences, aiming to strengthen technology transfer and university-industry linkages. Colciencias also allocates up to USD 510 000 (COP 550 million) per year since 2009 to support collaborative projects between companies and universities or research centres.

Clusters and smart specialisation: Since 2005, Colciencias organised 25 regional Innovation Business Conferences in 9 regions. Furthermore, the Regional Innovation Alliances (also coordinated by Colciencias) initiative aims to foster public-private partnerships within regions. In collaboration with the DNP and several ministries, iNNpulsa designed Competitive Routes, a regional programme that designs roadmaps to support productivity growth and cluster formation in key sectors (e.g. ceramics, tourism, coffee, leather and agribusiness). This programme has covered 18 of Colombia's 32 administrative divisions.

Skills for innovation: The Colombian government prioritises increases in the number of researchers. In particular, two programmes promote the education of PhDs and their employments in the economy. Colciencias' Doctoral Training Support Programme funds graduate studies both domestically and abroad. It aims to double the current number of 7 000 PhDs by awarding 1 000 scholarships per year during the next four years. The programme will allocate USD 678 million (COP 752 billion) during 2011-14, targeting researchers in the business sector, academics and those who work in strategic technology areas. Colciencias will also launch in 2014 the Brain Repatriation Programme that aims to attract 500 diaspora doctorate holders of Colombian origin in the next four years. This initiative provides subsidies to companies and universities so that they can offer internationally competitive salaries.

COSTA RICA

Costa Rica is known for its substantial export-led growth. In 2011 it was the second largest economy in Central America with GDP per capita of USD 12 157. The aim of the 2011-14 STI Strategic Plan (PNCTI) is to achieve further growth.

Hot issue 1: Improving overall human resources and skills. Costa Rica has few top universities (Panel 1[b]). At 20.9%, the tertiary-qualified adult population is at the bottom of the mid-range of OECD countries (Panel 1[t]), and the performance of 15-year-olds in science is poor. The government therefore seeks to improve the country's human resource by investing in education, boosting secondary school coverage, promoting entrepreneurship, developing skills that meet firms' requirements, bringing ICTs to the education system, and matching the education programme with the needs of the private sector. It relies in part on a World Bank Higher Education Improvement Project Loan (see below). Following the recommendations of a 2010 assessment of the country's STI strategic priorities by the Inter-American Development Bank (IDB), the government has decided to allocate 50% of its S&T funds to development of human capital.

Hot issue 2: Improving framework conditions for innovation (including competitiveness). To improve conditions for innovation, Costa Rica focuses on obtaining FDI in certain high-technology sectors. The Free Zone Regime (FZR) offers tax exemptions and other incentives to foreign companies that meet eligibility criteria, including specified investment targets in qualified priority industries. The Commission for Export Linkages promotes supply-chain links between domestic SMEs and MNEs through a matchmaking programme. It also helps identify and build capabilities in selected local firms to help them become suppliers to MNEs.

Hot issue 3: Strengthening public R&D capacity and infrastructures. In July 2013, the government approved a USD 286 million (CRC 14.4 billion) initiative, financed by a World Bank Higher Education Improvement Project Loan, to develop research in public universities, particularly in priority sectors and technology areas. The government has allocated 30% of its S&T funds to research projects based on the priorities identified in the above-mentioned IDB assessment.

Hot issue 4: Improving the governance of innovation system and policy. In 2010 the government created the Presidential Council on Competitiveness and Innovation (CPCI). Its objective is to co-ordinate public policies among the institutions involved in Costa Rica's innovation system. The Council linked the different players to the priority sectors to contribute to the definition of the main strategies of the PNCTI (2011-14). The Council later established an inter-institutional working group on human capital for competitiveness. In defining the PNCTI for 2011-14, the Ministry of Science, Technology and Telecommunications focused on the following priority areas: human capital, innovation, productivity and the digital strategy. In 2011, a set of annually updated indicators was created to evaluate the achievement of the National Development Plan (PND) and PNCTI goals.

Highlights of the Costa Rican STI system

New sources of growth: The PND emphasises seven technology areas: renewable energy, nanotechnology, biotechnology, health, biodiversity, ICT, and Earth and space sciences. Tax concessions are also provided for FDI projects in high value-added electronics, manufacturing, materials and electrical components; medical devices, equipment and supplies; automotive devices and supplies; high-precision machinery parts and components; pharmaceuticals and biotechnology; and renewable energy.

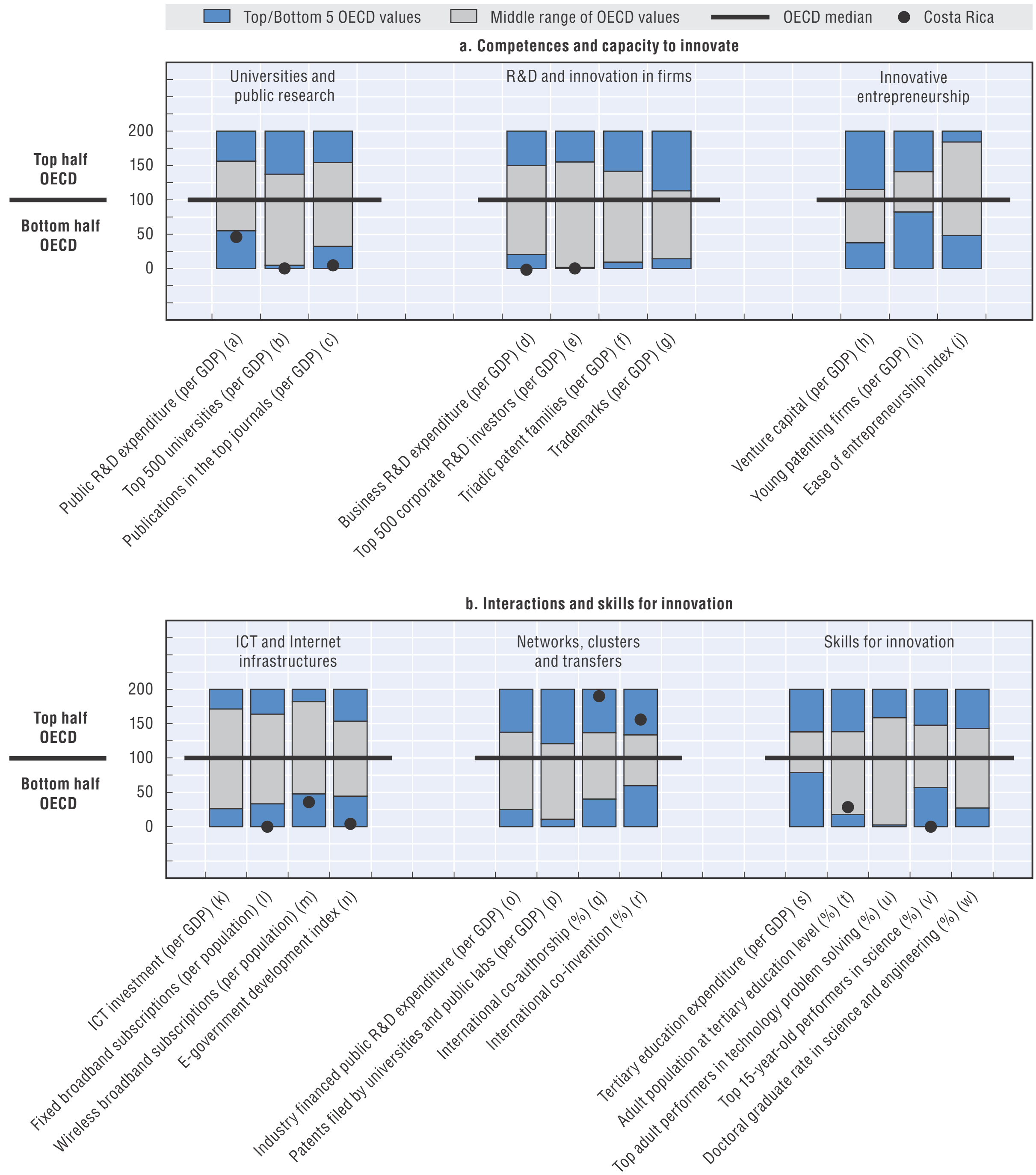
Innovative entrepreneurship: Since the 2000s, Costa Rica has made a number of reforms to the country's intellectual property system. The Inter-institutional Commission for the Protection and Promotion of Intellectual Property (CIPPI) co-ordinates the introduction and enforcement of IP-related legislation. In 2011 it developed, with the support of the World Intellectual Property Organization, a national IP strategy. On that basis, Costa Rica is amending the patent law and has reinforced prosecution of IP violations. In 2012, the government's Funding Programme for SMEs (PROPYME) started to support SMEs for obtaining and protecting IPRs. In addition to the funding programmes (see below) other

Key figures, 2013

Economic and environmental performance	CRI	OECD	Gross domestic expenditure on R&D	CRI	OECD
Labour productivity			**GERD**		
GDP per hour worked, USD PPP, 2013	n.a.	47.7	Million USD PPP, 2011	275	1 107 398
(annual growth rate, 2008-13)	n.a.	(+0.8)	As a % of total OECD, 2011	0.0	100
Green productivity			**GERD intensity and growth**		
GDP per unit of CO_2 emitted, USD, 2011	7.7	3.0	As a % of GDP, 2011	0.48	2.40
(annual growth rate, 2007-11)	(+1.5)	(+1.8)	(annual growth rate, 2007-11)	(+9.9)	(+2.0)
Green demand			**GERD publicly financed**		
NNI per unit of CO_2 emitted, USD, 2011	n.a.	3.0	As a % of GDP,	n.a.	0.77
(annual growth rate, 2007-11)	n.a.	(+1.6)	(annual growth rate, 2008-11)	(+19.4)	(+2.8)

Figure 9.10. **Science and innovation in Costa Rica**

Panel 1. Comparative performance of national science and innovation systems, 2014



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

support programmes include EXPOPYME, an SME forum, CREAPYME, a business consulting service, and diffusion of lectures and success stories about SMEs on PYME TV and PYME Radio.

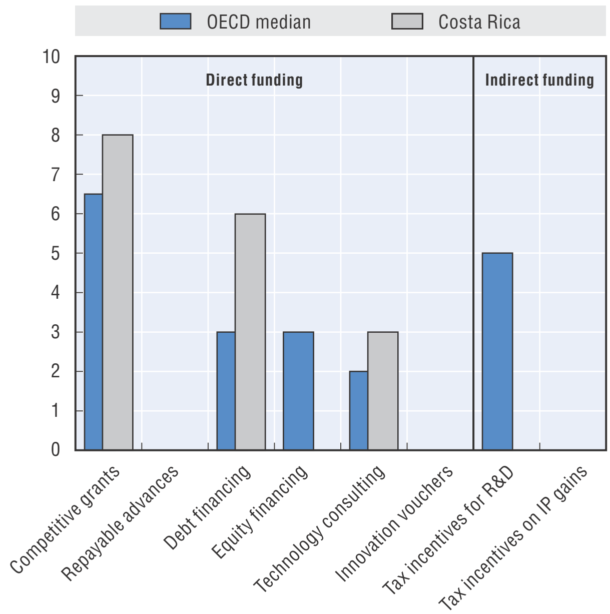
Innovation in firms: Costa Rica's BERD as a share of GDP was 0.08% in 2011 (0.18% in 2012 according to national source), well below the OECD median (Panel 1[d]), but similar to that of Latin American countries such as Colombia (0.05%) and Argentina (0.16%). The 2010-14 PND recognised the private sector's weak performance in innovation and the need to provide further support. Over the last ten years, the government has shifted the emphasis of its policy mix from supply- to demand-side instruments. MINCITT has created and reinforced a set of promotional funds and non-financial programmes. PROPYME supports SME innovation in high-technology industries such as aerospace, automotive and electronics. A seed capital fund, managed by the Ministry of Economy, Industry and Commerce (MEIC), supports technology-oriented start-ups in conducting R&D and in commencing operations. Other funds include the Fondo de Incentivos, FINADE and FORINVES, which also supports business innovation through venture capital financing.

ICT and Internet infrastructures: In July 2013, the Ministry of Public Education announced a plan to increase the use of ICTs in public schools with an investment of about USD 28.4 million (CRC 10 billion). The value of this plan is clear from the low levels of fixed and wireless broadband subscriptions in Costa Rica relative to the OECD median (Panel 1[l, m]).

Globalisation: Costa Rica's research and innovation are well connected internationally. International co-authorships account for 74% of S&T publications, and international co-inventions for 46% of PCT patent application, both well above the OECD median (Panel 1[q, r]). However, this also reflects the small size of the country's innovation system. Connecting domestic business to foreign MNEs to boost local industry is also an important policy approach.

Recent developments in STI expenditures: While Costa Rica's GERD was only 0.48% of GDP in 2011 (0.57% in 2012 according to national source), well below the OECD median, it grew at a rapid 9.9% annually over 2007-11. Publicly funded GERD increased from USD 118.9 million (CRC 30.7 billion) in 2008 to USD 225.5 million (CRC 79.4 billion) in 2012. At 0.40% of GDP, public expenditure on R&D is weak compared to the OECD median (Panel 1[a]), but is similar to that of Latin American countries such as Argentina (0.57%) and Mexico (0.25%). The government plans to increase the share by the mid-2010s.

Panel 2. Most relevant instruments of public funding of business R&D, 2014



Note: Policy information comes from country responses to the OECD STI Outlook policy questionnaire 2014. Costa Rica's response is available in the *OECD STI Outlook Policy Database*, edition 2014 at *http://qdd.oecd.org/Table.aspx?Query=B021AE35-2564-410E-B9D2-24F0ED1BED72*.
Source: See reader's guide and methodological annex.

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CZECH REPUBLIC

The Czech Republic is an open European economy. Industry accounts for more than a third of GDP, considerably above the OECD average. An export-led recovery spurred by the automotive sector started in early 2013, after six quarters of contraction. Economic growth is expected to gather pace in 2014. While its STI system is catching up with OECD standards in some respects, the system as a whole is still lagging behind.

Hot issue 1: Improving the framework conditions for innovation (including competitiveness). The Czech Republic's business environment is in need of improvement: while the Ease of Entrepreneurship Index has improved over time, it is still below the OECD median (Panel 1[j]) and venture capital for innovation is scarce (Panel 1[h]). An aim of the 2013 update of the National Research, Development and Innovation Policy (NRDIP) (2009-15 with an outlook to 2020) is to create better framework conditions for innovation. The International Competitiveness Strategy for the Czech Republic (2012-20) introduced more than 40 measures and several hundred sub-measures with a view to creating conducive framework conditions for creative businesses, innovation and growth.

Hot issue 2: Reforming and improving the public research system (including university research). The public research system has gradually improved in recent years, but challenges remain. Public R&D expenditures as a percentage of GDP are well above the OECD median, and publications in top quartile journals have almost reached the OECD median (Panel 1[a, c]); however, there are still relatively few top universities (Panel 1[b]). Following the above-mentioned evaluation and update, the NRDIP also seeks to increase the efficiency and responsiveness of public research and cut institutional funding from 56% of GBAORD in 2009 to 50% in 2013. In addition, a new annual performance-based evaluation is to be used to allocate funding to PRIs and universities.

Hot issue 3: Improving overall human resources, skills and capacity building. The indicators for innovation skills are mixed: tertiary education expenditure is at the OECD median (Panel 1[s]) and only 17% of the adult population is tertiary-qualified, compared to 27% for the EU28 (Panel 1[t]). However, adults' technical problem-solving ability, 15-year-olds' performance in science, and the share of doctoral graduates in S&E are either above or at the OECD median (Panel 1[u, v, w]). The 2009 White Paper on Tertiary Education is the basis for reform. Co-ordinated and executed by the Ministry of Education, Youth and Sports (MEYS), the reform aims to improve financial support for students, standardise PhD programmes, and increase university research. ERC CZ and NAVRAT (2012-19), both launched in 2012, support research excellence and researcher mobility with USD 80.6 million (CZK 1 065 million).

Hot issue 4: Encouraging innovation in firms and supporting entrepreneurship and SMEs. In spite of efforts to move to a knowledge-intensive economy, innovation performance is lagging. While BERD as a share of GDP is slightly below the OECD median (Panel 1[d]), innovation output is far below the median (Panel 1[e, f, g]). Both the NRDIP and the International Competitiveness Strategy seek to strengthen business innovation. In spite of the impact of the economic downturn on public finance, public support for business R&D and innovation has increased in both relative and absolute terms since 2009, accounting for 58% of all public R&D and innovation expenditures in 2012.

The Centres of Competence programme, launched in 2011, is a major programme aimed at increasing long-term collaboration between public R&D institutions and businesses. The GAMA Programme (2014-19), with a budget of USD 209 million (CZK 2 770 million), promotes transfer of public R&D results by funding the proof-of-concept phase. Similarly, the ALFA Programme (2011-16) seeks to fuel business innovation through collaboration with scientific research on advanced and green technologies with a total budget of USD 556.8 million (CZK 7.5 billion). Furthermore, 10 out of 14 Czech regions have introduced some kind of innovation voucher scheme to support SMEs for purchasing services from HEIs and PRIs.

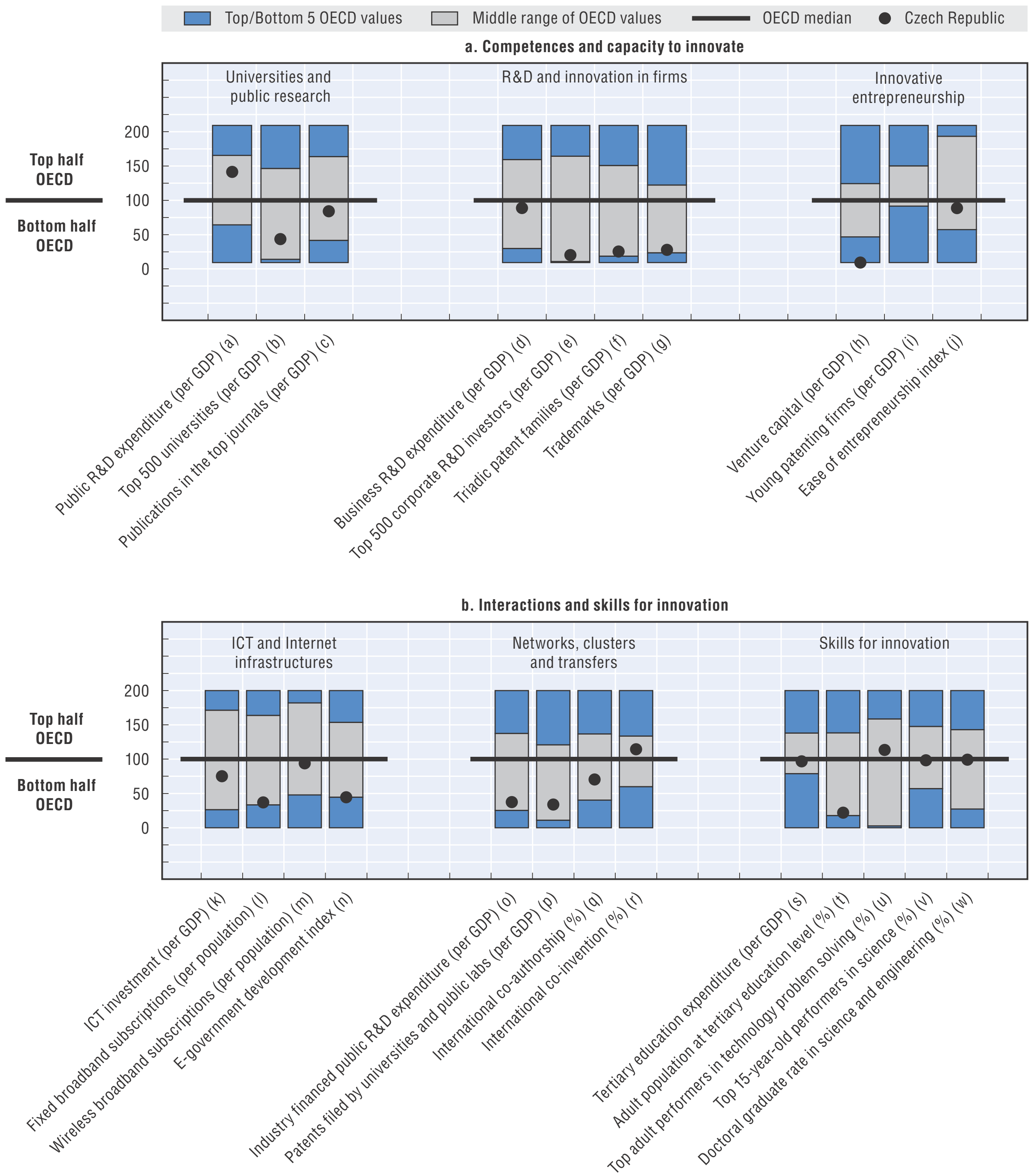
Hot issue 5: Addressing the challenges of STI globalisation and increasing international co-operation. The Czech Republic is linked to global science and innovation networks to varying degrees. International co-patenting is above and international co-authorship is below the OECD median (Panel 1[q, r]). The Interdepartmental Policy of International Co-operation

Key figures, 2013

Economic and environmental performance	CZE	OECD	Gross domestic expenditure on R&D	CZE	OECD
Labour productivity			**GERD**		
GDP per hour worked, USD PPP, 2013	32.2	47.7	Million USD PPP, 2012	5 443	1 107 398
(annual growth rate, 2008-13)	(+0.2)	(+0.8)	As a % of total OECD, 2012	0.5	100
Green productivity			**GERD intensity and growth**		
GDP per unit of CO_2 emitted, USD, 2011	2.2	3.0	As a % of GDP, 2012	1.88	2.40
(annual growth rate, 2007-11)	(+2.9)	(+1.8)	(annual growth rate, 2007-12)	(+7.0)	(+2.0)
Green demand			**GERD publicly financed**		
NNI per unit of CO_2 emitted, USD, 2011	1.8	3.0	As a % of GDP, 2012	0.71	0.77
(annual growth rate, 2007-11)	(+2.2)	(+1.6)	(annual growth rate, 2007-12)	(+3.0)	(+2.8)

Figure 9.11. **Science and innovation in the Czech Republic**

Panel 1. Comparative performance of national science and innovation systems, 2014



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

in R&D (see below) will set objectives for increasing international collaboration in STI, for improving conditions for the participation of Czech researchers in international research programmes, and for increasing the effectiveness of R&D co-operation. National initiatives to foster internationalisation include COST CZ (2011-17), EUREKA CZ (2011-17), EUPRO II (2011-17), KONTAKT II (2011-17), MOBILITY (2011-18), GESHER (2010-16) and INGO II (2011-17).

Highlights of the Czech STI system

STI policy governance: The Technology Agency of the Czech Republic was established to make the governance of the public support system for applied research and development more efficient by removing overlaps. There is no comprehensive strategy for the internationalisation of STI. The Interdepartmental Policy of International Co-operation in R&D is being developed as part of the update of the NRDIP by the end of 2014.

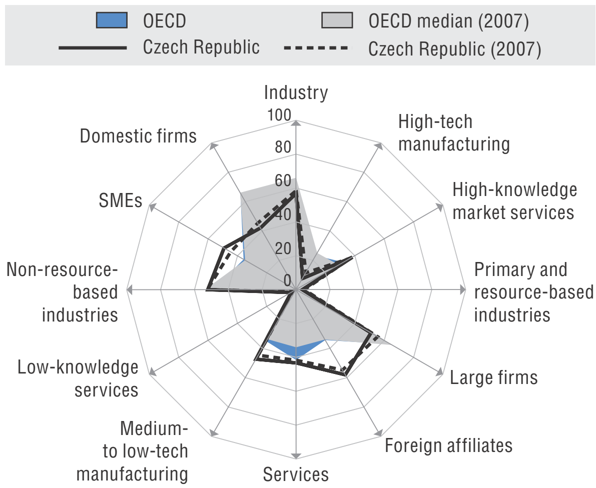
New challenges: New long-term national priorities have been prepared through the Review of National Priorities for Research, Experimental Development and Innovation, which seeks to identify future challenges, threats, needs and opportunities. The priorities reflected in the updated NRDIP (2009-15) are: competitive knowledge-based economy; sustainability of energy and material resources, environment for quality life; social and cultural challenges; healthy population and safe society. Implementation plans were approved in 2013. In line with the priorities set by the NRDIP, as well as the thematic focus of other programmes, the Omega Programme seeks to strengthen research activities in the applied social sciences to increase the competitiveness of the Czech Republic, enhance the quality of life of its citizens and balance socio-economic development. A total of USD 23.2 million (CZE 309 million) will be invested between 2012 and 2017.

Clusters and smart specialisation: The National Smart Specialisation Strategy, with 14 regional strategies (annexes), is being developed and co-ordinated by MEYS. Science and technology parks, regional innovation centres and agencies play a significant role in the regional innovation infrastructure and in the formulation, implementation and evaluation of regional strategies. The European Union and the Czech government have invested USD 7.7 million (CZK 102 million) in the establishment of these parks, e.g. Technology and Innovation Centre of the Czech Technical University in Prague, the South Moravian Innovation Centre in Brno, the Science and Technology Park of Palacky University and the University of West Bohemia in Plze , and the Innovation Centre of the Technical University in Ostrava.

Recent developments in STI expenditures: The NRDIP (2009-15) set targets of GERD at 2.7% of GDP and public R&D expenditures at 1% of GDP by 2020. GERD increased from 1.37% of GDP in 2007 to 1.88% of GDP in 2012, averaging a 7% increase a year over 2007-12, well above the OECD average. The share of industry-funded GERD dropped from 47.2% to 36.4%, and government-funded GERD from 44.7% to 36.8%. GERD financed from abroad rose from 7.3% to 25.9%, during the period with EU funding and foreign companies (Panel 2) the main sources of the increase.

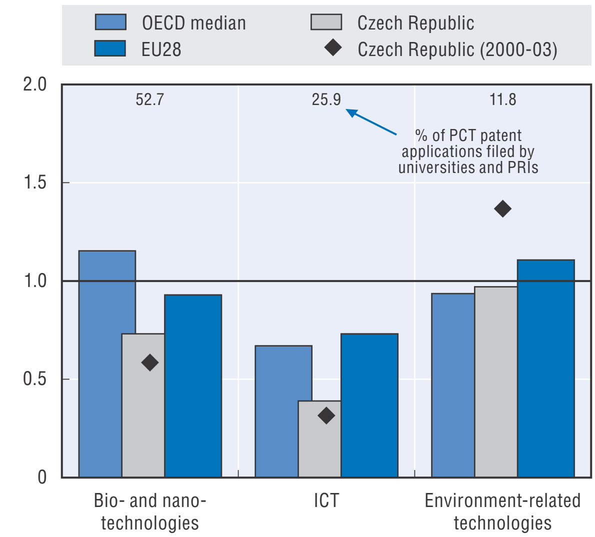
Panel 2. Structural composition of BERD, 2011

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

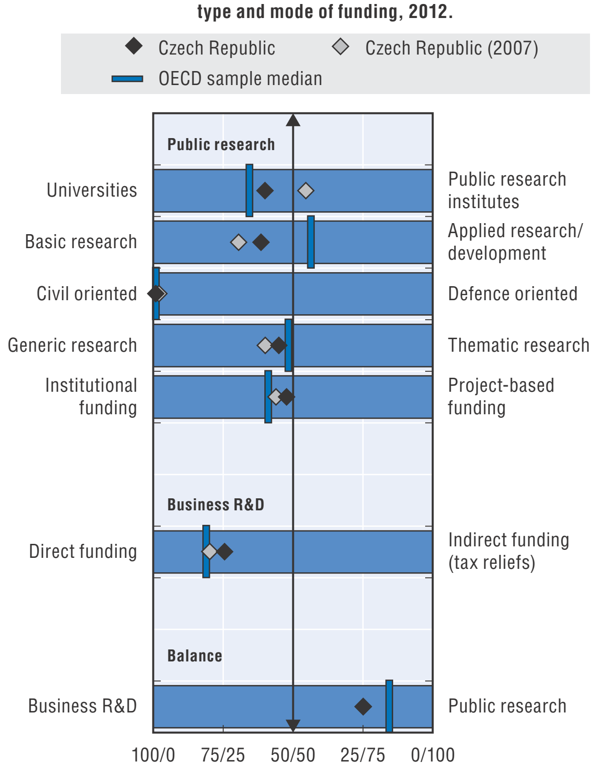


Panel 3. Revealed technology advantage in selected fields, 2009-11

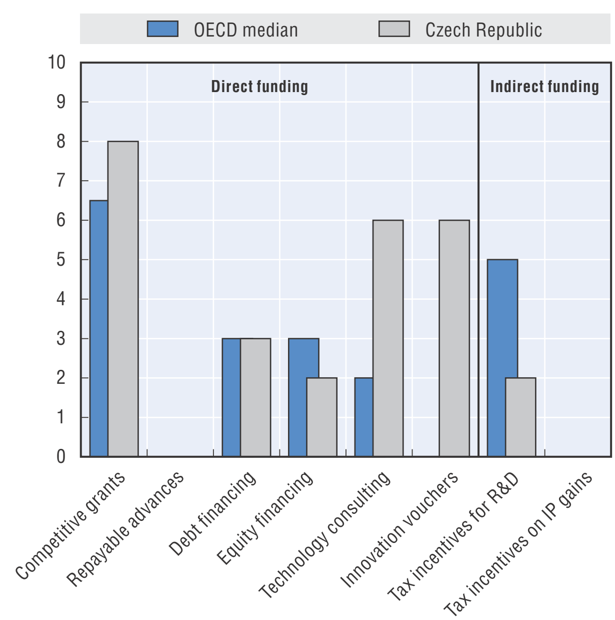
Index based on PCT patent applications



Panel 4. Allocation of public funds to R&D, by sector, type and mode of funding, 2012.



Panel 5. Most relevant instruments of public funding of business R&D, 2014.



Note: Policy information comes from country responses to the OECD STI Outlook policy questionnaires 2014 and 2012. Czech Republic's responses are available in the *OECD STI Outlook Policy Database*, edition 2014 at *http://qdd.oecd.org/Table.aspx?Query=6B36463F-C683-4F05-ADB6-8628A93E050A*.

Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888933152118

DENMARK

Denmark is a highly developed European economy with strong business innovation and the world's leading renewable energy technology. The Innovation Strategy: Denmark A Nation of Solutions (2012-20), launched in December 2012, represents a shift to a demand-driven innovation policy approach, with enhanced knowledge flows and stronger innovation capabilities in the educational sector.

Hot issue 1: Improving the framework conditions for innovation (including competitiveness). Except for availability of venture capital, which is on par with the OECD median, Denmark ranks near the top among OECD countries on the Ease of Entrepreneurship Index (Panel 1[j]), and the entrepreneurship environment has improved regularly over the last decade. Since November 2013, the Danish Growth Fund (*Vaekstfonden*) can support Danish entrepreneurs with subordinated loans. Other new initiatives to facilitate entrepreneurship include the Green Entrepreneurship House and the Entrepreneurial Company Registration (IVS). The tax on capital gains from unlisted portfolio shares, also known as the entrepreneurship tax, was abolished as part of the 2012 tax reform; as part of the growth plan adopted in April 2013, the government has increased efforts to diffuse knowledge on IPRs to companies and entrepreneurs, particularly to designers and creative industries, as well as to students. Since July 2013, initiatives have been launched to enhance enforcement of IPR rules by the police and public prosecutors. Standard contracts for commercialisation aim to make it easier for large and small businesses in creative industries to collaborate on the commercialisation of designs and ideas.

Hot issue 2: Innovation to contribute to structural adjustment and new approaches to growth. Denmark is a leader among OECD countries in terms of its RTA in bio- and nano-technologies and environmental technologies (Panel 3). The Danish government has commissioned eight growth teams with members from industry in areas in which Danish businesses are or can be internationally competitive. Based on their recommendations the government has published specific growth plans for each of the following seven areas: the Blue Denmark; Creative Industries and Design; Water, Bio and Environmental Solutions; Health and Care Solutions; Energy and Climate; Food Sector; and Tourism and Experience Economy. A growth plan for ICT and Digital Growth remains to be published. The plans address specific barriers to investment and focus on areas in which new markets can be developed. For example, government regulations mandating efficiency improvements in the wastewater sector could help to develop more cost-effective technology, through which savings can be achieved in the cost of wastewater treatment for large businesses that currently pay higher costs to treat their wastewater. In terms of corporate development activities, the creation of a single, transparent and efficient means of access to Danish health data could attract medical research to Denmark.

Hot issue 3: Improving overall human resources, skills and capacity. Overall, Danish STI skills lie in the mid-range of OECD countries (Panel 1[t, u, v, w]), although expenditure on higher education and the rate of PhD graduates in science and engineering are at the top of the mid-range of OECD countries (Panel 1[s, w]). Denmark's national innovation strategy includes a range of initiatives to strengthen innovation capacity through education. The government anticipates that at least 25% of a youth cohort will complete a master's degree by 2020, and that the uptake of PhD students will remain at the 2010 level of 2 400 a year. The Danish government established (end of 2013) the Quality Committee (kvalitetsudvalget) to look into how to improve the quality and relevance of higher education.

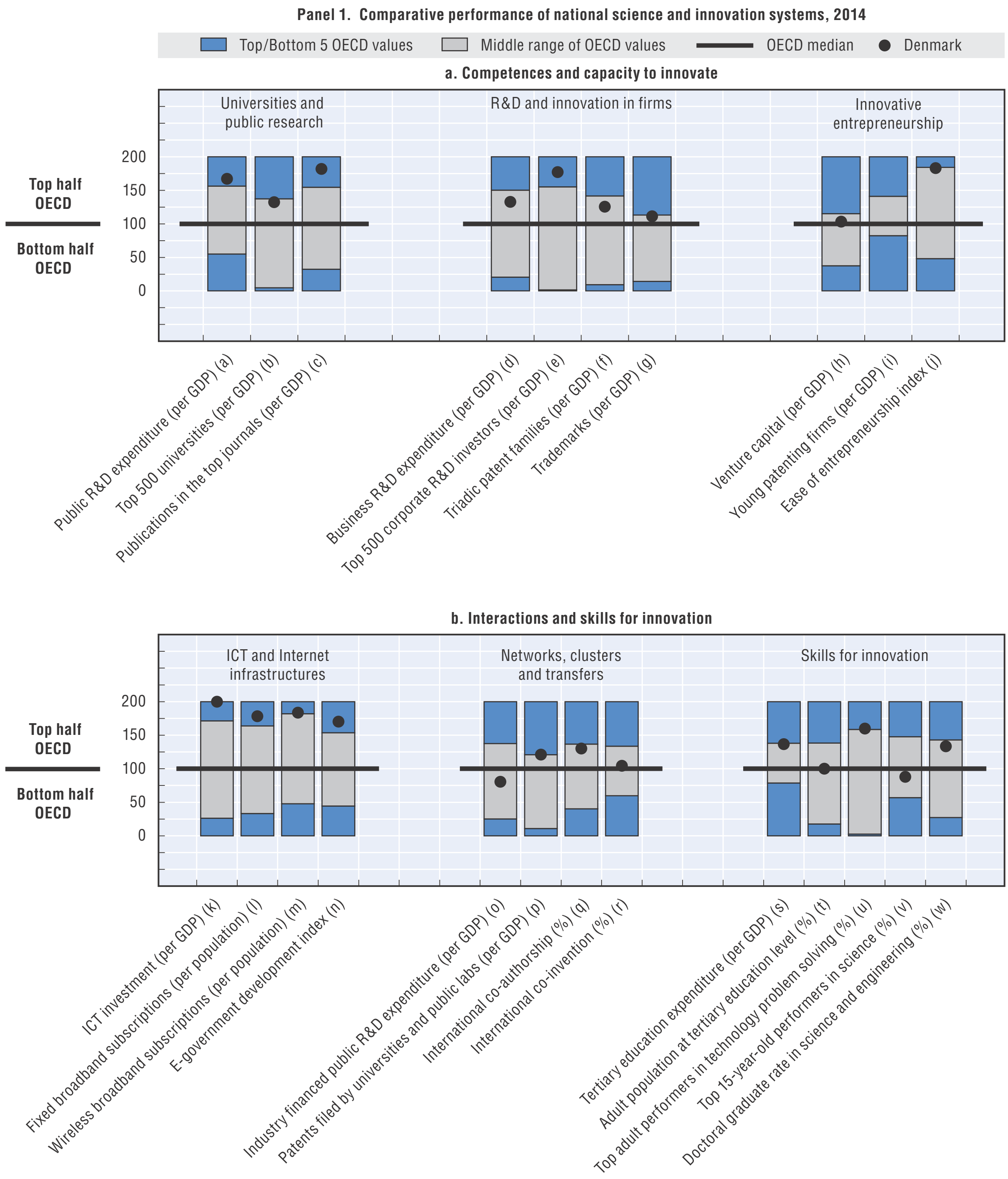
Highlights of the Danish STI system

STI policy governance: One of the initiatives of the Danish innovation strategy is to create a coherent and cross-cutting research and innovation council. As a result, the Danish National Advanced Technology Foundation, the Danish Council for Technology and Innovation, and the Danish Council for Strategic Research have been merged into a new foundation (*InnovationsFonden – Denmark*). In 2013, the Ministry of Higher Education and Science (MHES) called on a broad variety of stakeholders to prepare the so-called INNO+ catalogue containing promising focus areas for strategic investments in innovation. In November 2013, five focus areas were selected and are to be carried out as part-

Key figures, 2013

Economic and environmental performance	DNK	OECD	Gross domestic expenditure on R&D	DNK	OECD
Labour productivity			**GERD**		
GDP per hour worked, USD PPP, 2013	61.6	47.7	Million USD PPP, 2012	7 138	1 107 398
(annual growth rate, 2008-13)	(+0.7)	(+0.8)	As a % of total OECD, 2012	0.6	100
Green productivity			**GERD intensity and growth**		
GDP per unit of CO_2 emitted, USD, 2011	4.3	3.0	As a % of GDP, 2012	2.98	2.40
(annual growth rate, 2007-11)	(+5.5)	(+1.8)	(annual growth rate, 2007-12)	(+2.0)	(+2.0)
Green demand			**GERD publicly financed**		
NNI per unit of CO_2 emitted, USD, 2011	4.7	3.0	As a % of GDP,	n.a.	0.77
(annual growth rate, 2007-11)	(+5.6)	(+1.6)	(annual growth rate, 2007-12)	(+4.4)	(+2.8)

Figure 9.12. **Science and innovation in Denmark**



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

nerships addressing social challenges. The five areas selected for 2014 are: blue jobs via green solutions; intelligent, sustainable and efficient plant production; Denmark as a preferred country for early clinical testing of new medicines; water-efficient industrial production; and building renovation of world-class standard. The mandate of the Danish Council for Research Policy was widened as of spring 2014 to include technological development and innovation. The development of quantitative impact assessments is continuing, and the Central Innovation Manual on Excellent Econometric Impact Analyses of Innovation Policy (CIM) has been updated and is now called CIM 2.0.

New sources of growth: To encourage the business sector's contribution to growth and job creation, new societal innovation partnerships to start next year will focus on accelerating innovation efforts in areas in which Denmark has a solid knowledge base and a strong business-sector advantage. The five areas selected from the INNO+ catalogue as priorities so far will receive funding from the *InnovationsFonden – Denmark*.

New challenges: The Fund for Green Business Development was established in 2013 and will be extended through 2016. It provides grants to Danish companies to help address increasing resource scarcity, raise business competitiveness and growth and make environmental improvements. The fund runs a programme to promote green industrial symbiosis between companies so that waste or reserves of a given resource, e.g. water or materials, of one company become a resource for another company.

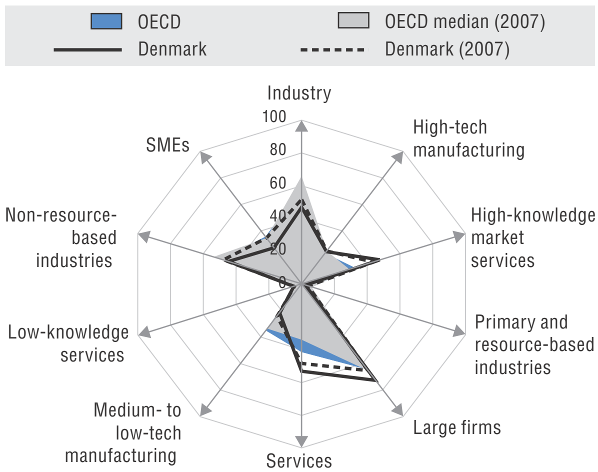
Universities and public research: Denmark has a strong science base, which has been increasingly dominated by universities over the past five years (Panel 4). Public expenditures on R&D were among the top five OECD countries (Panel 1[a]). Danish scientists perform well in terms of S&T publications in top international journals and patent applications (Panel 1[c, p]). The University Act was amended to give universities more autonomy for arranging their management structures. As part of the government's effort to increase the internationalisation of higher education, a two-part action plan has been launched. The first part, Enhanced insight through global outlook, focuses on sending more Danish students to study abroad, creating stronger international learning environments, and improving Danish students' foreign language skills. The second part, Denmark – an attractive study destination, focuses on attracting the most capable international students and retaining international graduates in Denmark. Danish universities are also in the process of implementing open access policies regarding research data.

Innovation in firms: While the ratio of BERD and triadic patents to GDP are at the top of the mid-range of OECD countries (Panel 1[d, f]), Denmark has a large share of leading global corporate R&D investors for the size of its economy. The Market Development Fund (2013-15), a new type of initiative, supports the development process just before commercialisation, when a functioning prototype must be customised to fit the demands of the market. The fund co-finances facilitation of end-consumer testing and adaptation of the new product or service, thereby shortening the developer's time to market and strengthening the potential for growth and employment. In 2013 the Danish Growth Fund introduced subordinated loans to facilitate the access of SMEs to debt financing. In 2012 a tax credit scheme was introduced to provide the opportunity for firms with a negative balance sheet to obtain a credit for the tax value of their R&D expenditures. The scheme has greater impact on young small innovative companies owing to a built-in maximum of R&D expenditure to be granted a tax credit. The maximum is increased fivefold from 2012.

Technology transfer and commercialisation: Danish universities and PRIs are active in patenting (Panel 1[p]) although the share of public R&D expenditures financed by industry is slightly below the OECD median (Panel 1[o]). The new innovation strategy: Denmark A Nation of Solutions (2012-20) focuses on better knowledge exchange between companies and knowledge institutions, between public and private sectors, as well as across national borders.

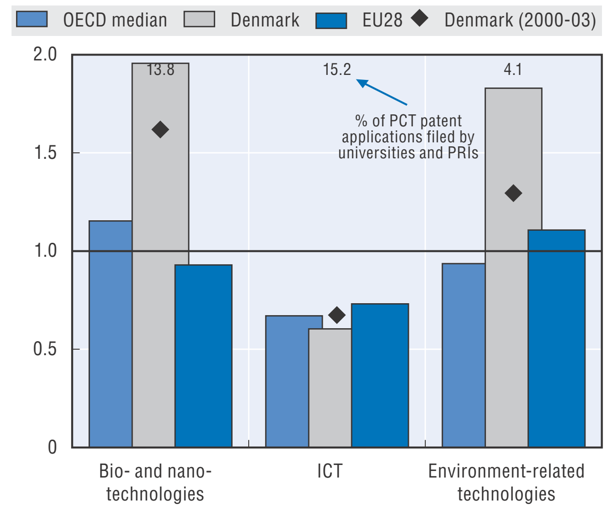
Panel 2. Structural composition of BERD, 2011

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

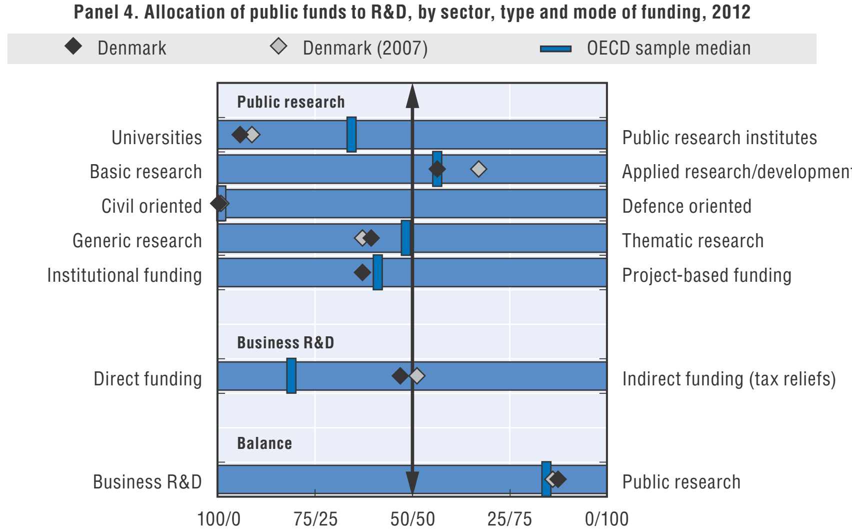


Panel 3. Revealed technology advantage in selected fields, 2009-11

Index based on PCT patent applications



Panel 4. Allocation of public funds to R&D, by sector, type and mode of funding, 2012



Note: Policy information comes from country responses to the OECD STI Outlook policy questionnaires 2014 and 2012. Denmark's responses are available in the *OECD STI Outlook Policy Database*, edition 2014 at *http://qdd.oecd.org/Table.aspx?Query=1033BA05-5BA0-4FC9-9990-F4A19F2AF649.*
Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888933152128

ESTONIA

Estonia is a small European economy, which has experienced turbulence since 2008 from contraction of 14.1% in 2009, to growth of 9.6% in 2011, to growth of just 0.8% in 2013. Following the Knowledge-Based Estonia II Research and Development and Innovation Strategy (2007-13), the government has created two medium-term strategies: the Estonian Research and Development and Innovation Strategy (2014-20) and the Estonian Entrepreneurship Growth Strategy (2014-20).

Hot issue 1: Improving framework conditions for innovation (including competitiveness). Estonia has a conducive business environment, and an improved supply of venture capital (Panel 1[j, h]). Through the Estonian Entrepreneurship Growth Strategy, the government aims to shift to a market-based approach to public support, with fewer direct grants and more financial instruments, including venture capital. In addition to project financing, it will put services (e.g. strategic business analysis, project planning, and capacity building for enterprises) at the heart of its support for business innovation. Over 2014-20, the government has allocated USD 155 million (EUR 85 million) for the Entrepreneurs' Development Programme and Innovation Voucher scheme, USD 87 million (EUR 48 million) for various entrepreneurship schemes, and USD 12.7 million (EUR 7 million) for innovative start-ups (Start-up Estonia).

Hot issue 2: Targeting priority areas/sectors. Investing in smart specialisation high-growth areas to increase the return on public investment in R&D is the guiding principle for targeting priority areas. The new R&D and Innovation (RDI) Strategy (2014-20) prioritises RDI investments selected and managed by the smart specialisation method to foster faster growth in the selected fields. These are: ICT, including the use of ICT in industry and other sectors, cyber-security and software development; health technologies and services, including biotechnology, e-health (IT use in the development of medical services and products); and more effective use of resources, including materials science and industry, innovative construction, i.e. "smart houses", health-promoting foods, chemical industry (more effective use of oil shale). The Estonian Entrepreneurship Growth Strategy targets the same priority areas as above, and both strategies have the same focus.

Hot issue 3: Encouraging innovation in firms and supporting entrepreneurship and SMEs. During the decade ending in 2012, BERD grew faster than in most OECD countries and has reached the OECD median (Panel 1[d]). Innovation performance, however, has yet to reach OECD levels (Panel 1[e, f, g]). BERD is concentrated in medium-high to low-technology manufacturing and services (Panel 2) and in a small number of firms. Productivity growth and higher employment through capital deepening and structural change to higher added value activities are central objectives of the government's economic policy. Innovation is considered essential to achieving these goals and the government is committed to stimulating business R&D and innovation through direct funding and non-financial measures with a combined budget of USD 255 million (EUR 140 million) over 2014-20. The Entrepreneurs' Development Programme was launched in 2013 to increase the international competitiveness of Estonian firms through better strategic planning, R&D and skills development. Launched in 2012, the Baltic Innovation Fund (BIF), with USD 182 million (EUR 100 million) for 2013-16, will invest in private equity and VC funds in Estonia, Latvia and Lithuania.

Hot issue 4: Improving the returns to and impact of science. Public research has improved significantly over more than a decade. Today, Estonia has a relatively strong public research system, with a high level of public R&D expenditures and strong performance in terms of international scientific publications (Panel 1[a, c]). The system is quite well connected to global knowledge and innovation networks (Panel 1[q, r]). However, industry-science linkages are not very strong (Panel 1[o]). Efforts are being made to strengthen interactions between the scientific and business communities. For example, the University of Tartu has adopted a new governance structure that involves external partners in the university's management. The government has a programme for training doctoral students in co-operation with firms as well.

Highlights of the Estonian STI system

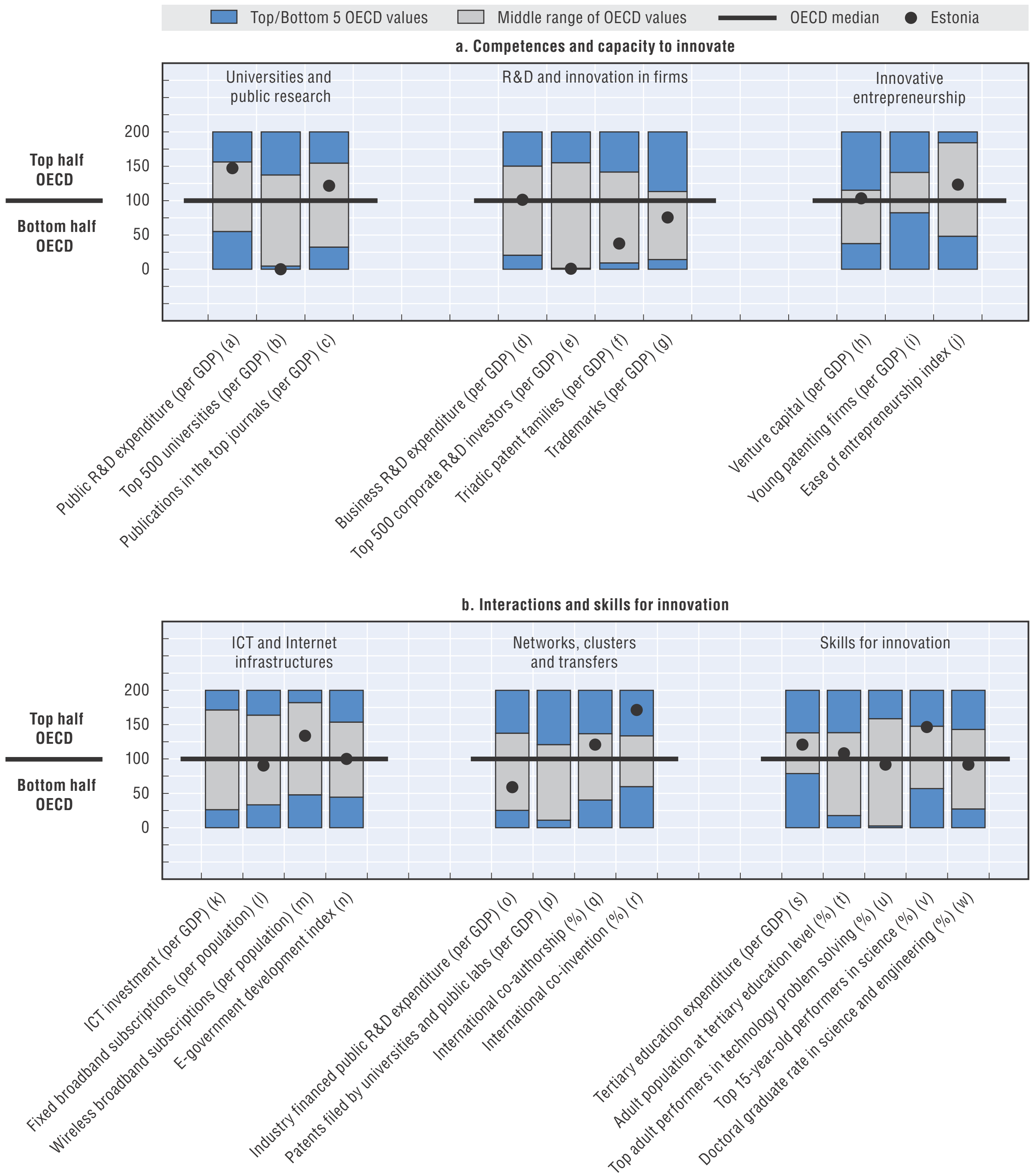
STI policy governance: The two new medium-term strategies mentioned above were prepared together in a co-ordinated

Key figures, 2013

Economic and environmental performance	EST	OECD	Gross domestic expenditure on R&D	EST	OECD
Labour productivity			**GERD**		
GDP per hour worked, USD PPP, 2013	29.3	47.7	Million USD PPP, 2012	710	1 107 398
(annual growth rate, 2008-13)	(+2.2)	(+0.8)	As a % of total OECD, 2012	0.1	100
Green productivity			**GERD intensity and growth**		
GDP per unit of CO_2 emitted, USD, 2011	1.3	3.0	As a % of GDP, 2012	2.19	2.40
(annual growth rate, 2007-11)	(-4.4)	(+1.8)	(annual growth rate, 2007-12)	(+14.2)	(+2.0)
Green demand			**GERD publicly financed**		
NNI per unit of CO_2 emitted, USD, 2011	1.3	3.0	As a % of GDP, 2012	0.84	0.77
(annual growth rate, 2007-11)	(-4.4)	(+1.6)	(annual growth rate, 2007-12)	(+10.1)	(+2.8)

Figure 9.13. **Science and innovation in Estonia**

Panel 1. Comparative performance of national science and innovation systems, 2014



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

process. Based on the 2011 amendments of the Organisation of Research and Development Act (ORDA), several changes in governance have been made since 2012. The Estonian Research Council was established in March 2012 and combines the functions of several previous bodies (the Estonian Science Foundation, the Research Competence Council, and the Department of International Co-operation of the Archimedes Foundation). A strategic aim of the Estonian R&D and Innovation Strategy (2014-20) is to strengthen the role of branch ministries in supporting R&D in socioeconomically important areas. Representatives of these ministries are being invited to the advisory bodies of the Ministry of Research and the Ministry of Economic Affairs and Communication (MEAC) and are involved in preparations to join international research networks (such as joint programming initiatives).

New challenges: Energy, sustainable development and environmental issues are increasingly important government priorities. In 2008-15 the Estonian government has six national programmes in support of R&D in energy technology, ICT, biotechnology, health, environment technology and material technology. The Estonian Energy Technology Programme is a co-operative programme involving research, business and the state to develop oil shale technologies and new, mainly renewable, energies. The centres of excellence and competence centres also target ICTs, the environment, new materials, health care and medicine.

Universities and public research: In 2010, the government adopted a Research Infrastructures Roadmap for upgrading existing research infrastructures and creating new ones. It lists 20 research infrastructures of national importance to guide public investments in R&D infrastructures over the next 10-20 years. Over 2007-13, investments in R&D infrastructures – USD 322 million (EUR 177 million) – were largely funded by EU Structural Funds. In continuing to modernise R&D infrastructures, the government's priorities are to achieve sustainable funding and maintenance of R&D infrastructures and to support the effective use and sharing of these infrastructures, including with the business sector. The Research Infrastructures Roadmap will be renewed in 2014.

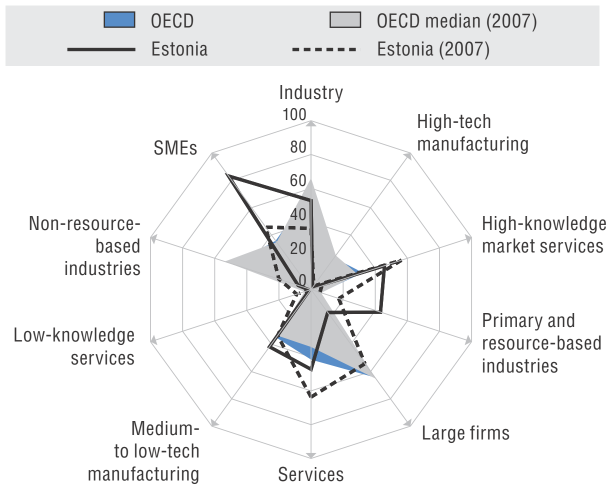
Clusters and smart specialisation: A smart specialisation strategy serves as the overall theme of several government policies. The government aims to harmonise the priorities of R&D, higher education and enterprise policies through such a strategy. Instruments to support smart specialisation include co-operation schemes (such as competence centres and clusters), demand-side measures, and the Start-up Estonia programme.

Skills for innovation: Estonia already has a good skills base, and its 15-year-olds perform very well in science (Panel 1[s, t, v]). With regard to skills development, the government's priorities are to continue to develop human resources with a focus on engineers, to turn brain drain into balanced brain circulation, and to increase the attractiveness of careers in research. The R&D and Innovation Strategy aim for 300 PhD graduates a year by 2020. The Estonian Euraxess Services Network provides information services and customised assistance for increasing the inward and outward mobility of foreign and Estonian highly skilled people. To address the relatively low rate of doctoral graduates in S&E (Panel 1[w]), several public initiatives aim to raise young people's interest in S&T careers. For 2014-20 specific measures are being planned to support the development of human resources and to raise the quality of teaching.

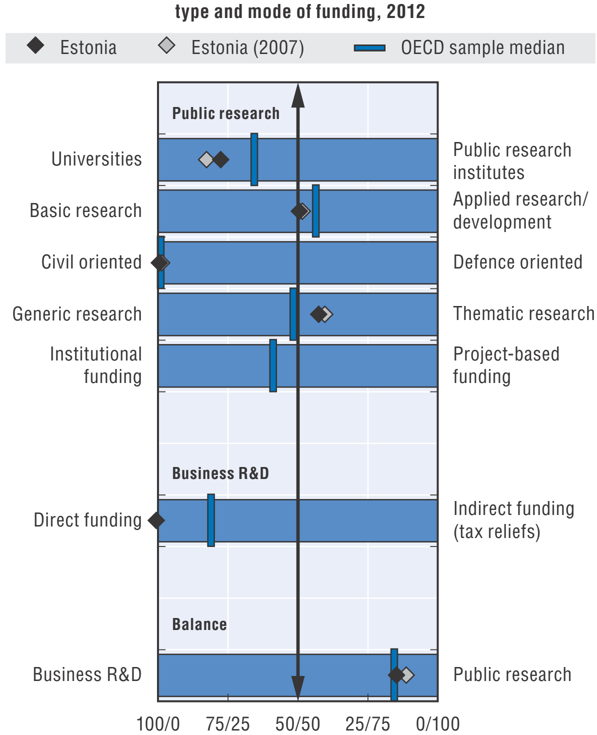
Recent developments in STI expenditures: Estonia has had one of the fastest increases in GERD in the OECD area, averaging 14.2% a year over 2007-12. In spite of the recent economic crisis, GERD rose from 1.28% of GDP in 2008 to 2.19% of GDP in 2012. The Strategy for R&D and Innovation targets GERD at 3% of GDP and BERD at 2 % of GDP by 2020.

Panel 2. Structural composition of BERD, 2011

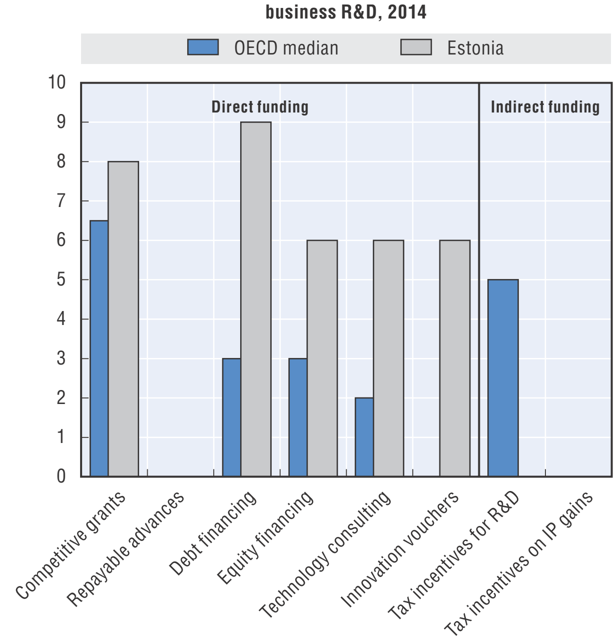
As a % of total BERD or sub-parts of BERD



Panel 3. Allocation of public funds to R&D, by sector, type and mode of funding, 2012



Panel 4. Most relevant instruments of public funding of business R&D, 2014



Note: Policy information comes from country responses to the OECD STI Outlook policy questionnaires 2014 and 2012. Estonia's responses are available in the *OECD STI Outlook Policy Database*, edition 2014 at *http://qdd.oecd.org/Table.aspx?Query=FCDF672A-33EF-4A60-A1B8-36DA2DA48EAD*.

Source: See reader's guide and methodological annex.

StatLink *http://dx.doi.org/10.1787/888933152132*

FINLAND

Finland is a northern European economy with an industrial structure dominated by high technology and medium-high technology. It has a strong and sustained technological specialisation in ICT (Panel 3). Overall, the Finnish STI system performs well by OECD standards. An Action Plan for Research and Innovation Policy (TINTO) has been implemented since December 2012 with a renewed focus on education and an emphasis on research and innovation at all levels.

Hot issue 1: Improving the governance of the innovation system and policy. In September 2013, the Finnish government adopted a Resolution on Comprehensive Reform of State Research Institutes and Research Funding, which focuses on building up multidisciplinary, high-level research of significant societal relevance and research in support of government decision making. The resolution covers reorganisation of PRIs, reallocation of some public research funding to competitive research funding, and creation of a new, strategic research funding instrument within the Academy of Finland to support long-term research on challenges facing Finnish society. The Team Finland Strategy published in June 2013 (see below), which is becoming an essential element of Finnish STI policy, will be updated annually but not continually reinvented, in order to maintain its long-term perspective and continuity. A first-ever evaluation of the Research and Innovation Council (RIC) was conducted to support the development and strengthening of the operation of the RIC. Its recommendations are under consideration by the government. The government is also carrying out the Central Administration Reform Project (KEHU) to improve co-ordination and coherence in government.

Hot issue 2: Improving returns to and impact of science. While Finland has a strong public research sector, universities and PRIs perform less well than those of other leading countries in filing for patents (Panel 1[p]). Until recently, Tekes, the Finnish funding agency for innovation, has emphasised research projects to address business needs. Recognising the importance of bringing entirely new businesses to life, Tekes has launched New Knowledge and Business from Research Ideas as a new type of funding for public research which allows scientists to explore an idea not only in the research phase but also in terms of its transformation into new businesses through commercialisation.

Hot issue 3: Innovation to contribute to sustainable/green growth. In spring 2014 the government adopted strategies on cleantech and bio-economy. The goal is to accelerate growth, create new businesses and renew traditional industries through innovation. In June 2013, the government adopted a decision-in-principle on the promotion of sustainable environmental and energy solutions (cleantech solutions) through public procurement. This encourages the public sector to make creation and implementation of clean-technology solutions a reference for public procurement.

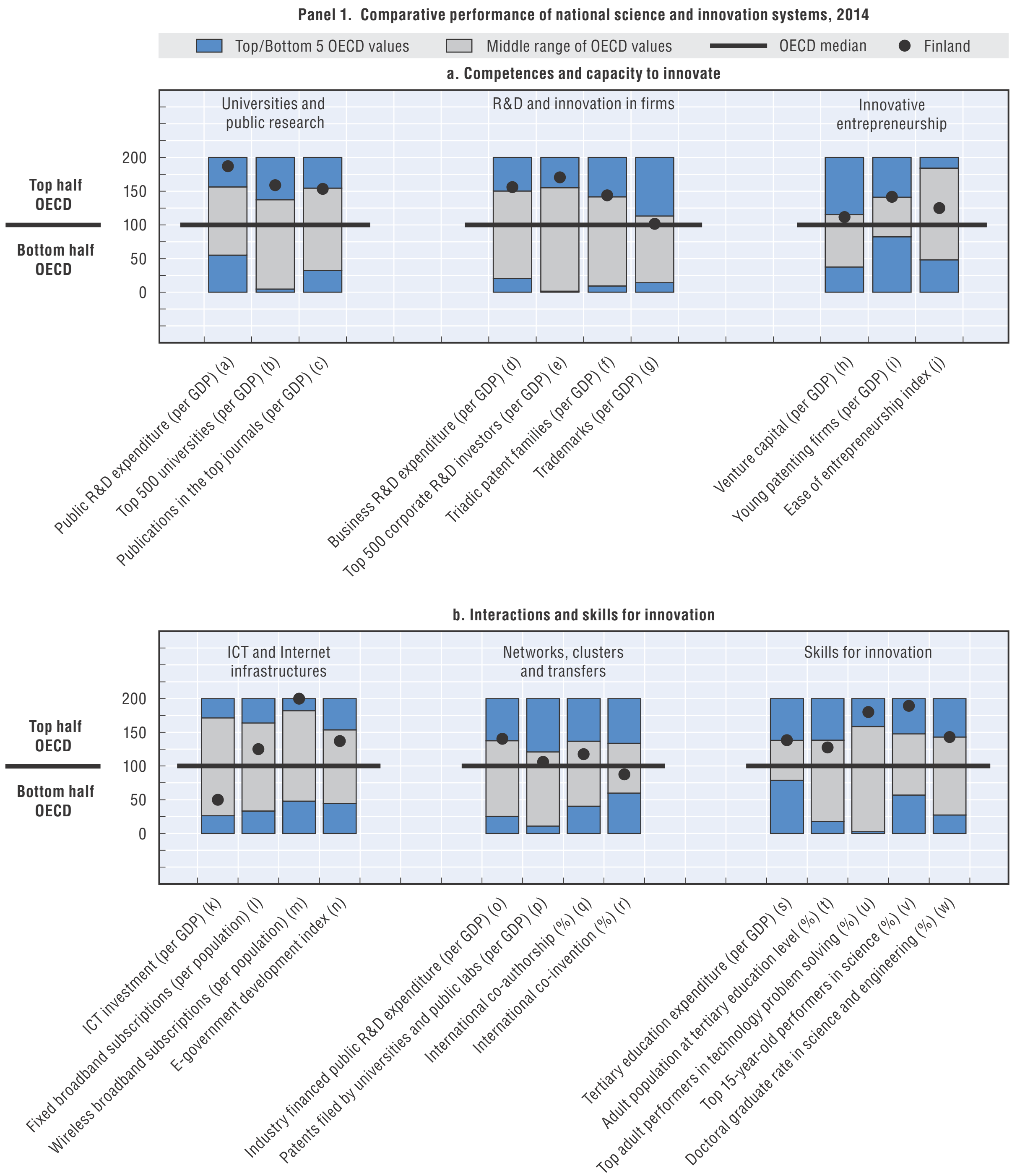
Hot issue 4: Business innovation, entrepreneurship and SMEs. Finland's BERD intensity is well above the OECD median (Panel 1[d]). BERD is primarily performed by the high-technology manufacturing sector and large firms such as Nokia (Panel 2). Overall patent applications and patenting by young firms rank at the top of the OECD mid-range (Panel 1[f, i]). To increase firms' R&D activity and create new high-value-added jobs, Finland introduced a fixed-term R&D tax incentive for 2013-14. Moreover, the Smart Procurement Programme (2013-16) aims to create new market opportunities for SMEs and produce ground-breaking innovative solutions to serve the needs of the Finnish public sector. In 2013 the government adopted an extensive growth funding programme (2014-17) for start-up and new innovative companies.

Hot issue 5: Addressing the challenges of STI globalisation and increasing international co-operation. With international co-publications above and international co-patenting below the OECD median, Finland's position in international co-operation on science and innovation is mixed (Panel 1[q, r]). To exceed the EU average in the stock of FDI as a share of GDP (46.6% in 2012) by 2020 from its current level (36% in 2012), the government adopted in December 2012 a decision-in-principle, Team Finland – Strategy for Promoting Foreign Investment. Rather than creating a new initiative or adding a new layer of bureaucracy, this strategy seeks to improve the efficiency of existing FDI promotion efforts by bringing them under a single umbrella. By doing so, the

Key figures, 2013

Economic and environmental performance	FIN	OECD	Gross domestic expenditure on R&D	FIN	OECD
Labour productivity			**GERD**		
GDP per hour worked, USD PPP, 2013	51.3	47.7	Million USD PPP, 2012	7 530	1 107 398
(annual growth rate, 2008-13)	(-0.3)	(+0.8)	As a % of total OECD, 2012	0.7	100
Green productivity			**GERD intensity and growth**		
GDP per unit of CO_2 emitted, USD, 2011	3.1	3.0	As a % of GDP, 2012	3.55	2.40
(annual growth rate, 2007-11)	(+4.6)	(+1.8)	(annual growth rate, 2007-12)	(-0.3)	(+2.0)
Green demand			**GERD publicly financed**		
NNI per unit of CO_2 emitted, USD, 2011	3.1	3.0	As a % of GDP, 2012	0.95	0.77
(annual growth rate, 2007-11)	(+4.0)	(+1.6)	(annual growth rate, 2007-12)	(+1.7)	(+2.8)

Figure 9.14. **Science and innovation in Finland**



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

government wishes to create a clear, flexible and customer-oriented model so that key actors at home and abroad work towards a coherent strategic goal. In addition, international companies conducting R&D activities in Finland can apply for Tekes' funding even without being registered in Finland or having a Finnish partner.

Highlights of the Finnish STI system

New challenges: The Strategic Centres for Science, Technology and Innovation (SHOK) are public-private partnerships for innovation to meet the needs of Finnish industry and society in the next five to ten years. They focus on energy, environment, bioeconomy, health and well-being, ICT, and metal products and mechanical engineering. SHOK activities are being developed on the basis of the international evaluation of SHOKs in 2013.

Universities and public research: Finland has a strong science base, high public expenditure on R&D, highly ranked universities and a high rate of scientific publications relative to GDP (Panel 1[a, b, c]). According to the Resolution on Comprehensive Reform, PRIs will be reformed. A new funding model for universities was introduced in 2013, with greater emphasis on quality, effectiveness and internationalisation, and strategic funding to support universities' profiles and their diversity has been increased. The new funding model will be reviewed in 2015. A new Polytechnics Act is to take force from the beginning of 2014 to help polytechnics to meet changes and challenges in Finnish workplaces and society by shifting responsibility for their basic funding to the state and by granting them the status of independent legal persons.

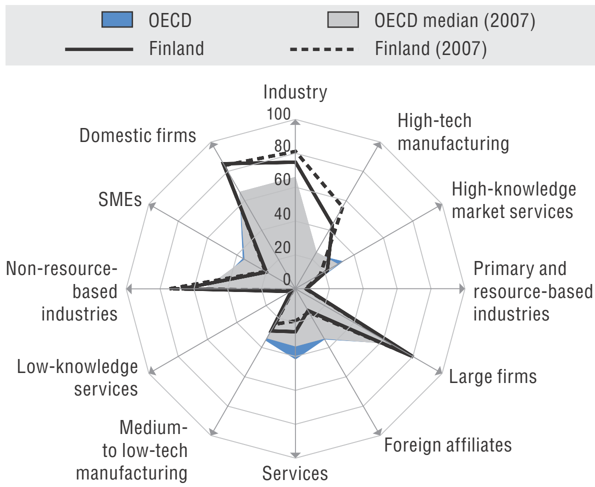
Innovative entrepreneurship: The Finnish government's venture capital activities for start-up funds will be transferred from Finnvera to Tekes from July 2014, with an annual budget of USD 22 million (EUR 20 million) and hopes of leveraging at least an equivalent amount from private VC sources. The Funding Scheme for Young Innovative Companies is intended to run in its current form until the end of 2014 and is then expected to continue in a modified form.

Clusters and smart specialisation: From 2014 the Centre of Expertise Programme (OSKE 1994-2013) will be replaced by INKA, the Innovative Cities Programme (2014-20). The programme has selected 12 urban regions in which to create and strengthen internationally attractive innovation clusters. The Witty City Programme (2013-17) supports collaborative projects between business, municipalities and research organisations to provide companies with opportunities to bring new products and services to the market. The new INKA programme has incorporated the EU smart specialisation concept. A synchronised national and regional innovation strategy was updated in 2013 when city regions organised large-scale planning in order to participate in INKA.

Skills for innovation: All human capital indicators for Finland are above the OECD medians (Panel 1[t, u, v, w]). Adults' ability to solve technical problems and 15-year-olds' performance in science are outstanding, and the high rate of doctoral graduates in science and engineering indicates a secure supply of the highly skilled for STI. The government's Action Plan for Gender Equality 2012-15 promotes equality between women and men and combats gender-based discrimination in education. The Ministry of Education and Culture uses several measures to make research careers attractive and aims at 1 600 doctoral graduates a year over 2013-16. A national working group of the Science Education Programme 2013-14 will review overall science education with a view to stimulating more interest in science and research among children and adolescents.

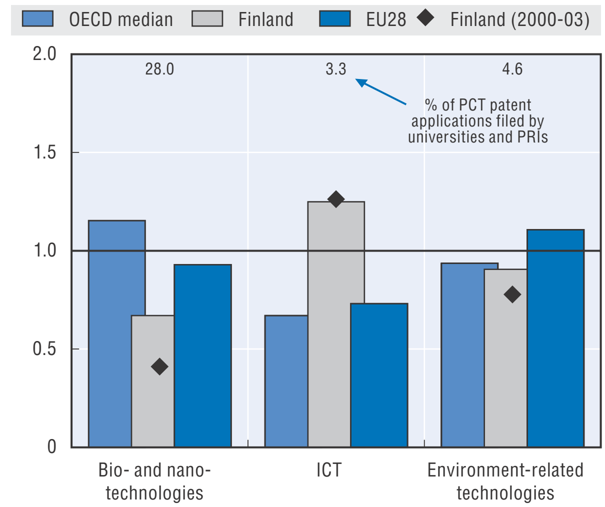
Panel 2. Structural composition of BERD, 2011

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

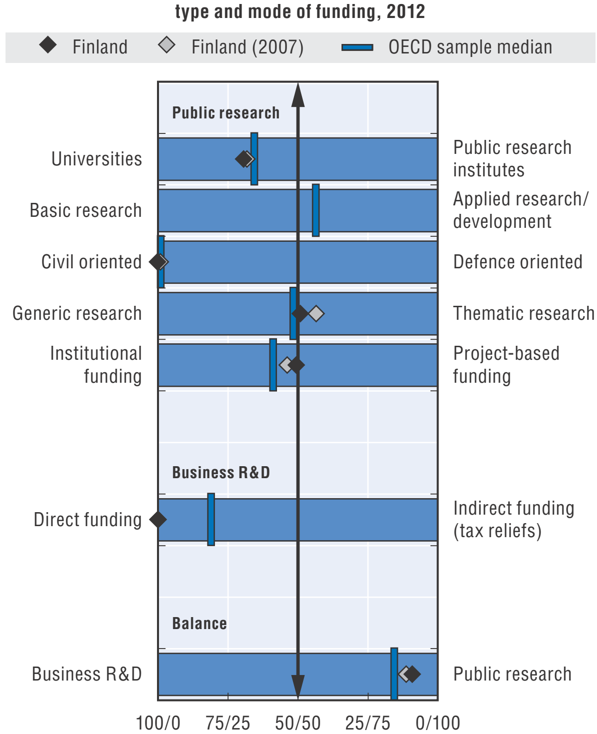


Panel 3. Revealed technology advantage in selected fields, 2009-11

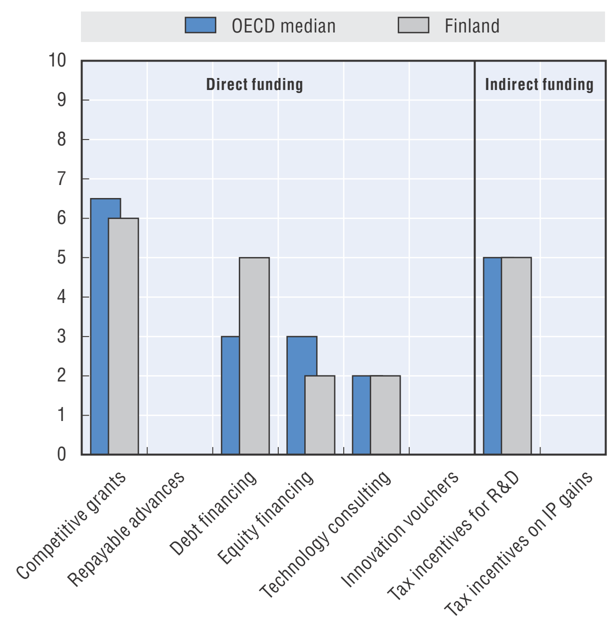
Index based on PCT patent applications



Panel 4. Allocation of public funds to R&D, by sector, type and mode of funding, 2012



Panel 5. Most relevant instruments of public funding of business R&D, 2014



Note: Policy information comes from country responses to the OECD STI Outlook policy questionnaires 2014 and 2012. Finland's responses are available in the *OECD STI Outlook Policy Database*, edition 2014 at *http://qdd.oecd.org/Table.aspx?Query=F0716DF1-E8C1-47D4-B5F2-D38D7ADC02F6*.

Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888933152141

FRANCE

The French economy is the second largest in the euro zone and has grown modestly in recent years. A marked deindustrialisation has implications for the competitiveness of the French export industry. In view of this, mobilising STI to promote innovation-based growth is at the top of the policy agenda.

Hot issue 1: Contributing to structural adjustment and the new approach to growth. France puts innovation at the heart of its policy for growth, which focuses on new industrial policy, particularly on "managing" the energy transition and on information technology. Policies to promote business R&D and the development of young firms have been strengthened and a number of specific plans have been announced. The New Face of Industry in France, of September 2013, selected 34 industrial activities that will benefit from co-ordinated state support and business efforts to commercialise new technologies (e.g. fuel efficient car, digital hospital, e-education tools), by 2020. A complementary plan, the New Deal for Innovation (November 2013), includes 40 measures to evaluate public policies, to foster an entrepreneurial culture, to facilitate technology transfer and to encourage the growth of innovative firms (by facilitating their access to markets, finance, intellectual property, etc.).

Hot issue 2: Addressing social challenges (including inclusiveness). France aims to improve the contribution of public research to meeting major societal challenges (the environment, ageing). This will be a major component of the National Strategy for Research French (SNR) being elaborated in the first half of 2014 through broad consultation with stakeholders, notably PRIs. The implementation plan will identify the needed resources. It will be linked with the Investments for the Future (PIA), with a budget of USD 23.8 billion (EUR 20 billion) for research and innovation over 2010-20.

Hot issue 3: Reforming the public research system. The French public research system continues to evolve. Measures have been implemented to strengthen the links between PRIs, universities, and social and economic stakeholders. Better integration of universities, engineering and business schools (*grandes écoles*) and PRIs is also a priority. This includes a programme funding excellent teams that are affiliated both to PRIs and to universities through the PIA. A new evaluation agency for universities and PRIs established in 2014 (the HCERES) has a status that guarantees its independence from the evaluated parties.

Hot issue 4: Increasing returns to and impact of science. To strengthen the competitiveness of businesses and address societal challenges through the commercialisation of public research and the reduction of the time to market of business R&D is a main goal of French policy and is linked to the EU Horizon 2020 agenda. A plan with this goal was established in 2012-13, and the New Deal for Innovation also includes some specific measures. Entrepreneurship courses are now given in all universities. Technology Transfer Acceleration Companies (SATT), are being set up as part of the PIA with a specific business plan and professional staff. Joint PRI-SME labs are being supported. The PIA also funds several dedicated joint research facilities of businesses and PRIs or universities, including some for developing technologies relating to the energy transition.

Highlights of the French STI system

Universities and public research: Public R&D expenditure as a share of GDP is above the OECD median (Panel 1[a]). The reforms started in the mid-2000s have continued. In July 2013, a law on the missions and organisation of the higher education and research system was passed, which encourages them to associate or merge so as to reach critical mass in research and teaching.

Innovation in firms: With business R&D at 1.48% of GDP in 2012, France is just above the OECD median (Panel 1[d]), but below Germany and countries in northern Europe. To boost R&D and innovation, the government has maintained the R&D tax credit, which is among the most generous in the world, with a total claim of around USD 6 billion a year (EUR 5 billion). It has also taken a number of measures to strengthen direct support, such as the 34 key industries mentioned above.

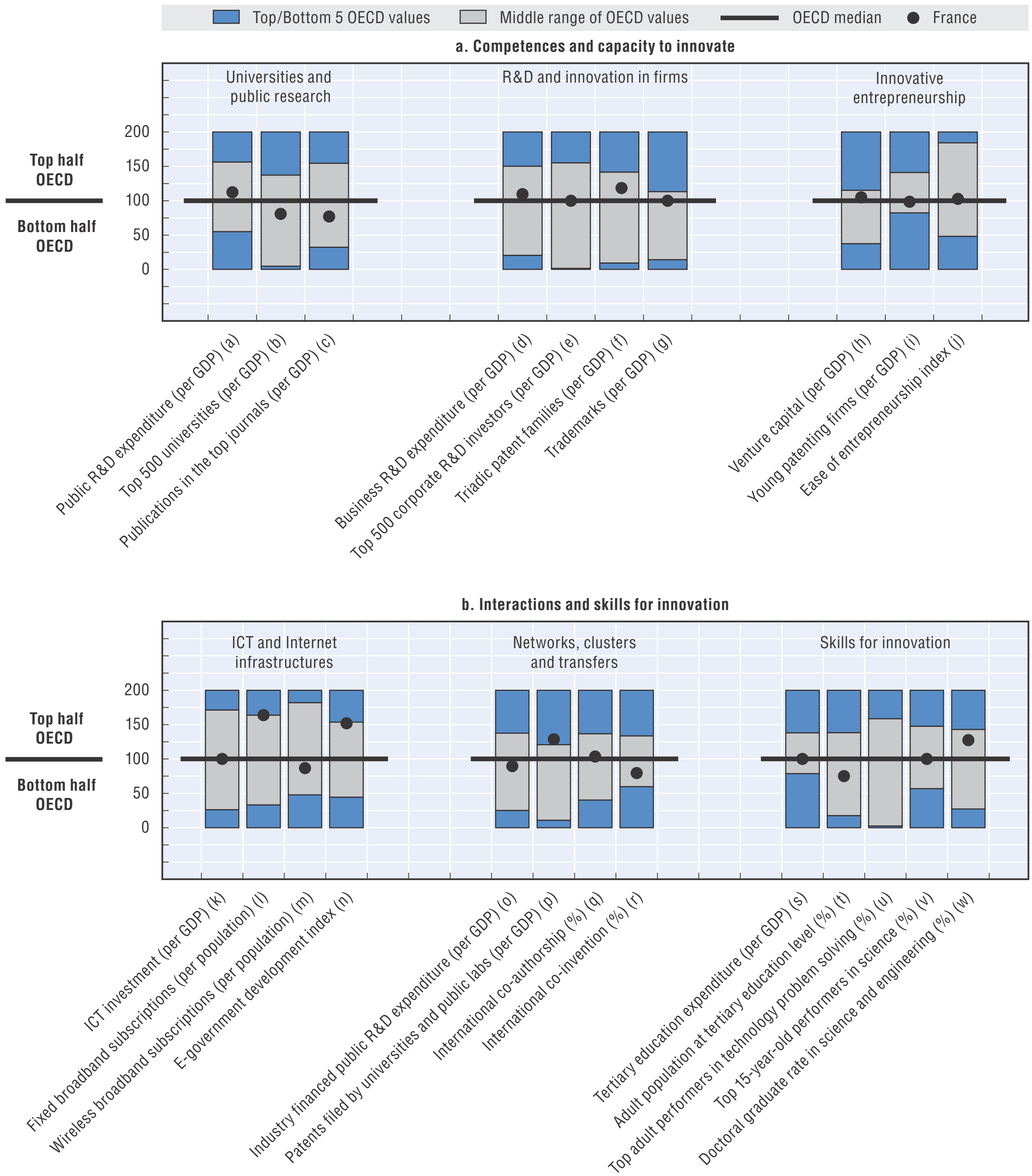
Innovative entrepreneurship: Boosting the creation and growth of innovative start-ups is a prominent goal of French policy. Recent measures include the creation of the

Key figures, 2013

Economic and environmental performance	FRA	OECD	Gross domestic expenditure on R&D	FRA	OECD
Labour productivity			**GERD**		
GDP per hour worked, USD PPP, 2013	61.6	47.7	Million USD PPP, 2012	55 352	1 107 398
(annual growth rate, 2008-13)	(+0.5)	(+0.8)	As a % of total OECD, 2012	5.0	100
Green productivity			**GERD intensity and growth**		
GDP per unit of CO_2 emitted, USD, 2011	5.9	3.0	As a % of GDP, 2012	2.29	2.40
(annual growth rate, 2007-11)	(+3.3)	(+1.8)	(annual growth rate, 2007-12)	(+2.0)	(+2.0)
Green demand			**GERD publicly financed**		
NNI per unit of CO_2 emitted, USD, 2011	6.2	3.0	As a % of GDP, 2011	0.82	0.77
(annual growth rate, 2007-11)	(+3.2)	(+1.6)	(annual growth rate, 2007-11)	(+0.1)	(+2.8)

Figure 9.15. **Science and innovation in France**

Panel 1. Comparative performance of national science and innovation systems, 2014



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

new *Banque Publique d'Investissement* (Bpifrance), which supports innovation by start-ups and SMEs, the broadening of the Young Innovation Firms (JEI), an instrument that supports young innovative companies, and the creation of an Innovation Tax Credit (CII) aimed at increasing innovation investments by independent SMEs. In 2011 a fund of funds (FNA), with USD 714 million (EUR 600 million), was established for seed capital. It had made 15 investments as of 30 November 2013 in digital technologies (45%), life sciences (40%) and clean technology (10%).

Technology transfer and commercialisation: PRIs file many patents (Panel 1[P]). To improve the return to public research, the aforementioned law of July 2013 established technology transfer as one of the missions of PRIs. As part of the PIA, the SATT aim to achieve critical mass and the professionalism needed for technology transfer.

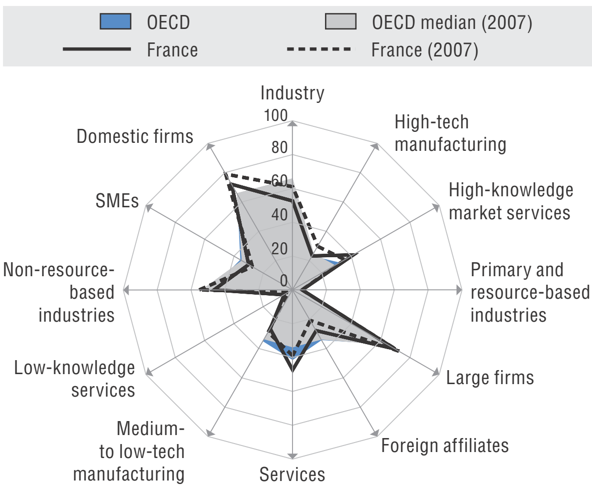
Clusters and smart specialisation: Since 2004, France's Competitiveness Clusters (*pôles de compétitivité*) have funded public entities' R&D projects on specific themes (e.g. nanotechnology, aerospace). Following an evaluation in 2012, the third phase of this policy places more emphasis on the downstream stage (i.e. prototyping and commercialisation of innovations).

Globalisation: Increasing the exposure of French researchers to foreign colleagues is an important policy goal. Several programmes help French researchers get temporary positions abroad and attract leading foreign researchers to France. For instance, the Chairs of Excellence give up to USD 2.4 million (EUR 2 million) to selected foreign researchers for a period of 18-48 months in France. In light of the modest French participation in the 7th Framework Programme, the government is actively preparing actors to participate in Horizon 2020.

Skills for innovation: The law of July 2013 expands the autonomy of HEIs, giving them greater freedom to design their curricula. France has a relatively high rate of doctoral students in S&E (Panel 1[W]). Doctoral students have a new statute (the Doctoral Contract), which includes a higher salary and the possibility of teaching, consulting, etc. Student entrepreneurship is also encouraged: e.g. dedicated classes, counselling by experienced entrepreneurs, facilitated access to funding, etc.

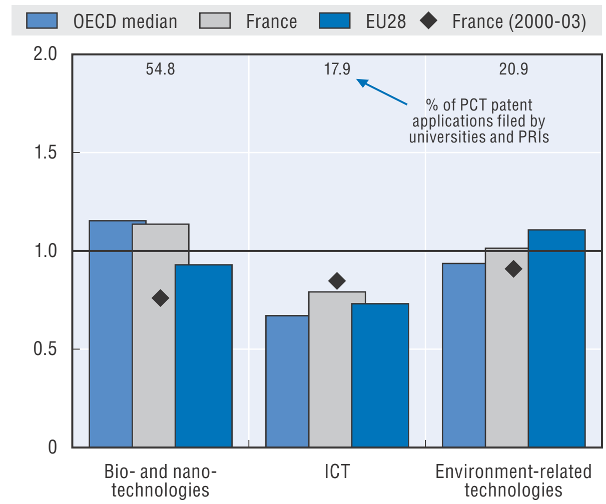
Panel 2. Structural composition of BERD, 2011

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

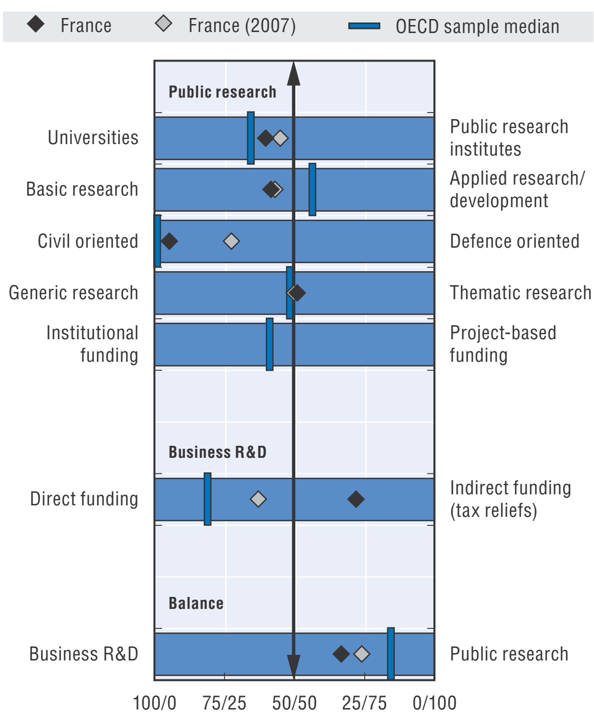


Panel 3. Revealed technology advantage in selected fields, 2009-11

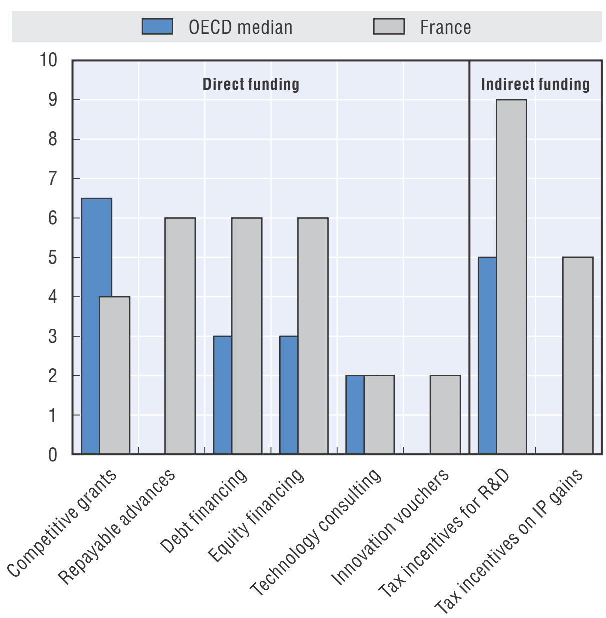
Index based on PCT patent applications



Panel 4. Allocation of public funds to R&D, by sector, type and mode of funding, 2012



Panel 5. Most relevant instruments of public funding of business R&D, 2014



Note: Policy information comes from country responses to the OECD STI Outlook policy questionnaires 2014 and 2012. France's responses are available in the *OECD STI Outlook Policy Database*, edition 2014 at *http://qdd.oecd.org/Table.aspx?Query=E1A91286-E3E7-4E83-9DA9-2FE5689B1090*.

Source: See reader's guide and methodological annex.

StatLink *http://dx.doi.org/10.1787/888933152159*

GERMANY

Germany is a leading player in global innovation and science. The Federal Government's High-Tech Strategy (HTS) sets the mid-term strategic orientations for Germany's R&D and innovation activity: reinforce the S&T base, enhance innovation and job creation, and help address global challenges to improve people's lives. The HTS will be expanded into a comprehensive interdepartmental innovation strategy and will cover both technological and societal innovations and seek to transform research results into practice better and faster.

Hot issue 1: Innovation to contribute to addressing social challenges (including inclusiveness). Unlike the R&D policy of the past, the HTS will promote not only individual emerging technologies but will also respond to society's need for sustainable solutions for clean energy, good and efficient health care, sustainable mobility, secure communications, and Germany's future competitiveness as an industrial location. The HTS also aims to create lead markets and identified wide-ranging forward-looking projects (*Zukunftsprojekte*) that are expected to affect society. Implementation of the HTS is supported by a host of initiatives, with priority to funding private and public R&D, reforming the education system, and improving industry-science linkages. With a budget of USD 960 million (EUR 770 million) for 2011-15, the German Centres of Health Research, research consortia involving 120 institutions, promote co-operation by the best researchers to speed up the bench-to-bedside transfer of health research.

Hot issue 2: Targeting priority areas. The goal of the above-mentioned forward-looking projects, such as Industry 4.0, Sustainable Mobility and Better Health, is to reach specific S&T objectives over the next 10 to 15 years. The Framework Programme Research for Sustainable Development (FONA) (2010-14) supports research on climate change mitigation and adaptation, sustainable resource management, and innovative environmental and energy technologies, with a budget of USD 2.5 billion (EUR 2 billion). It seeks to maintain and enhance Germany's position as a leader in these technology areas. The National Research Strategy Bioeconomy 2030, with a budget of USD 2.6 billion (EUR 2 billion) for 2011-16, aims to strengthen the future competitiveness of the German biotechnology industry and thus to help address global challenges in nutrition, climate change, etc. Other sectoral programmes include the Nano Initiative – Action Plan 2015, the Photonics Research Germany programme with USD 526 million (EUR 410 million) over 2012-15, and the German Space Activities with an annual budget of USD 1.5 billion (EUR 1.2 billion). The Leading Edge Cluster Competition (three rounds since 2007) supports high-performing clusters in their respective areas. The CLIENT project, a funding line under FONA, helps to establish international partnerships on R&D and application of environmental and climate protection technologies and to trigger the development of lead markets. The programme as of 2015 is currently under development. Some initiatives have been directed towards services, such as Innovation with Services (until 2013) and the Services Task Force within the Science and Industry Research Union.

Hot issue 3: Improving framework condition for innovation, including competitiveness. The HTS also aims to improve competitiveness, in particular of innovative SMEs. Germany has favoured direct public support for business R&D and innovation over R&D tax incentives. Technology funding for SMEs by the federal government increased from USD 943 million (EUR 783 million) in 2007 to USD 1.8 billion (EUR 1.4 billion) in 2013. The Central Innovation Programme for SMEs (ZIM), with USD 705 million (EUR 550 million) a year, offers grants for SMEs' applied R&D and innovation projects. The Innovation Vouchers (2011-16) fund 50% of the cost of professional advice on innovation management for SMEs.

As the venture capital market is at the OECD median (Panel 1[h]), VC holding companies investing in young technology companies obtain tax relief, and the Investment Grant for Business Angels, started in 2013, reimburses 20% of VC investments that remain for more than three years in the start-up. It complements existing instruments such as the *High-Tech Gründerfonds* for start-up firms (since 2005).

Highlights of the German STI system

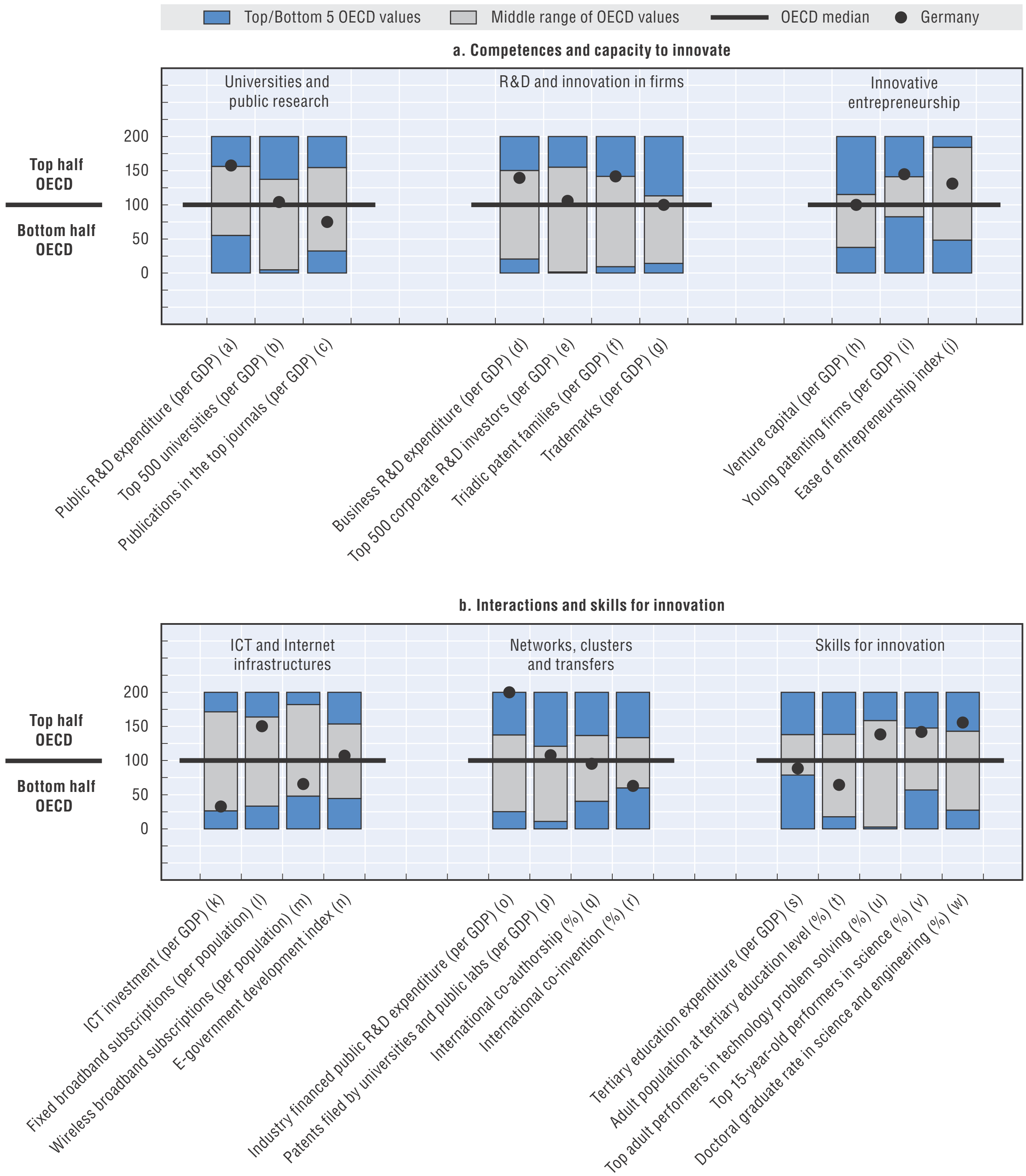
STI policy governance: The HTS has served to link various innovation policy fields across federal ministries. In line with the challenges-led approach, BMBF's second foresight cycle (2012-14) takes a demand-oriented perspective. To

Key figures, 2013

Economic and environmental performance	DEU	OECD	Gross domestic expenditure on R&D	DEU	OECD
Labour productivity			**GERD**		
GDP per hour worked, USD PPP, 2013	60.4	47.7	Million USD PPP, 2012	102 238	1 107 398
(annual growth rate, 2008-13)	(+0.4)	(+0.8)	As a % of total OECD, 2012	9.2	100
Green productivity			**GERD intensity and growth**		
GDP per unit of CO_2 emitted, USD, 2011	3.8	3.0	As a % of GDP, 2012	2.98	2.40
(annual growth rate, 2007-11)	(+3.6)	(+1.8)	(annual growth rate, 2007-12)	(+4.1)	(+2.0)
Green demand			**GERD publicly financed**		
NNI per unit of CO_2 emitted, USD, 2011	3.9	3.0	As a % of GDP, 2011	0.86	0.77
(annual growth rate, 2007-11)	(+2.9)	(+1.6)	(annual growth rate, 2007-11)	(+6.3)	(+2.8)

Figure 9.16. **Science and innovation in Germany**

Panel 1. Comparative performance of national science and innovation systems, 2014



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

keep abreast of recent developments, it will also update the results of the first cycle (2007-09) on cutting-edge technology fields, and link the two perspectives, which will help to shape future research and innovation policy. The German Energy Transition (*Energiewende*) has led to the creation of various new platforms and networks to co-ordinate actors across the innovation system (e.g. the *Energiewende* Research Forum).

Universities and public research: Germany has a strong science base, and high public spending on R&D (Panel 1[a]). Its performance in terms of top 500 universities is below the OECD median. Germany ranks fourth globally in terms of publication output and number of citations. Give the size of its GDP, publications in top journals are somewhat below the OECD median (Panel 1[c]). German researchers are well connected internationally; 46% of scientific articles are published with international co-authorship (Panel 1[q]). Major initiatives are under way to further strengthen the performance of universities and PRIs. The Pact for Research and Innovation (updated in 2009) is a joint effort of the federal government and the states (*Länder*) to increase R&D funding of major PRIs, including the German Research Foundation (DFG), by 5% a year over 2011-15. In all this will mean USD 6.3 billion (EUR 4.9 billion) in additional funding for R&D. As part of the Higher Education Pact 2020, DFG provides overhead funding (of 20%) for university research projects to improve their flexibility and latitude to carry out excellent research. The Academic Freedom Act, effective from the end of 2012, grants more autonomy to non-university PRIs in matters of funding and staffing. The goal of the Initiative for Excellence (2007-17) is to enhance the international visibility and competitiveness of universities as centres of research. It undertakes competitions in three areas: graduate schools, excellence clusters and institutional strategies. These have recently been complemented by funding schemes such as the Research Campus competition launched by BMBF in 2011 (see below).

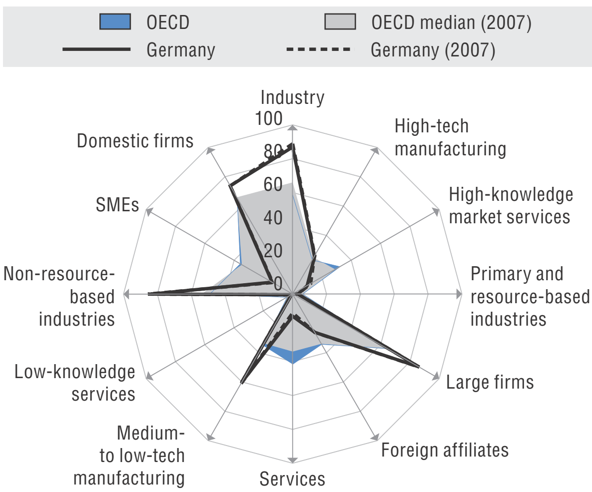
Technology transfer and commercialisation: German industry and science have strong links and a very high proportion of public research is funded by industry (Panel 1[o]). On-going initiatives to strengthen and improve collaboration between business and science include the Leading Edge Cluster competition (since 2007), with a total funding of USD 1.4 billion (EUR 1.2 billion) (50% private funds and 50% from BMBF), and Research Campus, a competitive funding scheme under the HTS. A research campus is required to bring together private and public research competences at a single location, have a medium to long-term perspective, and build a reliable public-private partnership. The Science and Industry Research Union is tasked among other things with advising on faster and more effective transformation of innovative ideas into innovative products.

Skills for innovation: The German innovation policy considers a lack of skilled personnel being an emerging constraint. Various measures promote MINT disciplines (mathematics, informatics, natural sciences and technology). The Graduate Schools competition of the Initiative for Excellence (managed by DFG) seeks to create optimal conditions for training doctoral students with a structured study programme in a stimulating research environment to prepare them for a career in research or industry. In total the annual budget is some USD 70 million (EUR 60 million). The Quality of Teaching Pact has a budget of USD 2.5 billion (EUR 2.0 billion) to improve the quality of teaching from 2011 to 2020. Following the adoption of the Pact for Research and Innovation, the number of employees in scientific research organisations rose by 26.5%, and the number of their doctoral students doubled between 2005 and 2012.

Recent developments in STI expenditures: Germany spent 2.98% of GDP on R&D in 2012, up from 2.53% in 2007. Public and business expenditures on R&D, at 0.96% and 2.02% of GDP, respectively, in 2012 are both well above the OECD average (Panel 1[a, d]), owing to the government's focus on R&D and to Germany's specialisation in R&D-intensive industries. GBAORD increased by about a third between 2007 and 2013, despite the recession and fiscal consolidation. GERD is targeted to reach 3% of GDP by 2020, and public investment in R&D and innovation continues to be a top political priority.

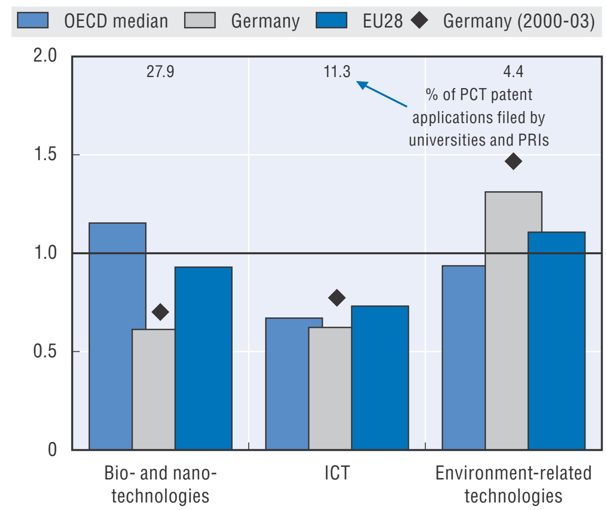
Panel 2. Structural composition of BERD, 2011

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

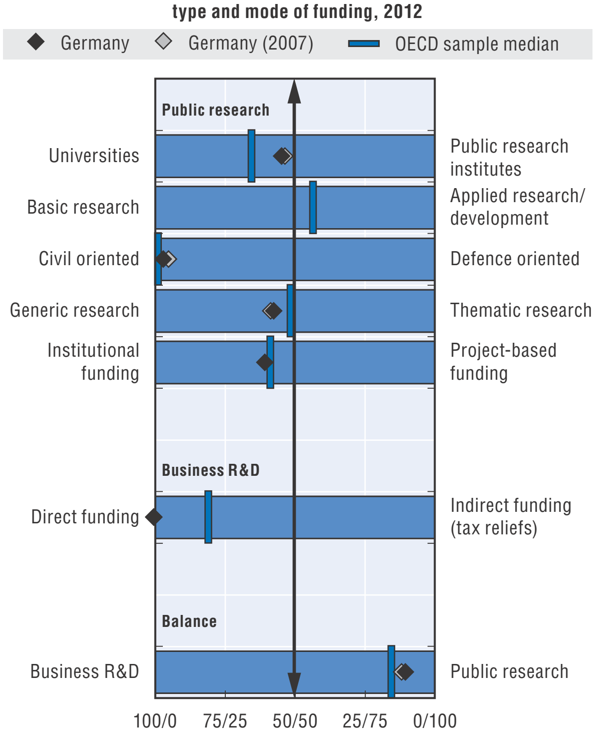


Panel 3. Revealed technology advantage in selected fields, 2009-11

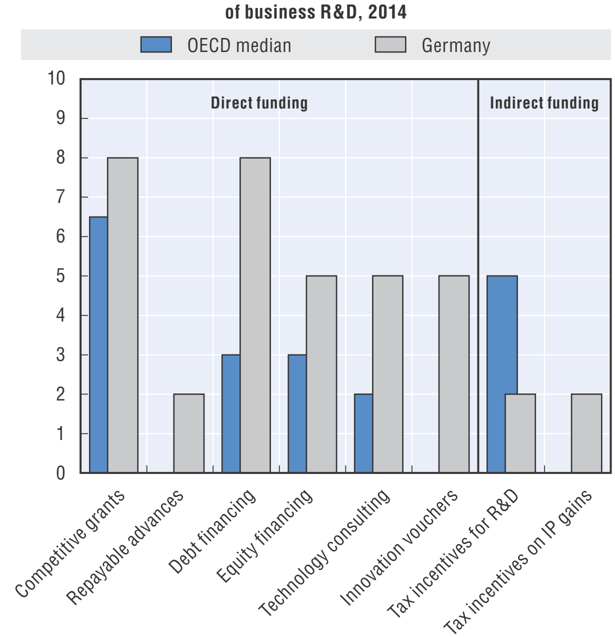
Index based on PCT patent applications



Panel 4. Allocation of public funds to R&D, by sector, type and mode of funding, 2012



Panel 5. Most relevant instruments of public funding of business R&D, 2014



Note: Policy information comes from country responses to the OECD STI Outlook policy questionnaires 2014 and 2012. Germany's responses are available in the *OECD STI Outlook Policy Database*, edition 2014 at *http://qdd.oecd.org/Table.aspx?Query=7D74C077-CFE5-491F-BBB1-8C6910D83A71*.

Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888933152162

GREECE

Greece has undergone a pronounced and protracted economic recession since 2008. In response, the Greek government has embarked on deep fiscal adjustments and wide-ranging structural reforms. Improving framework conditions for innovation and overcoming serious weaknesses in the innovation system are important steps in regaining competitiveness and sustainable growth.

Hot issue 1: Improving framework conditions for innovation (including competitiveness). Greece's framework conditions for innovation are far from favourable as indicated by the lack of venture capital and the low Ease of Entrepreneurship Index, compared to the OECD median (Panel 1[h, j]). Improving conditions for entrepreneurship is considered critical for Greece's economic recovery, and the government has made sustained efforts to improve framework conditions for innovation as a way to restore competitiveness, growth and job creation. Measures implemented include legislative and policy improvements address STI both directly and indirectly, development of e-infrastructure, support for alternative innovation models (including social and open innovation) and more and better metrics and indicators for STI. More specifically, structural reforms have been undertaken in the competition framework, the labour market and the tax system. The Investment Law (3908/2011) amended in 2012-13 puts more emphasis on young innovative entrepreneurship, on improving the climate for business investment in R&D and on green development. The Hellenic Fund for Entrepreneurship and Development (ETEAN S.A), established in 2011, provides guarantees for loans to SMEs by banks and other financial institutions (such as leasing and venture-capital companies). The national strategic plan for innovation and entrepreneurship aims at enhancing the government-owned VC Fund of Funds (TANEO SA) through new venture funds with the participation of Tier 1 global VCs as general partners. A new Framework Law on Research, Technological Development and Innovation is under preparation. It will help to improve conditions for private R&D investment.

Hot issue 2: Strengthening public R&D capacity and infrastructure. Relative to public expenditure on R&D, which is considerably below the OECD median (Panel 1[a]), Greece has comparatively better performance in terms of international publications and presence among the world's top 500 universities (Panel 1[b, c]). However, the pressures for fiscal consolidation have imposed further cuts on public funding of research in the last two years. To cope with this, the government emphasises efficient use of limited resources. Based on Law 4051/2012, PRIs are being reorganised and merged to improve disciplinary and geographical focus, enhance scientific co-operation within research fields, and reduce cost. The 2013 Athena Plan aims to rationalise higher education. Greece has made substantial efforts to improve its national R&D e-infrastructure through EU-Greece co-funded projects for cloud infrastructure-as-a-service (IaaS) for the research and academic community. Open access policies regarding publications and data have been formulated, and the largest-ever programme for the documentation, grouping and re-use of over two million cultural objects is being carried out. A national strategy and a roadmap for upgrading existing research infrastructure are being drafted and will be finalised in 2014.

Hot issue 3: Improving returns to and impact of science. Greece's public research system is largely insulated from the productive sector. PRIs and universities do not tend to commercialise their research results, as indicated by their extremely low number of patents (Panel 1[p]). Also, the share of industry-financed public R&D is quite low (Panel 1[o]), a further indication of weak links between academia and industry. In addition to supporting commercialisation by improving framework conditions for entrepreneurship, the national strategic plan for innovation and new entrepreneurship has introduced technology transfer offices (TTOs) in each university and PRI. Continuous efforts have been made to increase the protection and exploitation of IPR resulting from public research and to support alternative models of knowledge exploitation. Furthermore, open data policies will be implemented with a view to stimulating research and growth by increasing the return to and impact of public research.

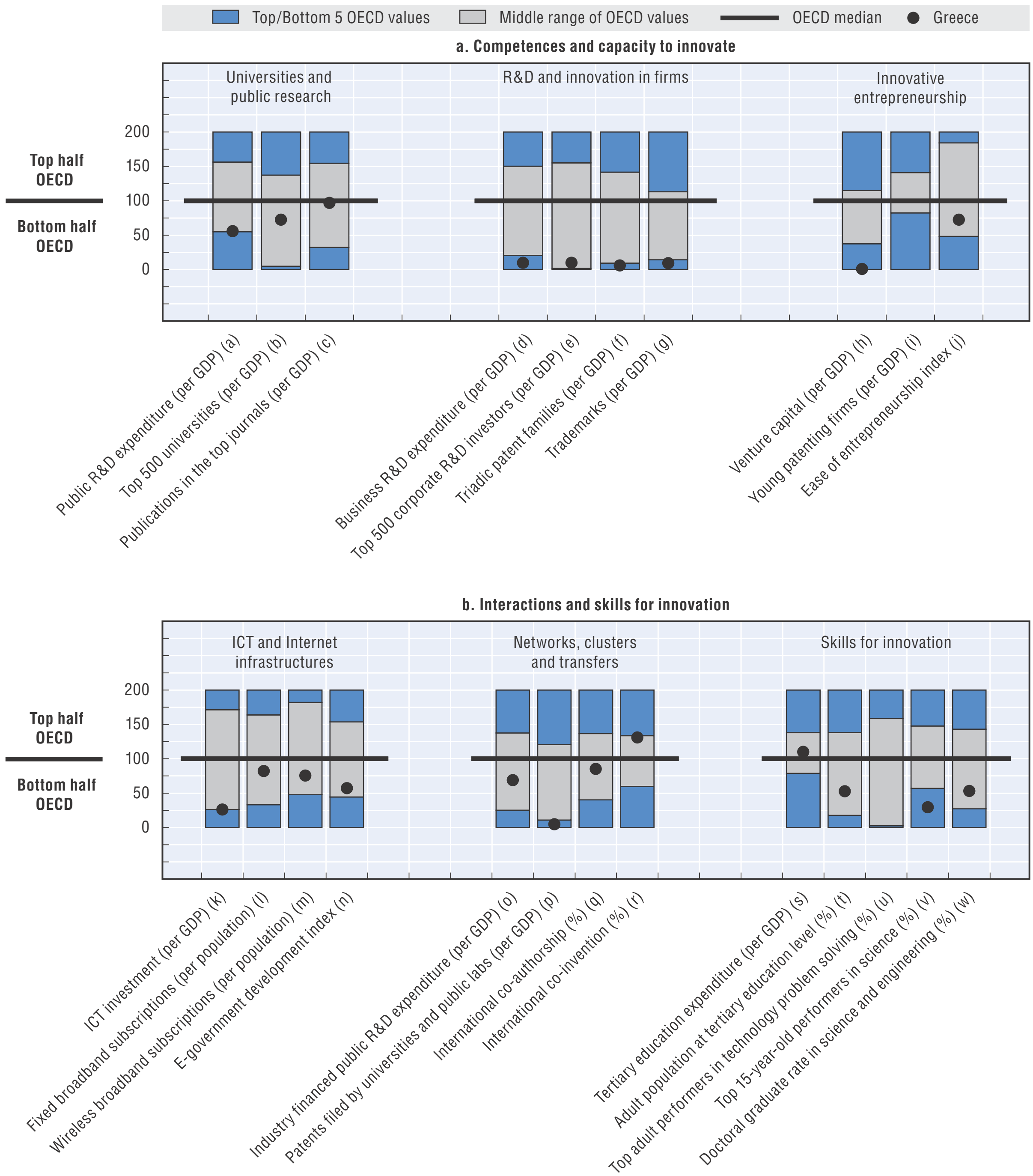
Hot issue 4: Addressing globalisation and increasing international STI co-operation. Pressures on national budgets have reinforced the importance of international co-operation on STI, which is also viewed as an opportunity to tap into external funding and infrastructures and profit from international

Key figures, 2013

Economic and environmental performance	GRC	OECD	Gross domestic expenditure on R&D	GRC	OECD
Labour productivity			**GERD**		
GDP per hour worked, USD PPP, 2013	35.4	47.7	Million USD PPP, 2012	1 994	1 107 398
(annual growth rate, 2008-13)	(-1.8)	(+0.8)	As a % of total OECD, 2012	0.2	100
Green productivity			**GERD intensity and growth**		
GDP per unit of CO_2 emitted, USD, 2011	3.0	3.0	As a % of GDP, 2012	0.69	2.40
(annual growth rate, 2007-11)	(0.0)	(+1.8)	(annual growth rate, 2007-12)	(-1.8)	(+2.0)
Green demand			**GERD publicly financed**		
NNI per unit of CO_2 emitted, USD, 2011	2.8	3.0	As a % of GDP, 2012	0.36	0.77
(annual growth rate, 2007-11)	(-2.0)	(+1.6)	(annual growth rate, 2011-12)	(-1.6)	(+2.8)

Figure 9.17. **Science and innovation in Greece**

Panel 1. Comparative performance of national science and innovation systems, 2014



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

transfers of knowledge. Funding from abroad accounted for 15.8% of GERD in 2012, with the European Union the most important external funder of R&D activities. Over the last two years, the Greek government has focused on supporting bilateral scientific co-operation and on encouraging further participation by PRIs and business in international (especially European) programmes, such as the ERA-NET scheme.

Hot issue 5: Improving overall human resources, skills and capabilities. Although Greece's expenditure on higher education is at the OECD median, its share of tertiary-qualified adult population is below the median (Panel 1[t, v]). The economic recession has also caused a loss of human resources for S&T and innovation, as austerity measures applied to pension rights have led many senior researchers to retire early, while wage cuts and recruitment freezes have driven a growing number of young scientists out of the country. The recent reform of higher education (laws 4009/2011, 4076/2012 and 4115/2013) has introduced major changes in governance and funding mechanisms to boost university autonomy and to improve the quality of teaching and services for students. The latest reforms (i.e. laws 4093/2012 and 4111/2013) have rationalised the legal framework of post-secondary education and introduced new provisions for the recognition of higher education degrees earned from other EU member states.

Highlights of the Greek STI system

New sources of growth: Micro- and nano-electronics and embedded systems have recently appeared on Greece's R&D landscape. They are developed through domestic measures (the Corallia cluster for microelectronics, 2008-15) and through participation in international programmes: the European Nanoelectronics Initiative Advisory Council and the Advanced Research and Technology for Embedded Intelligence and Systems. Four new clusters in space, gaming, life sciences and green energy are financed over 2011-15 with a total budget of around USD 38 million (EUR 27.6 million).

New challenges: The government seeks to improve the alignment of environmental and energy policy with domestic technological development, mainly through joint projects under the Co-operation programme. A related initiative is the Green Island – Ai Stratis project (2010) for the development of mature renewable energy and energy-saving technologies to cover the island's needs.

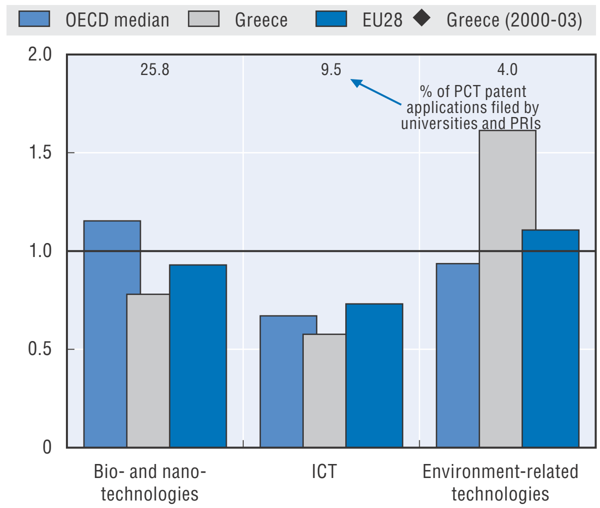
Innovation in firms: BERD is well below the OECD median (Panel 1[d]). Greece lacks world leading corporate R&D investors (Panel 1[e]), and the low values of innovation output indicators (Panel 1[f, g]) are the mirror image of the low innovation input of Greek firms. The tax law 4110/2013 (amending a law from 2004) provides for an annual deduction of R&D expenses from firms' net profits at the increased rate of 30% during the fiscal year in which the cost occurred. This tax incentive will apply from 2014 to help boost business R&D expenditures. Important changes to trademark legislation (e.g. reform of trademark registration procedures) were introduced over 2012-13, and modernisation of the country's patent system is currently under consideration.

Innovative entrepreneurship: Enterprise Europe Network-Hellas (EEN-Hellas) provides initial support to innovative Greek enterprises wishing to enter global value chains and become more export-oriented by using knowledge from third parties, transferring their knowledge to other parties and increasing the level of patenting and licensing. The new EEN programme is expected to commence in the last quarter of 2014.

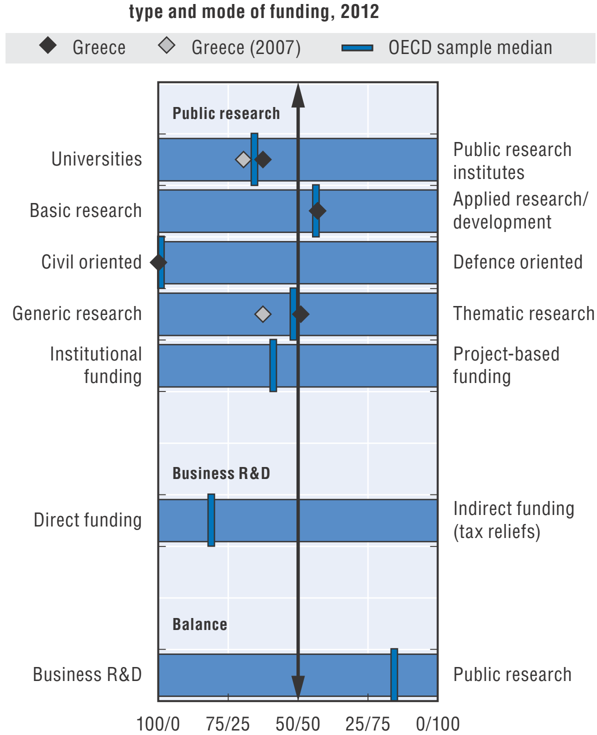
Clusters and smart specialisation: Since the beginning of 2012, smart specialisation strategies have been elaborated both at the national and regional level. National innovation platforms have been set up since 2013 in the framework of the EU's Research and Innovation Strategy for Smart Specialisation (RIS3) for 2014-20. Formed around the priority sectors, they involve all relevant stakeholders in priority setting for the ICT, energy, environment and agro-food sectors. They address the needs of enterprises (particularly SMEs) and other private investors in order to encourage R&D in the private sector.

Panel 2. Revealed technology advantage in selected fields, 2009-11

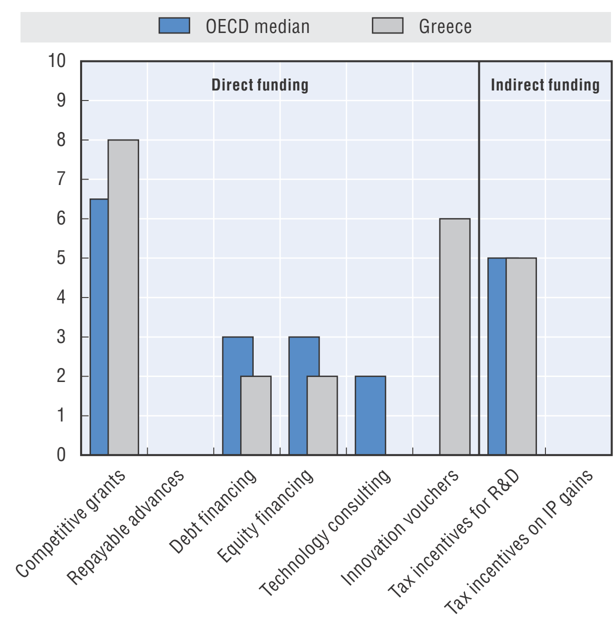
Index based on PCT patent applications



Panel 3. Allocation of public funds to R&D, by sector, type and mode of funding, 2012



Panel 4. Most relevant instruments of public funding of business R&D, 2014



Note: Policy information comes from country responses to the OECD STI Outlook policy questionnaires 2014 and 2012. Greece's responses are available in the *OECD STI Outlook Policy Database*, edition 2014 at *http://qdd.oecd.org/Table.aspx?Query=2D786F62-2F8F-4160-A934-636EAF1E4D50*.

Source: See reader's guide and methodological annex.

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HUNGARY

Hungary is a central European economy with a strong industry sector in which foreign investment and technology play a significant role. It has a longstanding tradition in scientific research. In June 2013 the government adopted the Investment in the Future: National Research and Development and Innovation Strategy (2013-20), which focuses on key strategic issues.

Hot issue 1: Strengthen public R&D capacity and infrastructures. Given Hungary's very low public R&D expenditure by OECD standards, its research sector's publication performance is quite strong (Panel 1[a, c]). However, research infrastructures have become increasingly obsolete owing to a lack of investment in maintenance and modernisation in the recent past. The National Research Infrastructure Survey and Roadmap (NEKIFUT), undertaken as a part of the government's mid-term STI strategy for 2007-13, identified measures to be taken and highlighted the importance of accessing international research infrastructure networks. The Extreme Light Infrastructure (ELI) programme to develop a super-laser is supported by both the European Union and the Hungarian government. Now in a preliminary phase, the aim is to have it operational by the end of 2015. The need for public investment in research infrastructure is recognised in the new Economic Development and Innovation Operative Programme (GINOP), which defines development priorities for 2014-20.

Hot issue 2: Strengthening business innovation, entrepreneurship and SMEs. Supporting business innovation and SMEs has always been a focus of Hungarian development policy. The government aims to boost business investment in R&D and innovation (Panel 1[d]); it currently emphasises start-ups, young entrepreneurs and incubation processes. Major support measures for business innovation and SMEs include EU co-financed initiatives under the Economic Development and Innovation Operative Programme (GINOP), with a budget of USD 21.1 billion (HUF 2 700 billion) for the next seven years, and the national R&D programmes financed by the Research and Technological Innovation Fund (KTIA) with USD 195 million (HUF 25 billion) a year. Other measures include the tax incentive that allows a deduction of 200% of the amount of R&D expenditures from the income of the company's pre-tax profit statement. Measures taken in this regard include innovation and technology parks along with the Mentor Programme and InnoPoint, which provide integrated information services, both of which are run by the National Innovation Office and the Open Laboratory programme. The government also supports business innovation through innovation and technology parks, innovative clusters, and improvements in the business infrastructure and investment climate. In the context of Horizon 2020, Hungary plans to launch the Precompetitive Procurement Programme as a new funding instrument to support business innovation in all industries in 2014.

Hot issue 3: Improving the education system. Hungary's public expenditure on higher education as a share of GDP is among the lowest of OECD countries, although it is home to two (to four, depending on the ranking exercise) of the world's top 500 universities (Panel 1[s, b]). Reform of the education system has long been an issue for the government. Based on the government resolution, the "university of national excellence" classification can be awarded to higher education institutions with strong educational and research capacities and outstanding scientific results in more than one discipline that allow them to contribute significantly to the attainment of national strategic objectives. The transition to tertiary education with a labour-market orientation and the introduction of tuition fees have been the key steps in the reform process. Companies are involved in the design of curricula and establish faculties at universities to teach students with up-to-date knowledge and to facilitate recruitment.

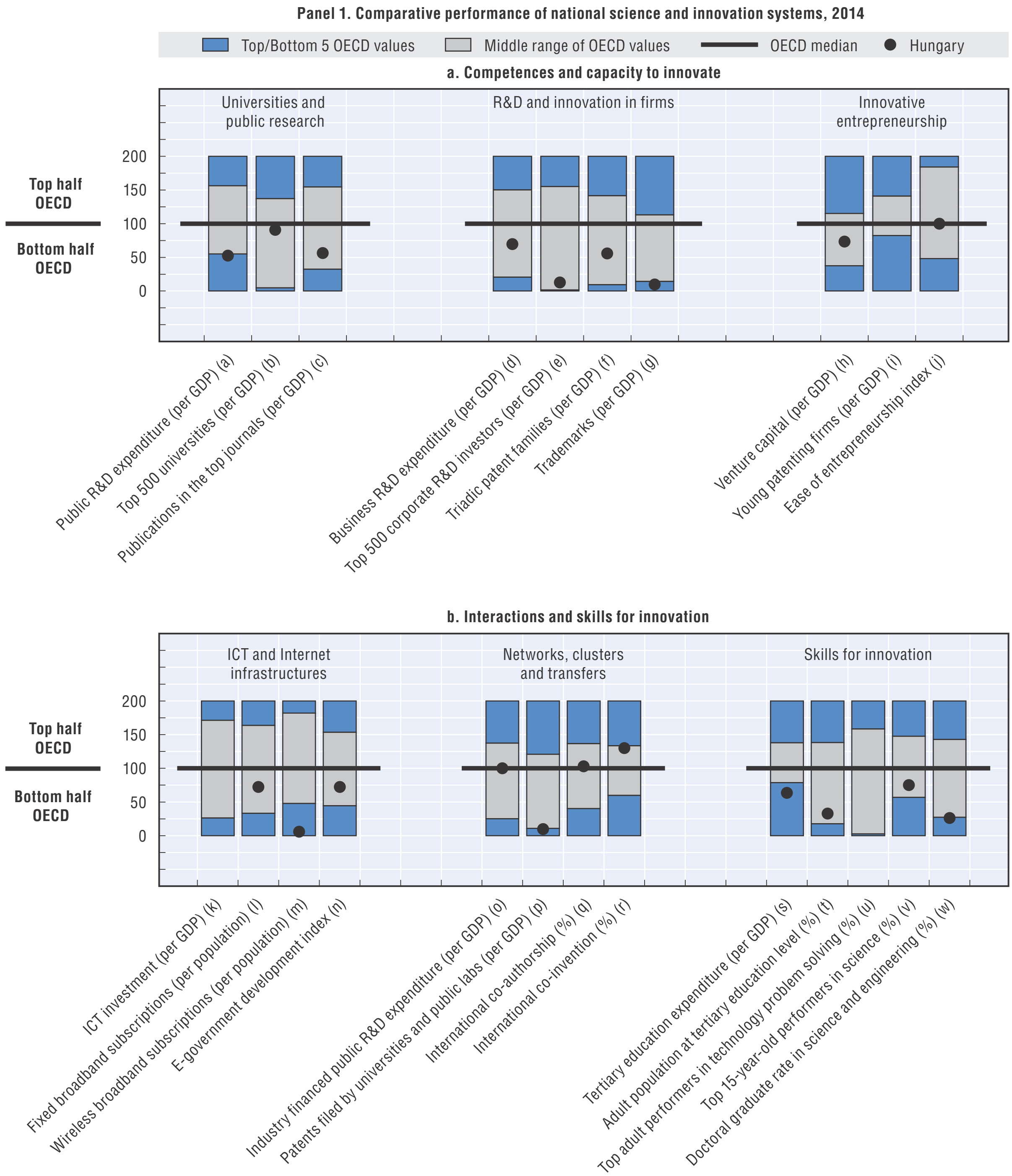
Other important initiatives for the education system and human resources include: the Momentum programme, which aims to foster excellence and reduce brain drain by supporting talented young researchers; the National seeks to attract Hungarian researchers and lecturers working abroad to work in Hungary.

Hot issue 4: Improving the return to and impact of public research. While strong in academic publications, the Hungarian public research sector has weak patenting performance (Panel 1[p]), even though business-funded public R&D is at the OECD median (Panel 1[o]). To strengthen linkages

Key figures, 2013

Economic and environmental performance	HUN	OECD	Gross domestic expenditure on R&D	HUN	OECD
Labour productivity			**GERD**		
GDP per hour worked, USD PPP, 2013	29.6	47.7	Million USD PPP, 2012	2 912	1 107 398
(annual growth rate, 2008-13)	(+0.2)	(+0.8)	As a % of total OECD, 2012	0.3	100
Green productivity			**GERD intensity and growth**		
GDP per unit of CO_2 emitted, USD, 2011	3.7	3.0	As a % of GDP, 2012	1.30	2.40
(annual growth rate, 2007-11)	(+2.8)	(+1.8)	(annual growth rate, 2007-12)	(+4.6)	(+2.0)
Green demand			**GERD publicly financed**		
NNI per unit of CO_2 emitted, USD, 2011	3.7	3.0	As a % of GDP, 2012	0.48	0.77
(annual growth rate, 2007-11)	(+2.4)	(+1.6)	(annual growth rate, 2006-12)	(+0.2)	(+2.8)

Figure 9.18. **Science and innovation in Hungary**



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

among key players in the national innovation system, the government has made enhancing knowledge flows a key policy objective. In addition, the Research, Development and Innovation Strategy supports knowledge utilisation through accredited technological incubators and the development of a technological start-up ecosystem with an estimated USD 1.1 billion (HUF 140 billion) over 2014-20. It focuses on small innovative firms, medium-sized firms with strong export potential and large firms to capitalise on the innovation potential of public research.

Highlights of the Hungarian STI system

STI policy governance: The fragmentation of society and of the political system and a weak collaboration culture are considered the main barriers to better co-ordination of national innovation policy. However, the government is remodelling these structures to obtain a better-focused STI system of ministries, institutions and business actors. The Ministry for National Economy has established a working group (Budapest HUB) composed of different stakeholders in Hungarian start-ups, in recognition of the joint responsibility of the government and stakeholders to create a favourable ecosystem for start-ups.

Universities and public research: Hungary has a strong public research sector, notably under the Hungarian Academy of Sciences (MTA). Owing to changes in the governance structure of the Academy, government funding of research institutions has stagnated. The 2011 Act on Higher Education aims to increase the role of universities in public research by granting five universities a research-intensive university status. The new law on higher education adopted in 2012 sets natural sciences and technologies as priorities of public research and education and concentrates public funding of university research in research-intensive universities.

Innovative entrepreneurship: The EU JEREMIE Programme has had a strong positive influence on the development of Hungarian entrepreneurship and the emergence of Hungarian venture capital funds, and Hungary's position in the EU has risen relatively quickly. According to the European Private Equity and Venture Capital Association, Hungary had the highest venture capital investments as a percentage of GDP among EU member states in 2012. In 2013, the National Development Agency (NFÜ) selected eight market intermediaries, each of which was granted USD 23.5 million (HUF 3 billion) to work with Venture Finance Hungary Plc. to strengthen the JEREMIE Fund (also known as the Joint Growth Fund).

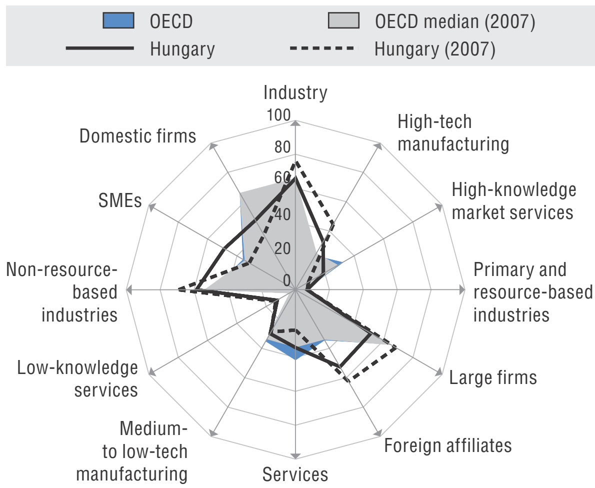
Clusters and smart specialisation: The Hungarian National Strategic Reference Framework (i.e. New Széchenyi Plan) emphasises enterprise networks and cluster development. Hungary is designing its national Smart Specialisation Strategy to promote the development and implementation of regional innovation systems in accordance with the government's decision and the agreement with the EU Commission.

Skills for innovation: In response to signs of skills shortages and needs, the education component of the national R&D and Innovation Strategy focuses on vocational training, interdisciplinary education, business management, fostering entrepreneurial and risk taking attitudes among youth through scholarship programmes and talent identification. To promote employment of researchers and S&E graduates, tax allowances are available for employers hiring doctorate holders, while the Be Entrepreneur in Hungary programme supports technology start-ups.

Recent developments in STI expenditures: In 2013 the Innovation Strategy set a target for GERD of 1.8% of GDP by 2020, with two-thirds of it performed by the business sector. Public budgets for R&D and innovation are expected to increase in the coming years.

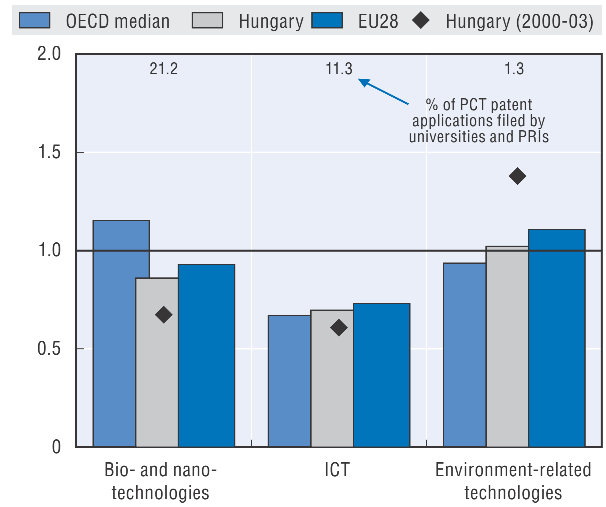
Panel 2. Structural composition of BERD, 2011

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

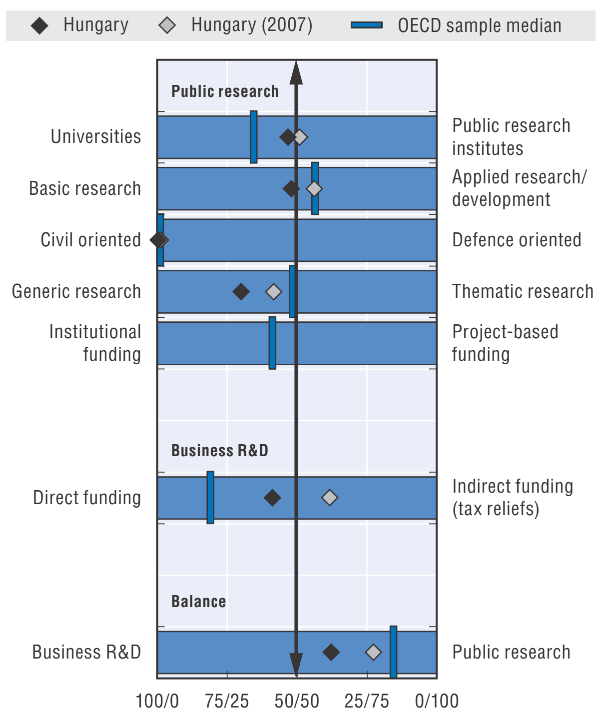


Panel 3. Revealed technology advantage in selected fields, 2009-11

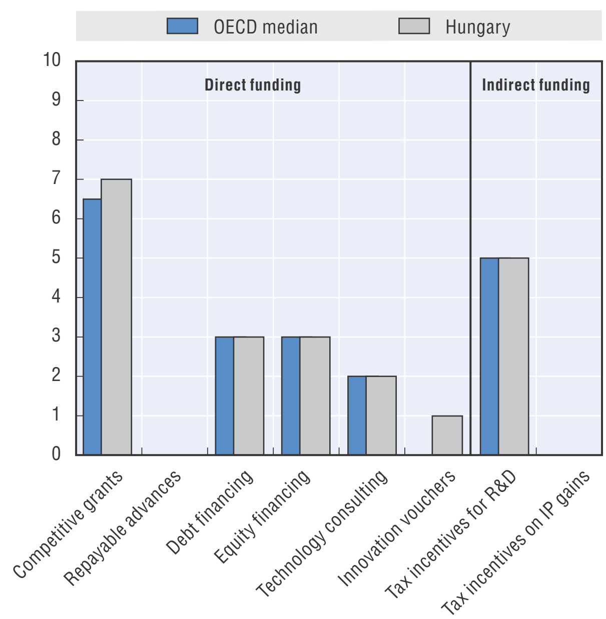
Index based on PCT patent applications



Panel 4. Allocation of public funds to R&D, by sector, type and mode of funding, 2012



Panel 5. Most relevant instruments of public funding of business R&D, 2014



Note: Policy information comes from country responses to the OECD STI Outlook policy questionnaires 2014 and 2012. Hungary's responses are available in the *OECD STI Outlook Policy Database*, edition 2014 at *http://qdd.oecd.org/Table.aspx?Query=4EB98911-4070-4821-A4E7-5D36060F9CF0*.

Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888933152184

ICELAND

Iceland has diversified into knowledge services over the last decade to complement its resource-based sectors, particularly fishing and aluminium production. The past years have also seen rapid growth in tourism. The 2008 financial crisis severely affected the economy and the STI sector is still in the recovery process. The new policy for Science and Technology (2014-16), which coincides with the inauguration of the new government, focuses on human resources and recruitment, co-operation and efficiency, growth and value creation, and impact and follow-up. An action plan based on the policy has been issued.

Hot issue 1: Improving overall human resources, skills and capacity building. By OECD standards, Iceland's 15-year-olds have relatively poor results in science and graduation rates at doctoral level in science and engineering are relatively low (Panel 1[v, w]). The new policy for S&T emphasises doctoral education and funding for young researchers, as well as increasing the number of science and engineering graduates. The Icelandic Research Fund for Graduate Students merged with the Icelandic Research Fund in 2013 and their financial capacity to support doctoral education and post-doctoral training was increased. The GERT initiative (Enhancing Education in the Natural Sciences and Technology) started in 2012 as a public-private partnership involving the central government, local authorities and industry federations to interest young people in the field. A White Paper on Reforms in Education will be issued in the summer of 2014 and will recommend restructuring education to shorten the time towards higher education.

Hot issue 2: Improving the return and impact of science. Technology transfer is supported upstream by strong industry-science linkages through research grants and contracts (Panel 1[o]), but universities and PRIs do not patent their research results. Iceland gives high policy priority to increasing co-operation between HEIs, PRIs and companies to enhance the efficiency of the system and the quality of its output.

Hot issue 3: Encouraging innovation in firms and supporting entrepreneurship and SMEs. Although BERD decreased from 1.42% of GDP in 2009 to 1.38% in 2011, Iceland remains at the OECD median in terms of business R&D intensity and technological and non-technological output (Panel 1[d, f, g]). Most business R&D activities are concentrated in knowledge-intensive services and high-technology manufacturing. Competitive grants and tax incentives are the most important instruments in the policy mix for business R&D and R&D-driven innovation (Panel 2). The tax incentive scheme provides a 20% reimbursement of companies' R&D costs through a tax rebate. Recently introduced, the total of the tax incentive scheme doubled from USD 4 million (ISK 540 million) to USD 8 million (ISK 1.1 billion) between 2011 and 2014.

Hot issue 4: Strengthening public R&D capacity and infrastructures. Iceland has a strong science base. The ratio of public R&D expenditure to GDP and academic publications in high-impact journals are at the top of the OECD area (Panel 1[a, c]). However, universities and PRIs have suffered severe and ongoing budgetary cuts since the onset of the crisis. Research expenditures at universities and PRIs dropped from 1.39% of GDP in 2009 to 1.06% in 2011. The new STI policy aims to increase the share of competitive funding in total STI funding from the current 20% to 27% by 2016 and to increase the use of performance indicators in allocating block funds. In addition to the existing tax incentive scheme, new schemes for investors in SMEs are being developed. University funding as a share of GDP is to reach the Nordic average by 2020. For research infrastructures, the Infrastructure Fund was established in 2013. It builds on and extends the role of the former Equipment Fund. A Working Group for Research Infrastructures will be established under the Science and Technology Policy Council in 2014 with the aim of updating the roadmap for infrastructures.

Highlights of the Icelandic STI system

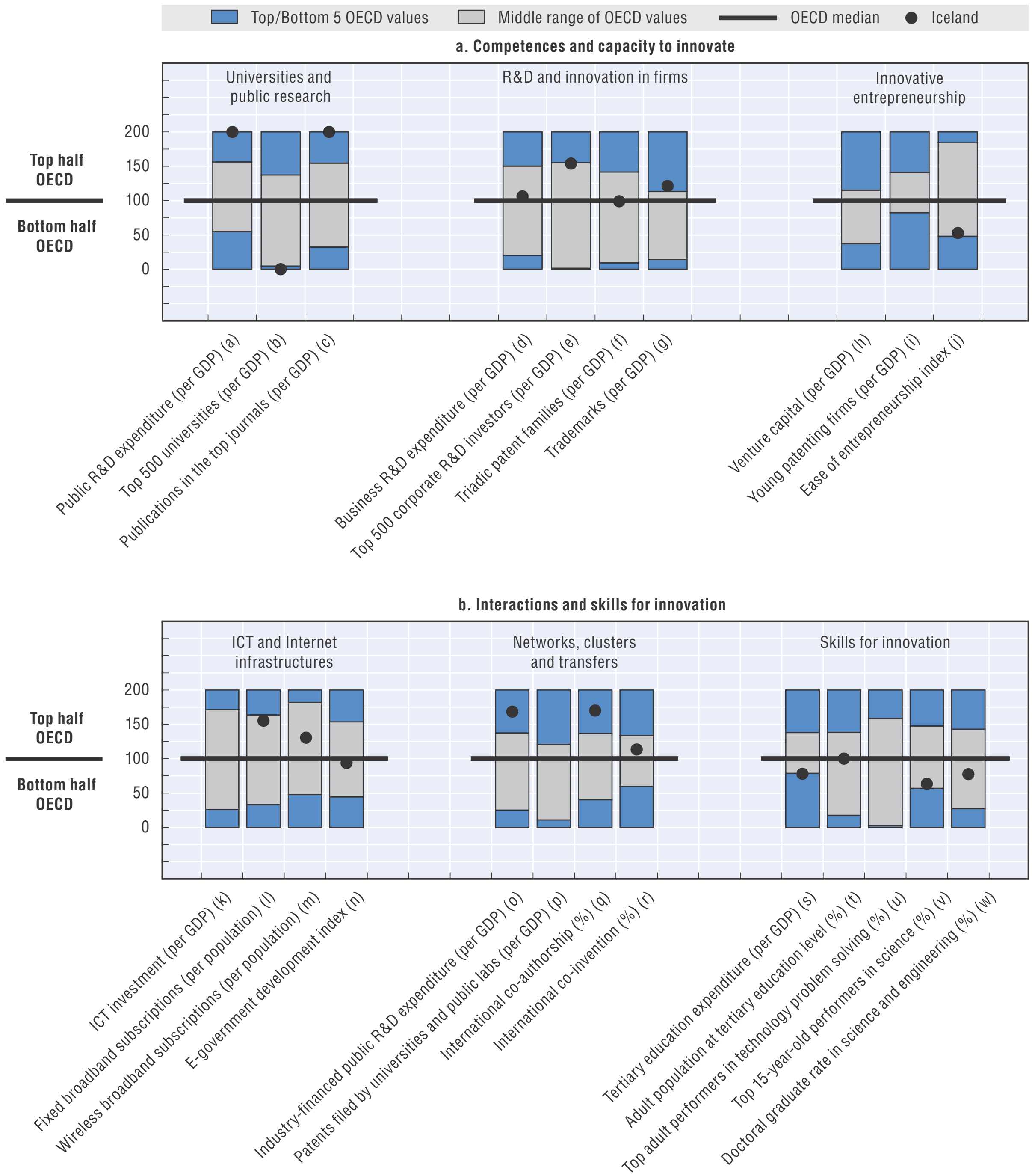
STI policy governance: Evaluation and monitoring of performance are key features of the new framework for S&T policy. Iceland seeks to improve the evaluation of science and innovation by developing a comprehensive system for monitoring science and innovation results, and improving industry statistics related to research, exports, value creation and innovation. An international evaluation of the STI system is being performed and results are expected by the autumn of 2014.

Key figures, 2013

Economic and environmental performance	ISL	OECD	Gross domestic expenditure on R&D	ISL	OECD
Labour productivity			**GERD**		
GDP per hour worked, USD PPP, 2013	43.4	47.7	Million USD PPP, 2011	318	1 107 398
(annual growth rate, 2008-13)	(+0.6)	(+0.8)	As a % of total OECD, 2011	0.0	100
Green productivity			**GERD intensity and growth**		
GDP per unit of CO_2 emitted, USD, 2011	5.9	3.0	As a % of GDP, 2011	2.61	2.40
(annual growth rate, 2007-11)	(+4.3)	(+1.8)	(annual growth rate, 2007-11)	(-2.5)	(+2.0)
Green demand			**GERD publicly financed**		
NNI per unit of CO_2 emitted, USD, 2011	n.a.	3.0	As a % of GDP, 2011	1.08	0.77
(annual growth rate, 2007-11)	n.a.	(+1.6)	(annual growth rate, 2007-11)	(-0.9)	(+2.8)

Figure 9.19. **Science and innovation in Iceland**

Panel 1. Comparative performance of national science and innovation systems, 2014



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

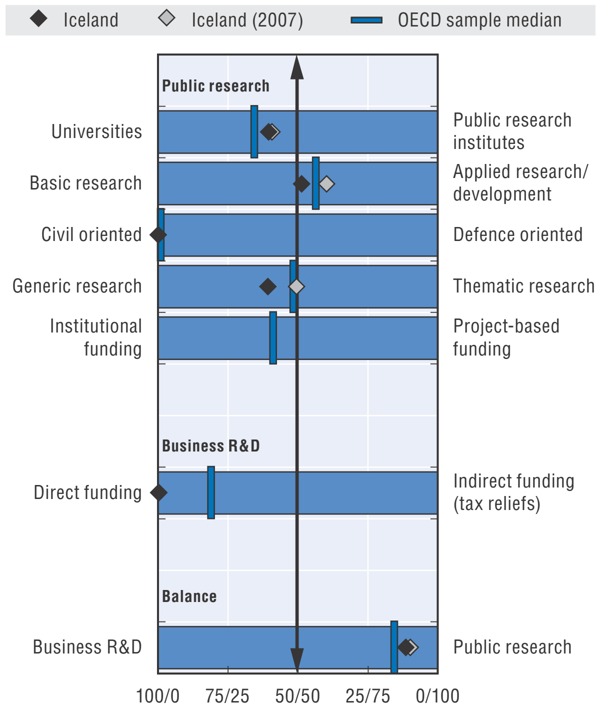
New challenges: In spite of the sharp economic slowdown, Iceland's green productivity increased almost twice as fast as in the OECD as a whole over 2007-11. It aims to become a leading international green economy focused on clean natural environments, sustainable use of energy, and education about sustainability. The Green Economy initiative was implemented in 2012. It makes the public sector a role model for the green economy. The concept of sustainable development has been integrated in the statutory missions of public institutions and green procurement practices are encouraged, with an objective of green national tenders of 50% of all public procurement tenders by 2015 and 80% by 2020. Economic incentives are provided through the Green Competitive Fund, the Green Venture Capital Fund, and Incentives for Initial Investment in Iceland by foreign investors.

Innovative entrepreneurship: Iceland offers a regulatory and administrative environment that is less conducive to entrepreneurship than the OECD median (Panel 1[j]). Red tape and entry barriers in the network and transport sectors impede product market competition. In addition firms' access to capital and debt funding has been hampered by major reforms of the financial sector to reduce risk of default, by the extensive fiscal consolidation to reduce public debt, and by the capital controls set in place as a result of the severe flight of capital during the crisis. Policy attention has recently been paid to strengthening equity funding and improving the environment for an effective stock market for growing companies. A working group was established in 2013 to consider tax incentives for individuals who purchase stocks in small growing companies. Public support for innovation is generally generic in nature, and there are few targeted instruments, e.g. centres for start-ups.

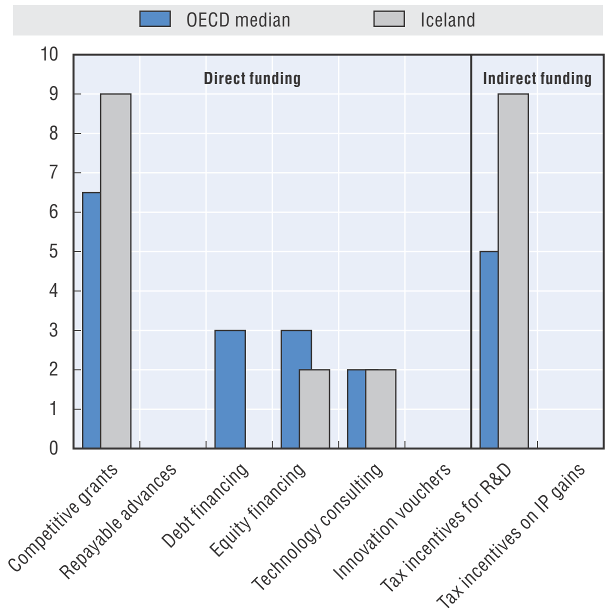
Clusters and smart specialisation: The public procurement scheme, Better service for less, was established in 2011 in co-operation with industry for a three-year period with an annual budget of USD 4.5 million (ISK 600 million). The project focuses on health, education, and energy and environmental issues. Clusters have become an important part of Iceland's policy. A notable example is the maritime cluster. There are on-going discussions to set up an aluminium cluster.

Globalisation: Owing to its small size and remote location, Iceland lacks world-class universities that attract talent and knowledge assets (Panel 1[b]). However, the University of Iceland is on the Times Higher Education World University Ranking, as one of the world's top 300 universities, and the number of large corporate R&D investors is high relative to its GDP (Panel 1[e]). ICT infrastructures are well developed and Iceland is strongly integrated in global academic networks; 69% of its scientific articles are produced with foreign co-authors (Panel 1[l, m, q]). The business sector is less well integrated as shown by co-patenting data (Panel 1[r]), but still above the OECD median. In addition, while Iceland previously received significant international S&T investments, foreign R&D funding dropped in the wake of the crisis from 12.1% to 5.4% of BERD between 2009 and 2011, but remained at 8-9% of public R&D expenditure. Iceland has announced better support for applications for external funding, both nationally and internationally, and for enhanced Icelandic participation in foreign programmes. Support will also be provided to firms seeking markets abroad. In the longer term, Iceland's competitiveness for highly skilled labour as well as increased international collaboration on research infrastructures is considered a likely policy issue.

Panel 2. Allocation of public funds to R&D, by sector, type and mode of funding, 2012



Panel 3. Most relevant instruments of public funding of business R&D, 2014



Note: Policy information comes from country responses to the OECD STI Outlook policy questionnaire 2014. Iceland's response is available in the *OECD STI Outlook Policy Database*, edition 2014 at *http://qdd.oecd.org/Table.aspx?Query=2A685F33-225F-4379-8825-42BE3649F63D*.
Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888933152194

INDIA*

India is a very large country and a fast-growing emerging economy. It is the global hub of offshore knowledge-intensive IT services and IT industry. However, its growth rate has slowed somewhat in recent years and poverty continues to be a major challenge. Innovation is seen as critical to India's socio-economic development. Through its national strategy, Decade of Innovations 2010-20, the government is committed to strengthening S&T capacities. The objective is to increase GERD to 2% of GDP with a doubling of the business contribution by 2020.

Hot issue 1: Innovation to address social challenges (including inclusiveness). The 12th Five-Year Plan (2012-17) seeks to address social challenges, especially poverty and exclusion, by catalysing a growth process that will promote more inclusive development. "Inclusive Innovation" initiatives that focus on innovation outcomes benefiting poor and excluded groups therefore receive particular attention. Innovation activities of the poor themselves are also important. Initiatives have been, or will be, launched to promote inclusive innovations, such as India's Inclusive Innovation Fund (IIF). The IIF is expected to mobilise USD 3.2 billion (INR 50 billion) and will support enterprises that develop innovative solutions for the "bottom 500 million" in India. About USD 320 million (INR 5 billion), or some 10% of the total, was raised by July 2012. India's National Innovation Foundation, created in 2000, supports grassroots innovators, i.e. those from poor and excluded groups, at various stages of the innovation process.

Hot issue 2: Innovation for sustainable/green growth. India faces energy security challenges, since economic growth creates more demand for energy and increases dependence on imports of coal. In response, several policies defined in the National Action Plan on Climate Change have been adopted to support renewable energy and energy conservation. The National Solar Mission aims to promote the development and use of solar energy for power generation and other uses with the ultimate objective of making solar energy competitive with fossil-based energy. The National Mission for Enhanced Energy Efficiency mandates specific decreases in energy consumption in large energy-consuming industries, with a system for companies to trade energy-savings certificates and incentives for adopting energy-efficient appliances. Finally, the national Mission for Sustainable Agriculture aims to support climate adaptation in agriculture through support for the development of climate-resilient crops. In addition, government subsidies are provided for all forms of renewable energy (whether on or off grid). Another emphasis is additive environmental technology with subsidies for cleaning up (or greening) existing manufacturing facilities.

Hot issue 3: Improving the design and implementation of STI policy. To improve the governance of STI policy making, the prime minister created the National Innovation Council (NInC) in 2010. With a mandate to formulate a roadmap for innovations for 2010-20, the NInC introduced the New Science, Technology and Innovation Policy in 2013, which focuses on inclusive growth.

Highlights of the Indian STI system

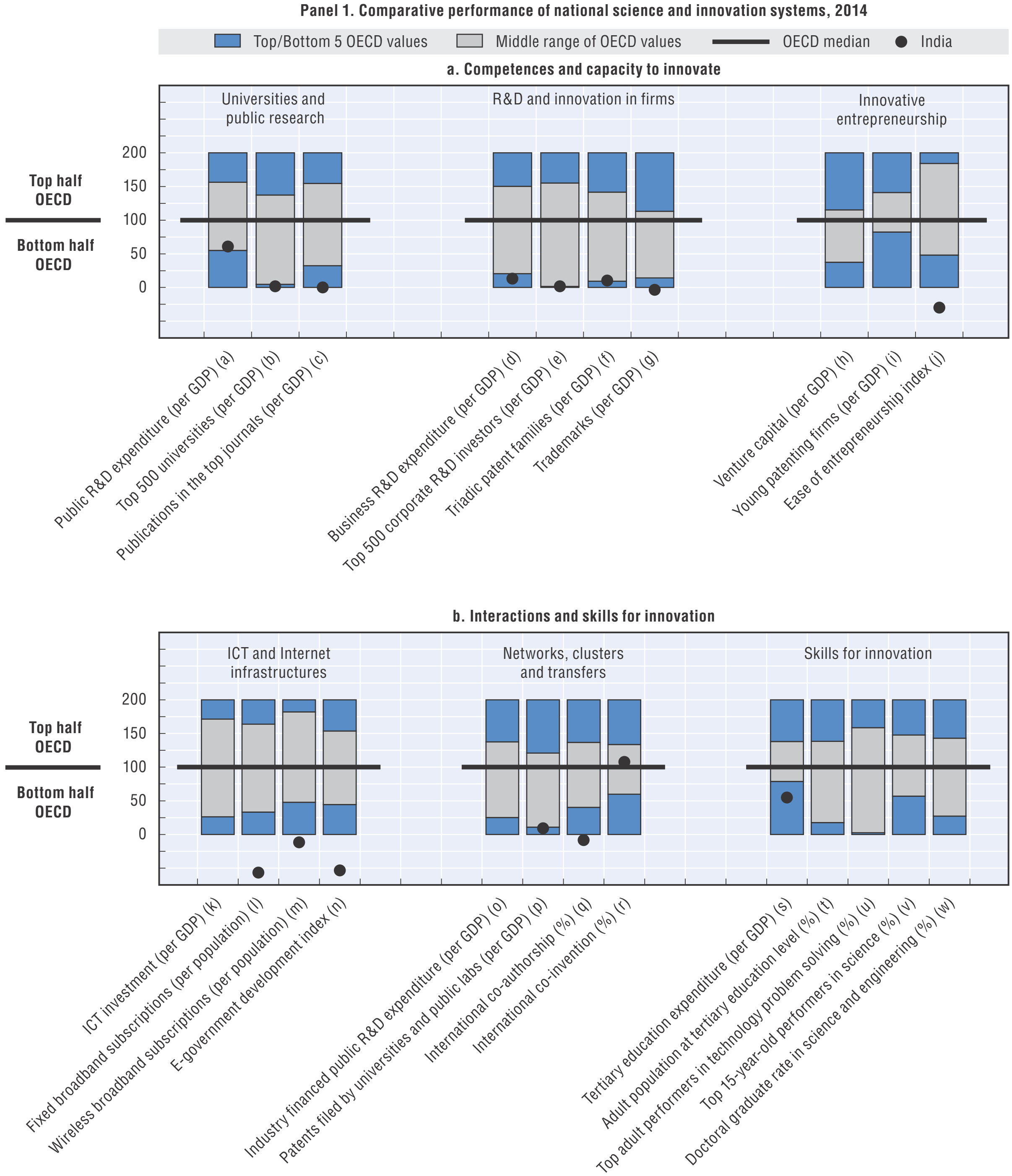
Universities and public research: As in many emerging economies, PRIs and universities dominate India's STI system. Public R&D expenditures accounted for nearly 62% of GERD in 2007 (the latest year for which data are available). At 0.50% of GDP in 2007, India is at the bottom of the OECD middle range (Panel 1[a]). Relative to GDP India has fewer world-class universities and a weaker S&T publication record in leading international academic journals (Panel 1[b, c]) than emerging economies such as Brazil, the People's Republic of China and South Africa. As PRIs are governed by the ministries in charge of sectoral research areas, there is no consolidated public research budget. India does not so far have a central research funding body. The budget for PRIs has recently declined in real terms. Evaluations are used more systematically to assess research performance in universities.

Key figures, 2013

Economic and environmental performance	IND	OECD	Gross domestic expenditure on R&D	IND	OECD
Labour productivity			**GERD**		
GDP per hour worked, USD PPP, 2013	n.a.	47.7	Million USD PPP, 2007	24 306	1 107 398
(annual growth rate, 2008-13)	n.a.	(+0.8)	As a % of total OECD, 2007	2.7	100
Green productivity			**GERD intensity and growth**		
GDP per unit of CO_2 emitted, USD, 2011	2.3	3.0	As a % of GDP, 2007	0.76	2.40
(annual growth rate, 2007-11)	(+0.9)	(+1.8)	(annual growth rate, 2007-12)	n.a.	(+2.0)
Green demand			**GERD publicly financed**		
NNI per unit of CO_2 emitted, USD, 2011	n.a.	3.0	As a % of GDP, 2012	n.a.	0.77
(annual growth rate, 2007-11)	n.a.	(+1.6)	(annual growth rate, 2007-12)	n.a.	(+2.8)

* This country profile was prepared based on India's response to the OECD Science, Technology and Industry Outlook 2014 policy questionnaire. The views expressed in the response were those of the experts who filled out the questionnaire, and do not necessarily represent the view of the Indian government.

Figure 9.20. **Science and innovation in India**



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

Innovative entrepreneurship: The Small Business Innovation Research Initiative (SBIRI) is a new scheme launched by the Ministry of Science and Technology to nurture and mentor innovative emerging technologies and entrepreneurs. A distinctive feature of SBIRI is that it supports high-risk pre-proof-of-concept biotechnology research as well as late-development stages in SMEs led by innovators with a science background. There is specific support for the commercialisation of technologies that meet societal needs in health care, food and nutrition, agriculture, and other sectors. Other government agencies have similar schemes.

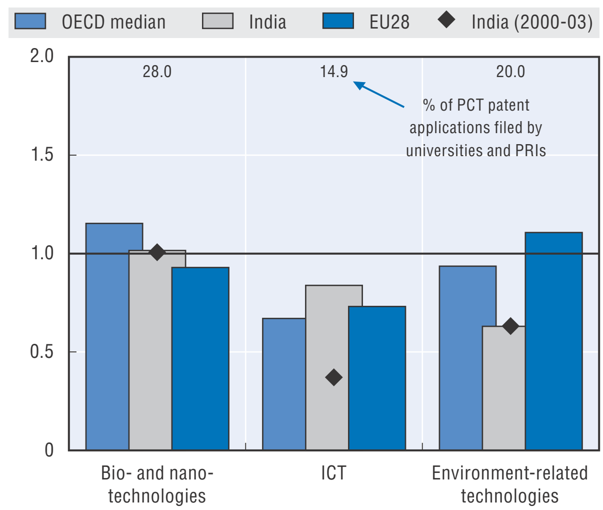
Technology transfer and commercialisation: India has no legislation on technology transfer and commercialisation. Various programmes provide access to knowledge developed in PRIs and HEIs. The creation and preservation of knowledge systems, the dissemination of knowledge, and better knowledge services are core concerns of the National Knowledge Commission. Created in 2005, it guides policy on these topics and directs reforms concerning education, science and technology, agriculture, industry, and e-governance. SBIRI also aims to strengthen the commercialisation of public research.

Globalisation: The presence of R&D centres of MNEs has accelerated India's integration in global R&D and innovation systems. While India hosts several top corporate R&D investors in automotive, industrial machinery and IT industries, it lags China, Brazil and Russia in this regard (Panel 1[e]). However, India is at the OECD median, and well ahead of Brazil, China and South Africa in international co-patenting (Panel 1[r]), although its share of internationally co-authored S&T publications is very low, not only by OECD standards, but also compared to South Africa, Brazil and the Russian Federation. In recent years Indian universities have progressively opened up internationally, much more than PRIs. Various government departments have programmes that facilitate international mobility of human resources.

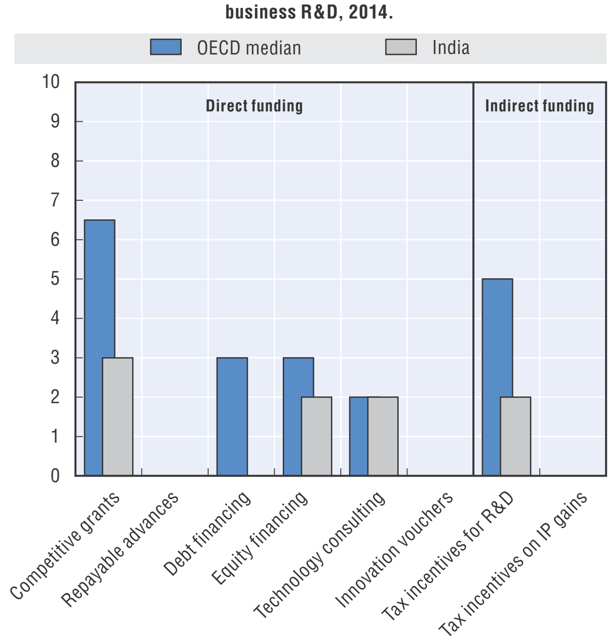
Skills for innovation: India has a large, young and growing labour force. However, low school attainment rates and the poor quality of the education system hamper the development of human resources for S&T and innovation. The National Skills Development Agency (NSDA) has been charged with co-ordinating and harmonising the skill development efforts of the government and the private sector with a view to achieving the skilling targets of the 12th Five-Year Plan. Related initiatives include the Confederation of Indian Industry (CII)'s Skills Centre at Chhindwara (in Madhya Pradesh), which teaches industrial techniques, and the joint CII-HPCL (Hindustan Petroleum Cooperation Limited) Swavalamban Project, which trains youth at the local level. The Ministry of Human Resources and the Ministry of Minority Affairs also have initiatives to reduce the gender and minority gap in S&T education, such as the Scheme for Providing Quality Education in Madrasas (SPQEM) and Sarva Shiksha Abhiyan (SSA).

Panel 2. Revealed technology advantage in selected fields, 2009-11

Index based on PCT patent applications



Panel 3. Most relevant instruments of public funding of business R&D, 2014.



Note: Policy information comes from country responses to the OECD STI Outlook policy questionnaire 2014. India's response is available in the *OECD STI Outlook Policy Database*, edition 2014 at *http://qdd.oecd.org/Table.aspx?Query=76708487-C497-4C59-AF7A-E2BCAF2458FA*.

Source: See reader's guide and methodological annex.

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INDONESIA

During the global financial crisis and the slowdown of the world economy, Indonesia maintained relatively high GDP growth, averaging 5.9% between 2009 and 2013. The government recognises the importance of innovation for maintaining strong growth.

Hot issue 1: Raising the returns to and impact of science. The role of universities and PRIs in supporting innovation has gained increasing attention, and the Ministry of Education and Culture has mandated universities to develop research plans based on national priorities, their existing resources and future development strategies. Excellence in basic and applied research is seen as essential and support for collaborative research is provided. In order to support universities' research capacity, their autonomy has also been strengthened.

Hot issue 2: Strengthening public R&D capacity and infrastructures. In carrying out the Master Plan for the Acceleration and Expansion of Indonesian Economic Development (MP3EI), the Ministry of Research and Technology (RISTEK) has developed the *Pusat Unggulan Iptek* (Centres of Excellence) Programme. Its aim is to increase the capacity and capability of Indonesia's leading research institutes by helping them improve their research infrastructures and by supporting strategic partnerships and networks and their contributions to the country's innovation system. Many of the institutions involved have connections abroad; these are reflected in Indonesia's indicator of co-authorship (Panel 1[q]). In 2013 leading Indonesian researchers joined the International Institute for Applied Systems Analysis.

Hot issue 3: Improving the governance of the innovation system and policy. Indonesia's STI governance is complex and many bodies are involved. Effective co-ordination is a major challenge, which the independent National Innovation Committee (KIN), established in 2010, seeks to address. In 2012, a new institution, the Lembaga Pengelola Dana Pendidikan (IPDP), was created to manage Indonesia's education budget and the budget for research and related infrastructure development.

Hot issue 4: Targeting priority areas/sectors. The MP3EI has identified six economic sectors for development. Depending on the region concerned, the focus is on developing natural resource processing industries to extract greater value added, developing industry as well as tourism, or advanced agricultural industries. The plan contains the main direction to be taken for specific economic activities, including infrastructure needs, recommendations for changes in or revision of regulations, and initiatives for accelerating or expanding investments. Innovation is part of the overall planning, but has yet to play a dominant role.

Highlights of the Indonesian STI system

Universities and public research: The bulk of R&D in Indonesia is undertaken by PRIs, in particular in government institutions. However, by international standards the intensity of public investment in R&D is very low. A major policy objective is to ensure that outcomes from public research will serve the national development and innovation agenda. This requires overcoming the low level of collaboration between research and industry. To achieve this, an increasing share of government funding is now provided for collaborative research. In areas such as defence and health, this has effectively led to more collaborative research.

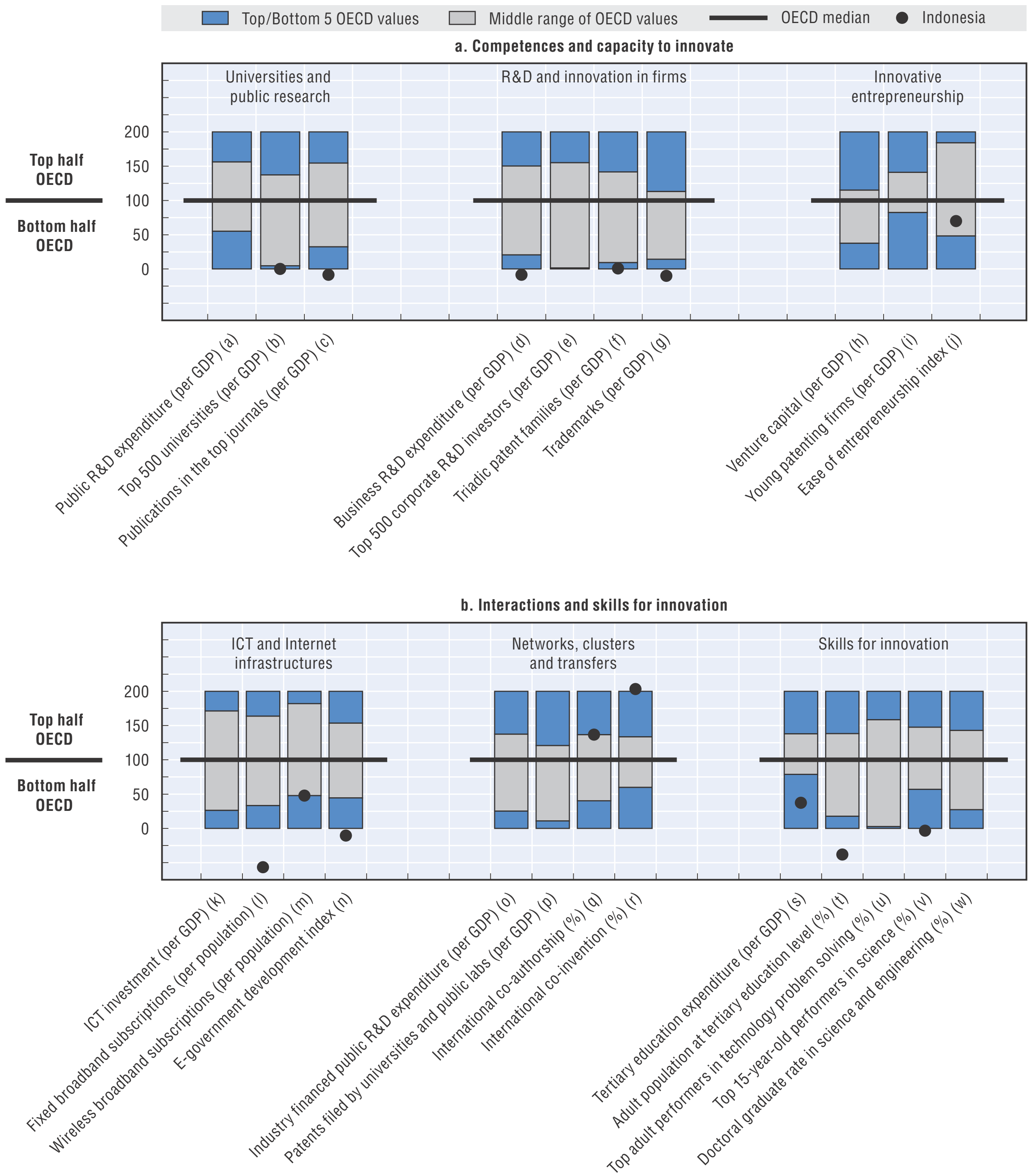
Technology transfer and commercialisation: Policy emphasis has recently shifted towards the contribution of public research to the country's innovation system. Industry, state-owned enterprises in particular, is encouraged to seek opportunities for collaboration with the countries' leading PRIs and universities. Indonesia is also investing in improving the quality of its intellectual property system, and is implementing support schemes that encourage researchers to patent. A law of 2002 mandated the creation of technology transfer offices in Indonesia's public research sector. A 2010-11 assessment found, however, that even where they had been established, few were in a position actively to support commercialisation efforts. A major constraint on academia-industry collaboration is the fact that all revenue from publicly funded projects must be returned to the Ministry of Finance; researchers therefore have no financial incentive to commercialise products based on their research results. The rules concerning the research budget are a further obstacle: project funding is for short time periods, after which it must be returned to the funding agency so that funding does not cover the full product development life cycle.

Key figures, 2013

Economic and environmental performance	IDN	OECD	Gross domestic expenditure on R&D	IDN	OECD
Labour productivity			**GERD**		
GDP per hour worked, USD PPP, 2013	n.a.	47.7	Million USD PPP, 2009	804	1 107 398
(annual growth rate, 2008-13)	n.a.	(+0.8)	As a % of total OECD, 2009	0.1	100
Green productivity			**GERD intensity and growth**		
GDP per unit of CO_2 emitted, USD, 2011	2.3	3.0	As a % of GDP, 2009	0.08	2.40
(annual growth rate, 2007-11)	(+2.2)	(+1.8)	(annual growth rate, 2009-12)	n.a.	(+2.0)
Green demand			**GERD publicly financed**		
NNI per unit of CO_2 emitted, USD, 2011	n.a.	3.0	As a % of GDP, 2012	n.a.	0.77
(annual growth rate, 2007-11)	n.a.	(+1.6)	(annual growth rate, 2007-12)	n.a.	(+2.8)

Figure 9.21. **Science and innovation in Indonesia**

Panel 1. Comparative performance of national science and innovation systems, 2014

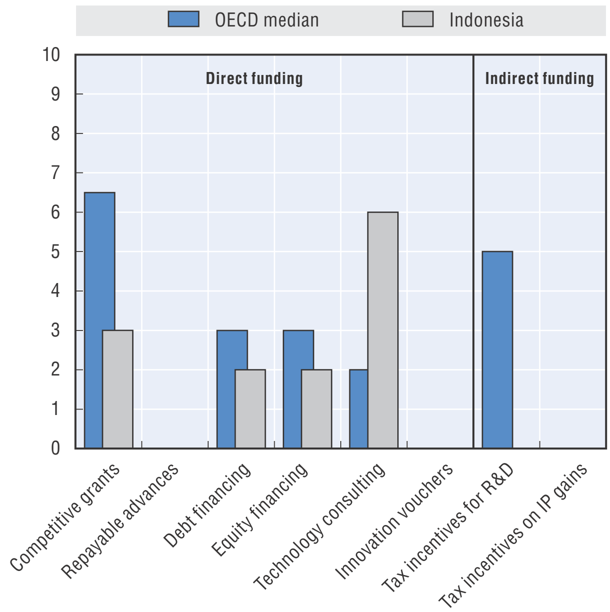


Note: Normalised index of performance relative to the median values in the OECD area (Index median = 100).

Innovation in firms: Few firms are part of the R&D system, and BERD intensity was estimated at an insignificant 0.01% of GDP in 2008 (Panel 1[d]). In the past, policy support for R&D and innovation largely meant financial support through research funding, tax deductions and related instruments. To encourage innovation activities, more emphasis is now put on providing support services and on raising awareness of the importance of innovation among entrepreneurs and businesses. With an informal economy that employs more than 68% of the workforce, identifying opportunities for this large segment of the economy to be part of the country's innovation system would be of critical importance. Seeking opportunities to develop innovation capacities related to the country's rich natural resource endowment is also critical if Indonesia is to reach the R&D intensity target of 1% of GDP by 2014 included in the Second National Medium-Term Development Plan (2010-14) of the Vision and Mission of Indonesia's S&T Statement for 2005-25.

Skills for innovation: The Second National Medium-Term Development Plan (2010-14) makes strengthening the skills base a key priority. While spending on education has increased substantially over the past two decades, the share of Indonesia's spending on higher education relative to GDP is still very low by OECD standards (Panel 1[s]), and the poor performance of 15-year olds in science (Panel 1[v]) points to shortcomings in the quality and structure of the education system (Panel 1[w]). The expansion of technical and vocational education and training is a priority, and a National Education Strategy has been adopted to reduce disparities in access to education, to enhance teaching quality, and to improve the management and accountability of schools.

Panel 2. Most relevant instruments of public funding of business R&D, 2014



Note: Policy information comes from country responses to the OECD STI Outlook policy questionnaire 2014. Indonesia's response is available in the *OECD STI Outlook Policy Database*, edition 2014 at *http://qdd.oecd.org/Table.aspx?Query=39B9D201-2CFA-4479-AED2-190C07ED4484*.
Source: See reader's guide and methodological annex.

StatLink *http://dx.doi.org/10.1787/888933152210*

IRELAND

Following a prolonged economic recession preceded by a severe financial crisis, the Irish economy has started to recover through a process of structural reforms and fiscal consolidation. The Strategy for Science, Technology and Innovation (SSTI) 2006-13 set Ireland's goals and objectives for R&D and innovation policy and the framework for implementation. The National Recovery Plan (NRP) 2011-14 also made R&D an investment priority, as does the National Strategy for Higher Education to 2030.

Hot issue 1: Addressing STI globalisation and increasing international co-operation. The Irish innovation system is well integrated in the international science and innovation landscape. In 2012, 52% of S&T publications and 36% of PCT patent applications involved international collaboration (Panel 1[q, r]), and funding from abroad accounted for 20.4% of GERD. Ireland engages in international co-operation on STI with a wide range of countries in Europe and beyond, including the United States and China. To promote further international co-operation in research and innovation, Science Foundation Ireland (SFI) recently introduced two programmes: the Research Centres Programme which aims to develop world-leading, large-scale, theme-based research centres by establishing and improving linkages between foreign MNEs and Irish SMEs, and the International Strategic Cooperation Award (ISCA) programme which supports new and existing research-based collaborations between Ireland's HEIs and partner organisations in four designated countries so far: Brazil, the People's Republic of China, India and Japan. ISCA will provide the funding to co-ordinate and carry out a range of activities designed to initiate and/or strengthen academic and associated linkages between one or more of SFI's eligible research bodies and one or more organisations in one of the four partner countries.

Hot issue 2: Strengthening public R&D capacity and infrastructures. While public R&D expenditures are below the OECD median (Panel 1[a]), Ireland is home to three of the world's top 500 universities (Panel 1[b]) and performs well in terms of international S&T publications (Panel 1[c]). In comparison with large EU member states, Ireland has relatively few PRIs, which mostly work on R&D related to natural resources (food, agriculture, forestry and marine), and societal issues (health, energy, the environment). A major objective of the National Strategy for Higher Education is to maximise the excellence and impact of the Irish public research system. To deliver on this objective, the Higher Education Authority has established a comprehensive strategic dialogue with each HEI to monitor and drive its performance. The strategy also fosters regional clusters, and in some cases mergers, of institutions to build critical mass and to ensure efficiency across the system.

Hot issue 3: Innovation in firms, entrepreneurship and SMEs. Ireland has a large number of top corporate R&D investors (Panel 1[e]), thanks to the strong presence of high-technology MNEs. The bulk of Ireland's BERD (71%) is performed by foreign affiliates, owing to Ireland's supportive environment for FDI. However, the Ease of Entrepreneurship Index (Panel 1[j]) indicates the need for improvement, owing in particular to a difficult licencing and permit system and complex regulatory procedures. Entrepreneurship has been given a strong policy focus. The government has committed to produce the first National Entrepreneurship Policy Statement within the context of the Action Plan for Jobs 2014. The statement will contain a set of cross-governmental actions to drive improvements in the overall environment for entrepreneurship and is due to be published in Q2 2014. The Entrepreneurship Policy Statement will build on work undertaken in 2013, which included the establishment of an Entrepreneurship Forum in May 2013 to examine the current environment and policy framework and to make further recommendations to support entrepreneurship and business start-ups. A public consultation was also undertaken in May 2013 inviting views from stakeholders.

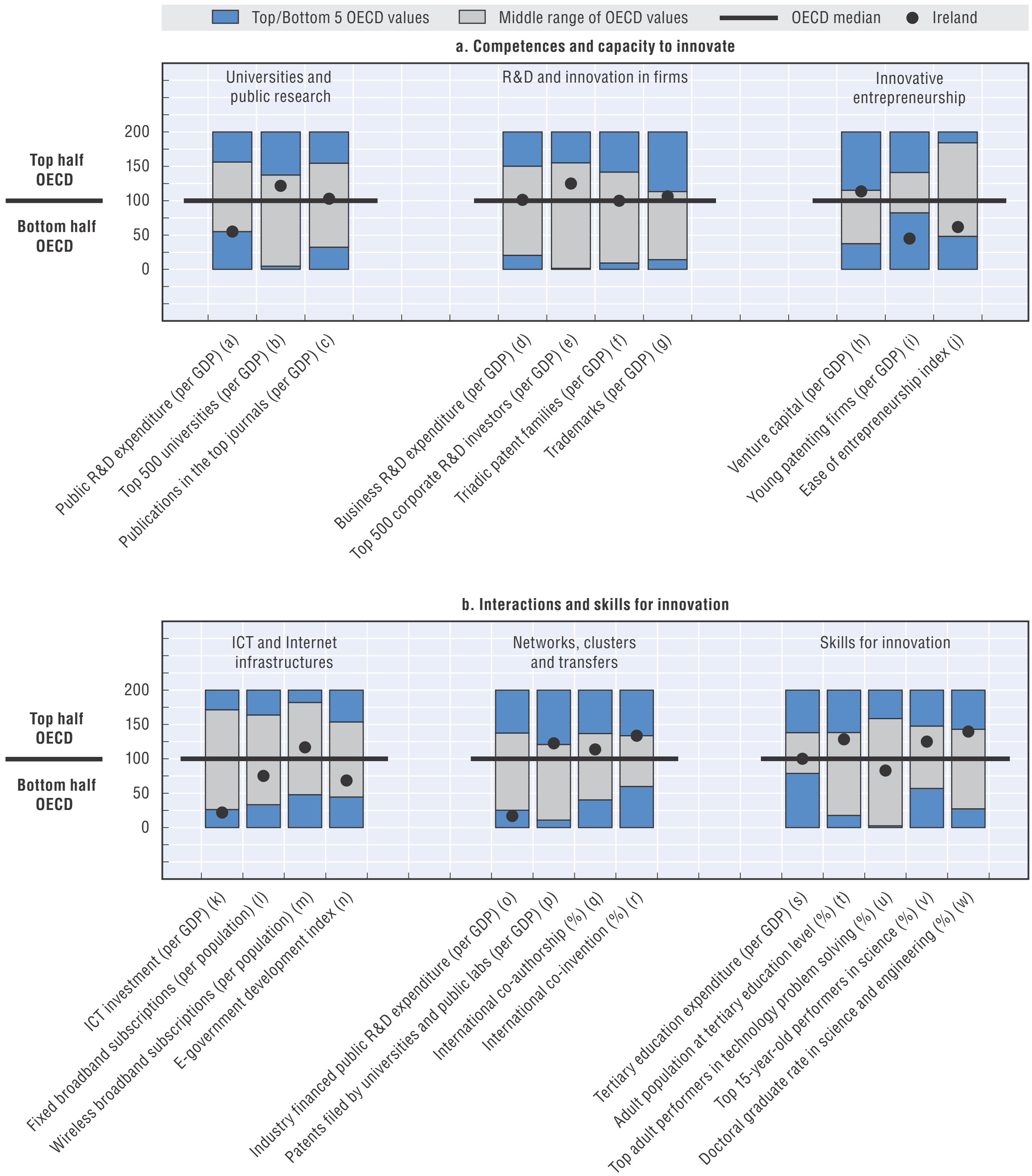
The performance of young patenting firms also requires improvement (Panel 1[i]). In 2014 a new central technology transfer office was launched to improve companies' access to and use of results from publicly funded research to develop innovative products and services and ultimately to generate jobs and exports. New programmes – the Credit Guarantee Scheme, the Microenterprise Loan Fund, the National Intellectual Property Protocol, the second phase of the Technology Transfer Strengthening Programme (TTSI2), the SFI Industry Fellowships Programme, and the SFI Investigators Programme – have been introduced to support innovation in all categories of firms.

Key figures, 2013

Economic and environmental performance	IRL	OECD	Gross domestic expenditure on R&D	IRL	OECD
Labour productivity			**GERD**		
GDP per hour worked, USD PPP, 2013	59.6	47.7	Million USD PPP, 2012	3 340	1 107 398
(annual growth rate, 2008-13)	(+1.7)	(+0.8)	As a % of total OECD, 2012	0.3	100
Green productivity			**GERD intensity and growth**		
GDP per unit of CO_2 emitted, USD, 2011	4.8	3.0	As a % of GDP, 2012	1.66	2.40
(annual growth rate, 2007-11)	(+5.2)	(+1.8)	(annual growth rate, 2007-12)	(+3.7)	(+2.0)
Green demand			**GERD publicly financed**		
NNI per unit of CO_2 emitted, USD, 2011	3.9	3.0	As a % of GDP, 2012	0.46	0.77
(annual growth rate, 2007-11)	(+2.9)	(+1.6)	(annual growth rate, 2007-12)	(+2.2)	(+2.8)

Figure 9.22. **Science and innovation in Ireland**

Panel 1. Comparative performance of national science and innovation systems, 2014



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

Hot issue 4: Targeting priority areas/sectors. The report of the Research Prioritisation Steering Group recommended 14 areas of opportunity as well as underpinning technologies, which should receive the majority of competitive public investment in STI over a five-year period. The areas were identified on the basis of existing strengths of the public research system and the enterprise base, opportunities in terms of the global marketplace and those that are most likely to deliver economic and social impact and benefits, including, most notably, jobs, These areas include: data analytics management, security and privacy; manufacturing competitiveness; smart grids and smart cities. The Centre for Applied Data Analytics Research (CeADAR), established in November 2012, aims to accelerate the development, deployment and adoption of Data Analytics technology and related innovations. In July 2013, the Insight Centre (INSIGHT) was established by SFI with funding of USD 94 million (EUR 75 million) from both public and industry sources to bring together leading Irish and international academics from five of Ireland's research centres to consolidate a national research platform and build critical mass in big data analytics.

Highlights of the Irish STI system

STI policy governance: In 2014, the policy research functions of *Forfás*, Ireland's policy advisory board for enterprise, trade, science, technology and innovation, will be integrated into the Department of Jobs, Enterprise and Innovation (DJEI) to strengthen the Department's capacity for job-creation policy and for evaluation. The current membership of the Advisory Council for Science, Technology and Innovation (ACSTI) stood down with effect from September 2013, pending the results of the Forfás integration process and overall policy on public service reform. This does not rule out the option of establishing an Advisory Council of a similar nature on an alternate footing, if this is deemed appropriate in the future. Following publication of the Research Prioritisation Steering Group report in March 2012, the Prioritisation Action Group (PAG), involving all relevant departments and funding agencies, was established to drive implementation of research prioritisation. Action plans for each of the priority areas, as well as a Framework of Metrics and Targets, were drawn up and approved by government in summer 2013. The Action plans represent the detailed blueprint for actions to be taken to re-align the majority of competitive public research funding around the priority areas over the following five years and include a vision, key objectives and specific actions, along with timelines and responsibilities for leading and supporting delivery of the action.

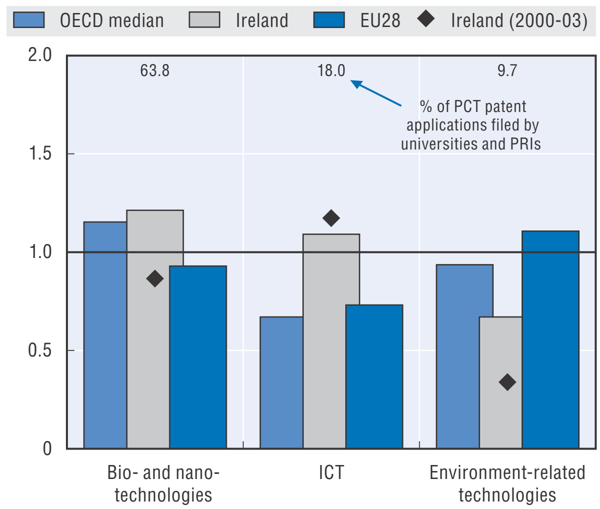
New challenges: Of the 14 priorities identified in the Research Prioritisation Exercise, several address societal challenges: sustainable food production and processing, connected health and independent living, and medical devices and therapeutics. These areas are priorities for competitive R&D funding.

Skills for innovation: Ireland has a relatively strong skills base for innovation: the share of the tertiary-qualified adult population (Panel 1[t]), the performance of 15-year-olds in science (Panel 1[v]) and doctoral graduates in science and engineering (Panel 1[w]) are all above the OECD median. Going forward, Ireland has initiatives – a new Junior Cycle, new science curricula at post-primary level, a review of mathematics curriculum at primary level and ongoing implementation of revised mathematics specifications at post-primary as well as bonus points for mathematics – for strengthening science education in primary and post-primary schools in order to improve education outcomes and increase throughputs to higher education.

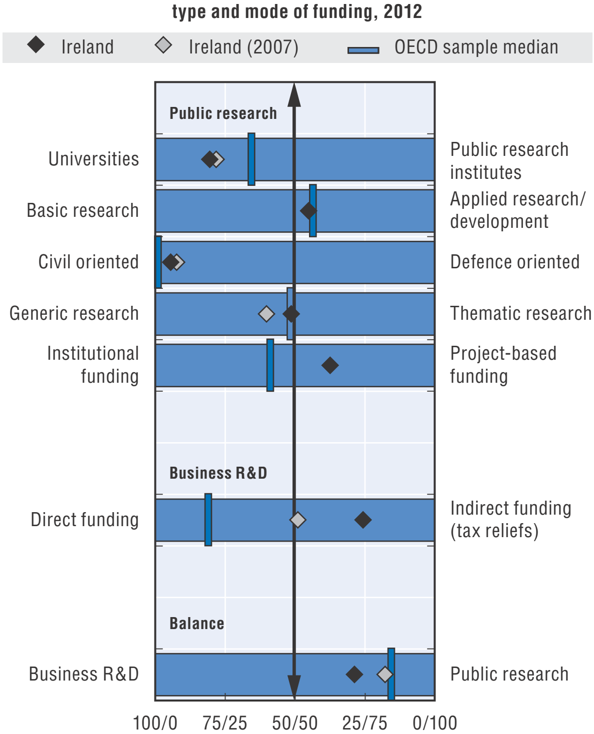
Recent developments in STI expenditures: GERD increased from 1.28% GDP in 2007 to 1.66% in 2012, mainly thanks to the rise in BERD from 0.85% to 1.2% of GDP during the years of financial crisis and economic recession. Owing to the impact of the recent crisis, however, public support for R&D and innovation is likely to remain under pressure in the years ahead.

Panel 2. Revealed technology advantage in selected fields, 2009-11

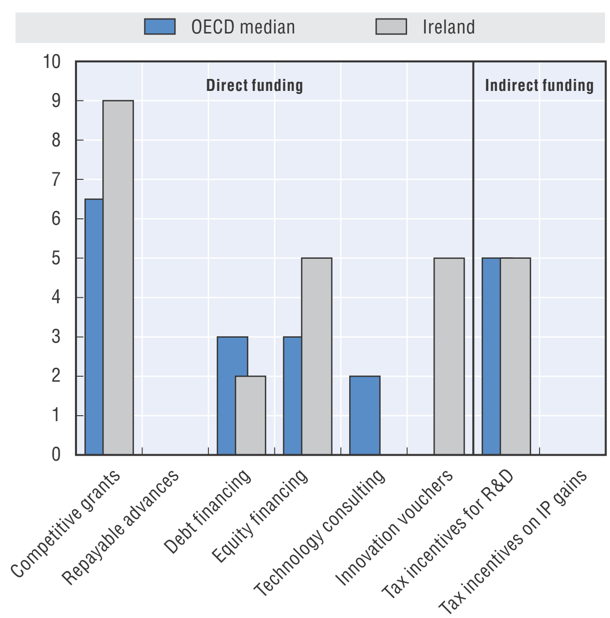
Index based on PCT patent applications



Panel 3. Allocation of public funds to R&D, by sector, type and mode of funding, 2012



Panel 4. Most relevant instruments of public funding of business R&D, 2014



Note: Policy information comes from country responses to the OECD STI Outlook policy questionnaires 2014 and 2012. Ireland's responses are available in the *OECD STI Outlook Policy Database*, edition 2014 at *http://qdd.oecd.org/Table.aspx?Query=3A5C5564-995F-482A-BC8A-BD6D0C427B8C*.

Source: See reader's guide and methodological annex.

StatLink *http://dx.doi.org/10.1787/888933152225*

ISRAEL

Israel's strong technology sector, particularly ICT, is a key driver of the economy. The global financial crisis only briefly slowed its growth and the recent discovery of natural gas fields has boosted GDP. However, the country's technology-driven growth has not been sufficiently inclusive; poverty and inequality have risen and the country is going through a period of fiscal consolidation. Given the pressures on public budgets and the consequent adjustments in public spending on STI, greater competition in the business sector could help make innovation more inclusive. Israeli STI policy follows a bottom-up approach with specific policies in various areas rather than an overall national strategy that guides STI policy orientations.

Hot issue 1: Encouraging innovation in firms and supporting entrepreneurship and SMEs. Israel's STI ecosystem relies both on foreign multinationals (Panel 2), and large corporate R&D investors (Panel 1[e]) as well as on start-ups (Panel 1[h]). BERD as a share of GDP is the second highest in the OECD area (Panel 1[d]), and venture capital (VC) as a share of GDP tops the OECD ranking (Panel 1[h]). Although seed funding declined during the global economic crisis, the new Young Companies programme helps firms up to three years old to raise private investment by supporting them with early funding and signalling business potential. However, the Ease of Entrepreneurship Index (Panel 1[j]) is at the bottom of OECD countries and shows a need for significant improvement in various aspects of the regulatory framework for business.

Hot issue 2: Reforming and improving public research (including university research). In spite of its modest public R&D expenditure, Israel hosts a number of world-class universities and produces high-impact publications (Panel 1[a, b, c]). The six-year Higher Education Plan was introduced in 2011 with USD 1.9 billion (NIS 7.5 billion) to promote academic excellence and upgrade research and teaching infrastructures. Universities' budgets have been increased, with a 30% rise in the budget of the Council for Higher Education; they have also become more competitive, with the doubling of the Israel Science Foundation's (ISF) competitive grants and an increased share of block funding allocated on performance criteria. Long-term funding has also been strengthened through larger block grants about USD 186 million (NIS 750 million). The most important initiative has been the creation of 16 centres of excellence (I-core) financed with USD 114 million (NIS 450 million) to advance cutting-edge academic research and offer an attractive research environment.

Hot issue 3: Addressing challenges of STI globalisation and increasing international co-operation. As a small country, Israel depends on exports and international openness, but research and innovation need to be better integrated in global networks, as illustrated by international co-patenting data (Panel 1[r]). Israel has made international co-operation a policy priority. Competitive grants have been offered to support strategic R&D collaboration and encourage high-technology exports to emerging markets. The share of GERD financed from abroad increased from 28% to 47% over 2007-11. Israel received USD 798 million (NIS 3.2 billion) from the EU Seventh Framework Programme (FP7) of which almost two-thirds went to universities. By the end of 2010, FP7 funding of USD 302 million (NIS 1.2 billion) was almost on par with ISF funding of USD 252 million (NIS 1.0 billion). Israel has just finalised its participation in EU Horizon 2020.

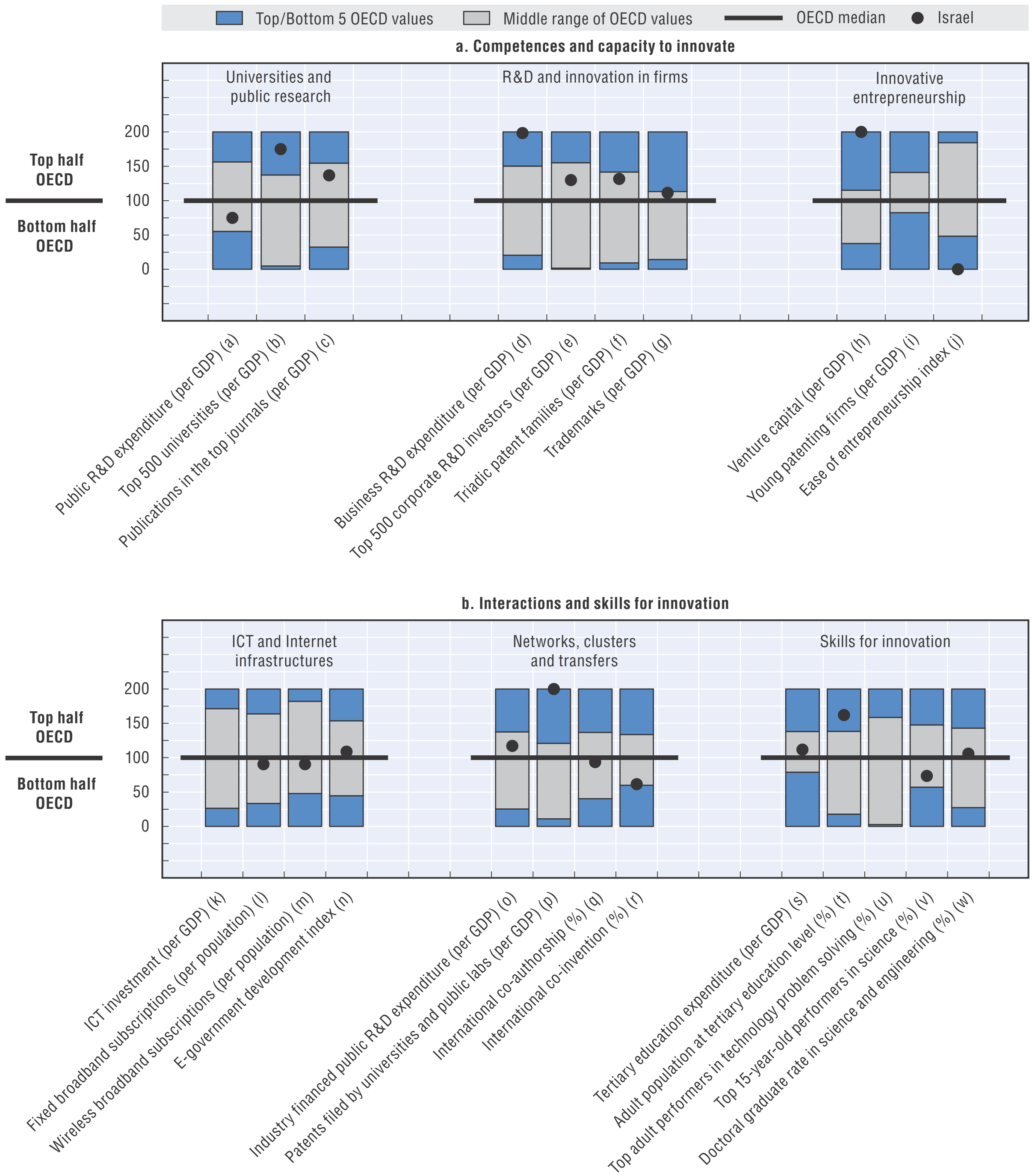
Hot issue 4: Innovation to contribute to sustainable/green growth. Inclusive innovation is one of the main challenges of Israel's STI policy. The government seeks to link the rest of the economy better to the high-technology growth engine, thereby enhancing the sustainability of growth. Because Israel faces challenges relating to water scarcity and security, several policy initiatives promote oil independence and water technologies. The Fuel Choice initiative intends to make Israel a centre of knowledge and industrial best practices in fuel alternatives for transport, and USD 25 million (NIS 100 million) are provided annually for the next decade to finance R&D, demonstrators, international prizes and awareness seminars. The Master Water Management Plan makes policy recommendations on water management systems and tariffs. In the search for new markets, Israel launched the Grand Challenges Israel programme in 2014 to encourage innovation to solve global health and food security challenges in the developing world. USD 3 million (NIS 12 million) were allocated in the form of grants to increase innovation-related exports to emerging and low-income markets.

Key figures, 2013

Economic and environmental performance	ISR	OECD	Gross domestic expenditure on R&D	ISR	OECD
Labour productivity			**GERD**		
GDP per hour worked, USD PPP, 2013	36.2	47.7	Million USD PPP, 2012	9 735	1 107 398
(annual growth rate, 2008-13)	(+1.1)	(+0.8)	As a % of total OECD, 2012	0.9	100
Green productivity			**GERD intensity and growth**		
GDP per unit of CO_2 emitted, USD, 2011	3.1	3.0	As a % of GDP, 2012	3.93	2.40
(annual growth rate, 2007-11)	(+2.4)	(+1.8)	(annual growth rate, 2007-12)	(+0.9)	(+2.0)
Green demand			**GERD publicly financed**		
NNI per unit of CO_2 emitted, USD, 2011	3.1	3.0	As a % of GDP, 2010	0.57	0.77
(annual growth rate, 2007-11)	(+2.7)	(+1.6)	(annual growth rate, 2007-10)	(+0.2)	(+2.8)

Figure 9.23. **Science and innovation in Israel**

Panel 1. Comparative performance of national science and innovation systems, 2014



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

Highlights of the Israeli STI system

STI policy governance: Maintaining STI leadership in the current fiscal context requires better co-ordination of government agencies and policy evaluation. The lack of a formal platform for all key players to exchange ideas on innovation strategies has been identified as a possible barrier to co-ordination. Such a platform is under development in order to involve STI policy shapers and implementers. There is also an on-going debate about the need for a more top-down strategy. Evaluation of STI policy has received particular attention. The new Strategy and Economic Research Unit (SERU) and a comprehensive evaluation methodology have supported the institutionalisation of evaluation, with a more impact-oriented approach. Major entrepreneurial programmes (e.g. Tnufa, the technological incubator and seed company programmes) have been evaluated recently with a view to assessing their impact on the innovation ecosystem. National reports and STI policy documents have also underlined the need to establish and develop an information system by means of innovation surveys and a database to support policy making.

Innovation in firms: Israel has the world's second most R&D-intensive business sector; firms spend 3.3% of GDP on R&D (Panel 1[d]). Competitive grants and tax incentives are the two main policy instruments in support of business R&D. The budget of the Office of the Chief Scientist (OCS), the main government agency for industrial R&D support, has been reduced significantly since the early 2000s and is likely to remain unchanged in the coming years. The OCS dedicates 85% of its USD 374 million (NIS 1.5 billion) to SMEs. Public support remains industry – and technology – neutral.

ICT and Internet infrastructures: Although the Internet and ICT infrastructures are modestly developed (Panel 1[l, m]), owing to the digital gap in Israeli society, Israel has an RTA in ICT as measured by patent applications which has continued over the past decade (Panel 3). The Cyber-Security initiative is a recent policy initiative to advance the development and adoption of secure technologies. A national cyber-security incubator based on a public-private partnership has been established and a National Cyber-Security Centre of Excellence has been created with the United States under a bilateral R&D co-operation agreement.

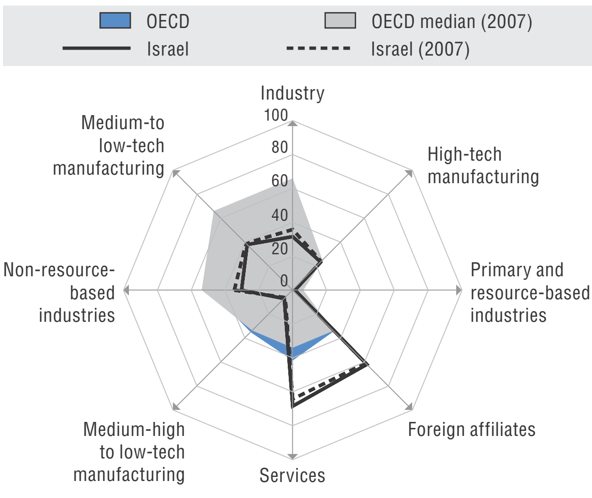
Technology transfer and commercialisation: Links between industry and science are relatively well developed and universities and PRIs patent their research results actively (Panel 1[o, p]). The OCS Magnet programme has supported knowledge transfer since 1994 through grants for new pre-competitive research consortia. The Magneton programme promotes industry-science co-operation that already exists for up to a 24-month period and the Nofar programme aims to advance applied research in bio- and nano-technology and its transfer to industry.

Clusters and smart specialisation: The Fuel Choices Initiative (formerly the Oil Substitutes Initiative) and the Cyber Security initiative are Israel's main smart specialisation programmes. The Fuel Choices Initiative includes a one-stop shop for firms, a VC-backed programme and assistance in establishing pilot facilities in petroleum substitutes. It has USD 380 million (NIS 1.5 billion) for 2011-20. The Cyber Security initiative comprises of a few dedicated funds to encourage R&D in the field, summing to USD 50 million (NIS 180 million) for 2012-14. The initiative encourages the development of human capital in the cyber security field and is engaged in linking relevant military know-how to the industry.

Skills for innovation: The shortage of professional manpower will be a major obstacle for the Israeli STI system in the coming years, as the demand for engineers and technical professionals begins to outpace supply. Although adult educational attainment is high, youth do not perform very well in science by international standards and the rate of doctoral graduates in science and engineering is relatively modest (Panel 1[t, v, w]). The Higher Education Plan (2011-15) aims to improve the quality and competitiveness of the higher education system. About 1 600 new researchers will be hired in universities to replace retiring senior researchers, resulting in a net gain of about 850 academic staff over the next six years. This new policy also aims to increase participation in tertiary education, in particular by encouraging minorities to study at universities.

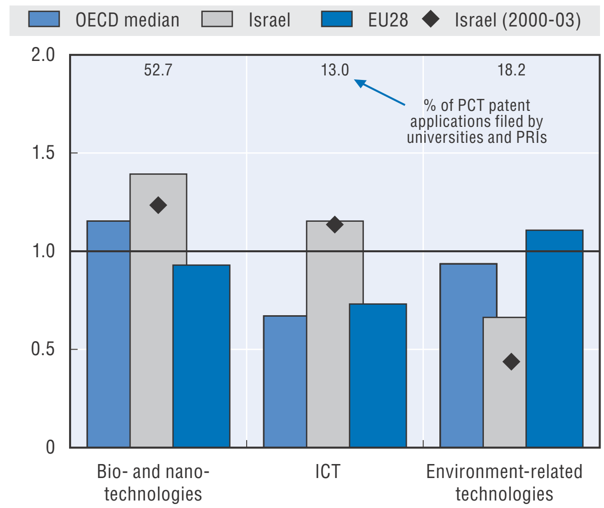
Panel 2. Structural composition of BERD, 2011

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

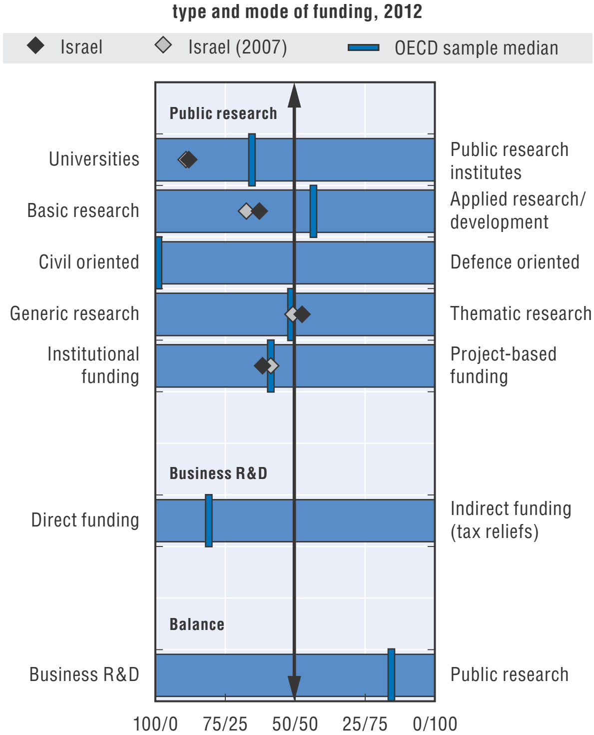


Panel 3. Revealed technology advantage in selected fields, 2009-11

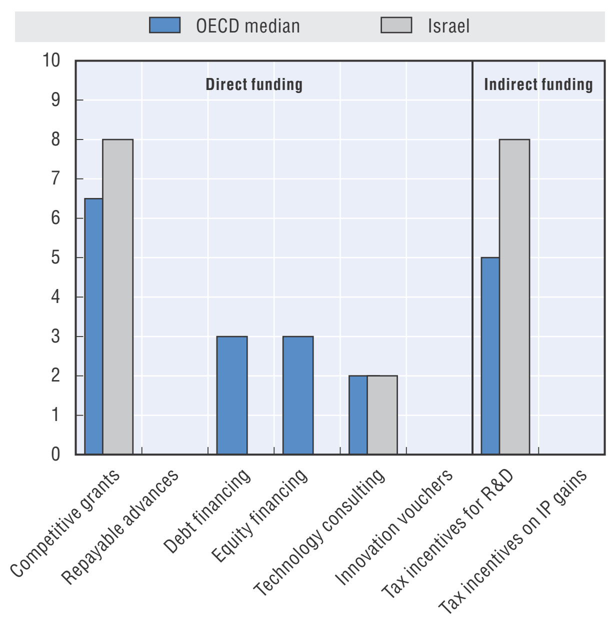
Index based on PCT patent applications



Panel 4. Allocation of public funds to R&D, by sector, type and mode of funding, 2012



Panel 5. Most relevant instruments of public funding of business R&D, 2014



Note: Policy information comes from country responses to the OECD STI Outlook policy questionnaires 2014 and 2012. Israel's responses are available in the *OECD STI Outlook Policy Database*, edition 2014 at *http://qdd.oecd.org/Table.aspx?Query=13245801-8246-44D3-B9B6-364D3A28929A*.

Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888933152232

ITALY

Italy has continued the structural reforms and fiscal consolidation undertaken since 2011 to put the economy on a sustainable growth path based on sound macroeconomic fundamentals. In 2013, the government launched Destination Italy, the national plan to attract FDI and improve the competitiveness of Italian enterprises.

Hot issue 1: Improving co-ordination of and participation in STI governance. Italy's research and innovation policy governance is the responsibility of the Ministry for Education, University and Research (MIUR) together with the Ministry for Economic Development (MISE) and the Presidency of the Council of Ministers. However, the regions, in the framework of the concurrency principle, can also develop local STI initiatives. The adoption of smart specialisation strategies by Italian regions such as Emilia Romagna and Puglia helps strengthen policy co-ordination and communication across different ministries and regional agencies and across a range of policy areas. The Italian government is also working to incorporate the objectives and priorities of the EU's Horizon 2020 in its main policies. A strategic document, Horizon 2020 Italy, was approved in 2013 and provides the framework for aligning national targets with European research and innovation objectives and initiatives over the next seven years.

Hot issue 2: Improving overall human resources, skills and capacity building. Italy has one of the lowest shares of tertiary qualified, and of technology-problem-solving skilled adult population among OECD countries (Panel 1[t, u]), and its tertiary education expenditure is also very low (Panel 1[s]). The country faces a dearth of highly skilled human resources, in part because the most qualified may find better opportunities abroad. The multi-annual planning for 2013-15 addresses these issues and encourages universities to improve guidance and tutoring services for students. The poor correspondence between the higher education system and labour market needs further underscores a structural mismatch. To tackle the issue, the action plan for future youth employment, Italia 2020, aims to align higher education curricula better with the changing demands of industry and to promote technical vocational education. Since 2011, academics' salaries and advancement have been frozen to contain public spending. However, to avoid further erosion of the human resource base for S&T and innovation due to unattractive career prospects and pay cuts, the most recent cuts in the public research budget safeguarded the jobs of professors, researchers and technicians. Since the university reform approved in 2010, significant efforts have also been made to strengthen researchers' careers. A reform of doctoral education focused on a stimulating research environment, collaborative doctorates and internationalisation, was implemented in 2013. Moreover, the financial law 2014 includes a commitment to encourage inter-institutional mobility of Italian researchers. MIUR has recently adopted measures to encourage the mobility of researchers between universities and PRIs and to attract researchers from abroad.

Hot issue 3: Supporting business innovation, entrepreneurship and SMEs. While BERD as a share of GDP is quite low, innovation outputs in terms international patenting and trademark registration are around the OECD medians (Panel 1[f, g]). Italian business sector performs slightly more than half of GERD, a low share for an industrialised economy. A set of innovative firms coexists with a large majority of small or micro enterprises with low productivity. The new Fund for Sustainable Growth, which replaced in 2013 the former Fund for Technological Innovation, supports business R&D with significant potential to affect national competitiveness. The 2013 Stability Law (L228/2012) introduced a tax credit on costs of R&D incurred by enterprises or enterprise consortia through contract R&D with public research bodies or direct investment in R&D.

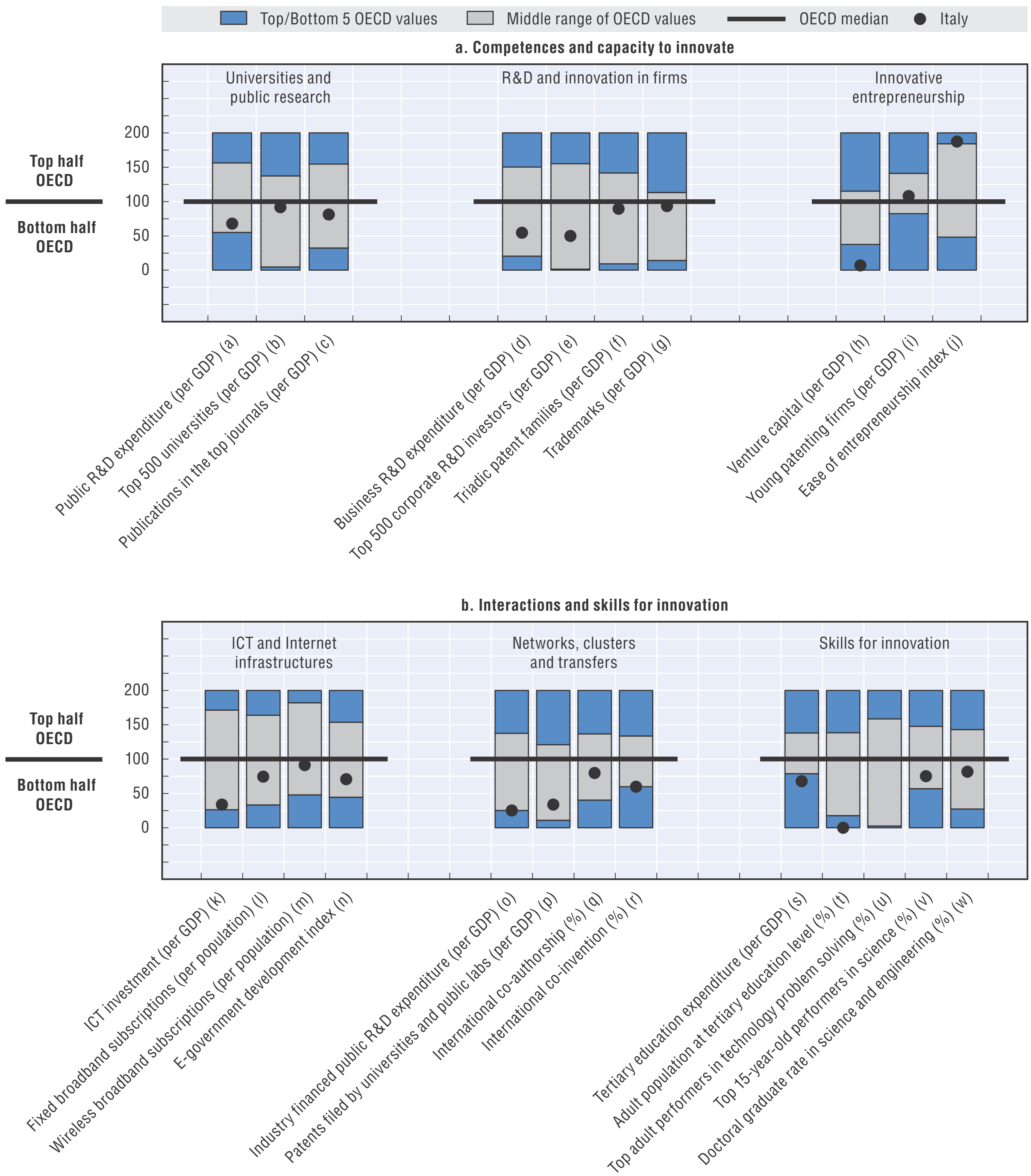
Hot issue 4: Improving framework conditions for innovation (including competitiveness). Italy's position on the Ease of Entrepreneurship Index is near the top of the OECD ranks, the sign of a favourable business environment for entrepreneurial activities and innovative ventures (Panel 1[j]). While young firms are reasonably active in patenting, venture capital is in severe short supply, which hinders the commercialisation of innovative ideas (Panel 1[i, h]). A 2012 Act of Parliament provided a new legislative framework to promote start-ups. During 2012-14, Italy made efforts to reduce the tax burden on and strengthen fiscal incentives for SMEs. Destination Italy also includes several measures to facilitate small and micro enterprises' access to bank credit

Key figures, 2013

Economic and environmental performance	ITA	OECD	Gross domestic expenditure on R&D	ITA	OECD
Labour productivity			**GERD**		
GDP per hour worked, USD PPP, 2013	48.9	47.7	Million USD PPP, 2012	26 321	1 107 398
(annual growth rate, 2008-13)	(-0.1)	(+0.8)	As a % of total OECD, 2012	2.4	100
Green productivity			**GERD intensity and growth**		
GDP per unit of CO_2 emitted, USD, 2011	4.2	3.0	As a % of GDP, 2012	1.27	2.40
(annual growth rate, 2007-11)	(+2.4)	(+1.8)	(annual growth rate, 2007-12)	(+0.1)	(+2.0)
Green demand			**GERD publicly financed**		
NNI per unit of CO_2 emitted, USD, 2011	4.2	3.0	As a % of GDP, 2011	0.54	0.77
(annual growth rate, 2007-11)	(+1.7)	(+1.6)	(annual growth rate, 2007-11)	(-1.0)	(+2.8)

Figure 9.24. **Science and innovation in Italy**

Panel 1. Comparative performance of national science and innovation systems, 2014



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

and equity financing, to support their internationalisation and to encourage venture capital investment.

Highlights of the Italian STI system

New challenges: Several initiatives to address societal changes were launched in 2013, including the new National Energy Strategy to 2020 and a special fund for youth employment in the green-economy sector. The national regulatory framework for renewable energies and energy saving was recently updated. MUIR has also issued a national position paper on an ageing society, based on analyses and suggestions from various stakeholders and the OECD CSTP discussions on this topic, to address the challenges arising from the ageing of the Italian population.

Universities and public research: Italy's public R&D expenditure is below the OECD median, as is its research output in terms of international publications in top scientific journals and its level of international co-authorship (Panel 1[a, c, q]). However, it has a relatively high share of top universities. Industry-science linkages are poorly developed and PRIs and universities do not actively patent their research results (Panel 1[o, p]). To improve public research performance, a reform of funding mechanisms for and management of universities was approved by Parliament in 2010 and is being implemented, as is the reform of PRIs under MIUR launched in 2009. In 2013, MIUR allocated new resources under the Cohesion Action Plan (CAP) to strengthen public research infrastructures, particularly in the country's southern regions.

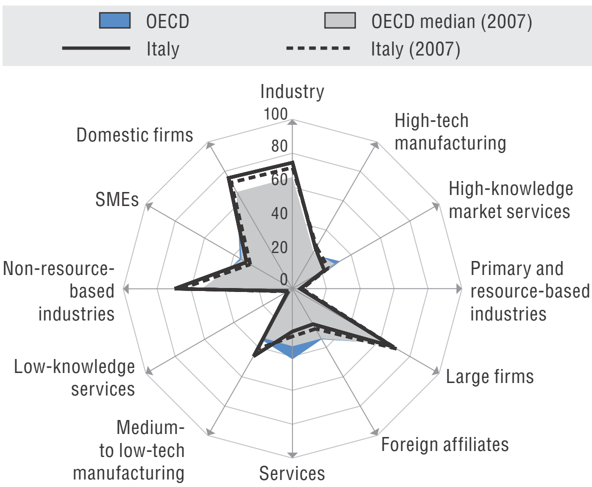
ICT and Internet infrastructures: While Italy's wireless subscription rate is close to the OECD median (Panel 1[m]), its overall ICT investment is significantly below the median (Panel 1[k]). The National Broadband Plan 2008-14 continues to serve as the main instrument for improving ICT services and infrastructures at the national level. A new Agency for Digital Italy was set up in 2012 to promote ICTs, with a focus on digitisation in the public sector. A strategic plan for the diffusion of ultra-broadband technologies in the southern regions was launched in 2013, and MISE was authorised in 2013 to allocate new funds for developing and disseminating digital technologies.

Clusters and smart specialisation: Business innovation performance varies across regions, and much R&D and innovation capacity is concentrated in Italy's northern and central regions. In 2012 MIUR launched a national call for the creation and strengthening of technological clusters. A project to support regional governments in designing and implementing their smart specialisation strategies was launched in 2013.

Globalisation: Over 2012-14, Italy has reinforced its network of bilateral agreements for scientific and technological co-operation with partner countries, in particular with Sweden, renewed for the period 2014-16. Since 2013 the ICE-Italian Trade Promotion Agency, which replaced the former Institute for Foreign Trade, supports the internationalisation of Italian firms. Strengthening the internationalisation of Italian universities, PRIs and businesses is also an aim of Destination Italy.

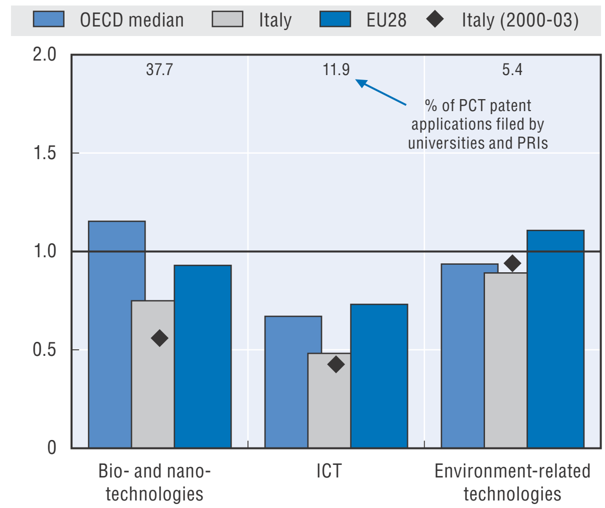
Panel 2. Structural composition of BERD, 2011

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

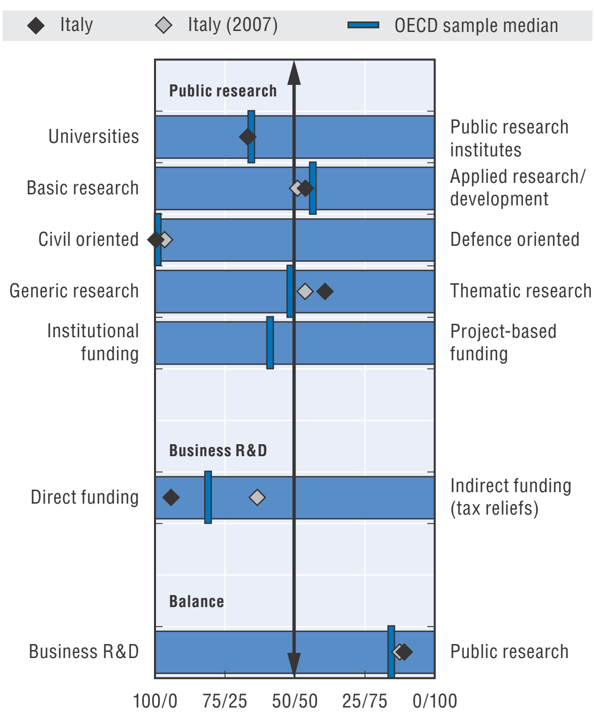


Panel 3. Revealed technology advantage in selected fields, 2009-11

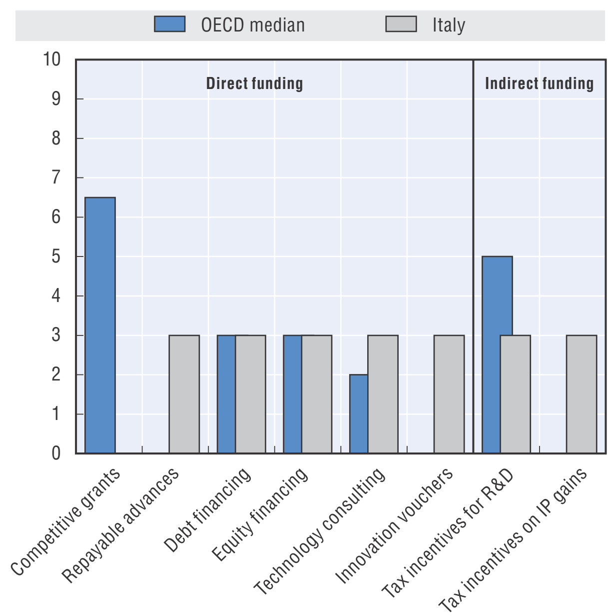
Index based on PCT patent applications



Panel 4. Allocation of public funds to R&D, by sector, type and mode of funding, 2012



Panel 5. Most relevant instruments of public funding of business R&D, 2014



Note: Policy information comes from country responses to the OECD STI Outlook policy questionnaires 2014 and 2012. Italy's responses are available in the *OECD STI Outlook Policy Database*, edition 2014 at *http://qdd.oecd.org/Table.aspx?Query=D8EF7A30-EC1B-4EF6-8407-B6DBB0C7A15D*.

Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888933152246

JAPAN

After two decades of slow economic growth, Japan shows signs of renewed dynamism. It is the world's third largest economy in GDP terms after the United States and China, and with 3.35% of GDP dedicated to R&D it ranks among the world's most R&D-intensive countries. Growth prospects are clouded however by an ageing population, high national debt (over 230% of GDP), and the effects of the Great East Japan Earthquake. The 4th S&T Basic Plan (2011-16) promotes an issue-driven, integrated approach to innovation policy, to be created and promoted together with society. Priority is given to environment, energy, health and medical care, and social challenges. In 2013, Japan adopted a Comprehensive Strategy on Science, Technology and Innovation as a long-term vision and roadmap to Japan's ideal economic society.

Hot issue 1: Innovation to contribute to addressing social challenges (including inclusiveness). The Comprehensive Strategy provides a set of issue-oriented policies and measures for building a healthy and active ageing society and creating next-generation infrastructures. Japan seeks to turn its medical equipment industries into world leaders and 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 and clinical applications will begin soon. Japan also promotes preventive medicine and supportive nursing, in addition to medical treatment. The 2nd Basic Programme for Shokuiku Promotion encourages education on food and nutrition. 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.

Hot issue 2: Improving the framework conditions for innovation (including competitiveness). Japan has recently reinforced the IP legislative framework and facilitated research and development. The Patent Law was amended in 2012 to enhance protection of licence agreements and provide appropriate protection for results of joint research activities. The Japan Patent Office (JPO) introduced in 2013 a system of "collective examination for IP portfolios" to grant rights on a cross-section basis in line with the timing of business expansion. The JPO also revised the examination guidelines in order to expand the allowable scope of unity of invention. The Department for Promotion of S&T was created in 2011 to make recommendations for the reform of the S&T system, and the Act of Strengthening R&D Capability and Efficient Promotion of R&D with Promotion of R&D System Reform (2008) was amended in 2013 to allow independent administrative agencies to contribute, including through IPR, to start-ups in order to encourage the commercialisation of R&D results.

Hot issue 3: Improving governance of the innovation system and policy. Japan faces two difficulties for better co-ordinating innovation policy. One is the need to bridge the gap between S&T and innovation components of the national innovation system. The other is the lack of co-ordination among the many ministries involved in STI policy making. To address these issues, the central role of the Council for Science and Technology Policy (CSTP) has been reinforced. The CSTP is the main forum for discussion, development and assessment of S&T policy. It is in charge of strengthening co-operation among ministries, changing silo governance structures and strengthening R&D activities at different research stages, including basic research. To this end, the Cross-Ministerial Strategic Innovation Promotion Programme has been allocated USD 494 million (JPY 51.7 billion) to reinforce the CSTP Secretariat's role in S&T budget formation, ministerial co-operation and evaluation.

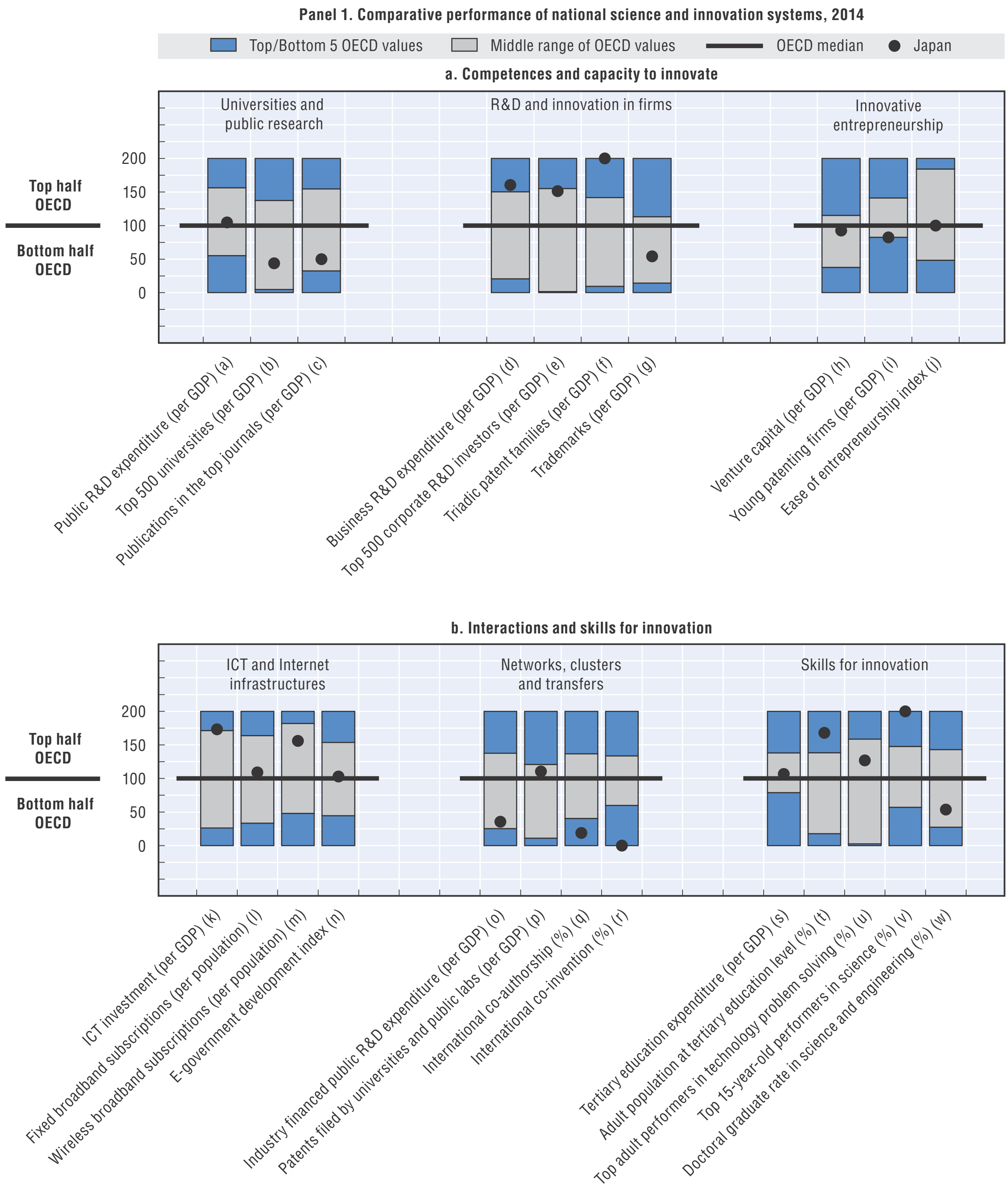
Highlights of the Japanese STI system

Universities and public research: Public R&D expenditure is modest (Panel 1[a]), especially in light of Japan's high GERD intensity. Applied R&D and experimental development absorb 50% of public R&D expenditures, and basic research about 30% of it. In terms of universities of global stature and high-impact publications, Japan is below the OECD median (Panel 1[b, c]). The 4th S&T Basic Plan aims to foster world-class basic research and emphasises the development and shared use of advanced research facilities as well as open data and open science infrastructures. The National Guidelines for Evaluating Government-Funded R&D were

Key figures, 2013

Economic and environmental performance	JPN	OECD	Gross domestic expenditure on R&D	JPN	OECD
Labour productivity			**GERD**		
GDP per hour worked, USD PPP, 2013	41.4	47.7	Million USD PPP, 2012	151 728	1 107 398
(annual growth rate, 2008-13)	(+0.9)	(+0.8)	As a % of total OECD, 2012	13.7	100
Green productivity			**GERD intensity and growth**		
GDP per unit of CO_2 emitted, USD, 2011	3.3	3.0	As a % of GDP, 2012	3.35	2.40
(annual growth rate, 2007-11)	(0.0)	(+1.8)	(annual growth rate, 2007-12)	(-0.9)	(+2.0)
Green demand			**GERD publicly financed**		
NNI per unit of CO_2 emitted, USD, 2011	3.0	3.0	As a % of GDP, 2011	0.75	0.77
(annual growth rate, 2007-11)	(0.0)	(+1.6)	(annual growth rate, 2007-11)	(-0.2)	(+2.8)

Figure 9.25. **Science and innovation in Japan**



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

revised in 2012 to reinforce the use of evaluation results in decision making regarding R&D programmes. Implementing agencies are also expected to make evaluation results public.

Innovation in firms: Japan's business sector is one of the world's most R&D-intensive (2.57% of GDP in 2012). The STI system is dominated by major corporate groups, which are among the world's largest corporate R&D investors (Panel 1[d, e]). Business investments in high-technology and medium-high-technology R&D (pharmaceuticals, communication equipment and motors vehicles) (Panel 2) have made Japan a world technology leader. Performance in non-technological innovation as measured by trademarks is modest (Panel 1[g]). Public support to the business sector is limited as firms finance 98% of their R&D activities. The R&D tax credit is the main public funding instrument.

Technology transfers and commercialisation: In Japan, innovation by large firms relies less on contracted public research (Panel 1[o]) and on co-operation with the science base than on innovation within the corporate group. As a consequence, researchers are highly mobile in the private sector but less so between industry and academia. A public-private consortium formed in 2014 encourages researchers' intersectoral mobility. The commercialisation of scientific research has been a priority of Japanese STI policy in recent decades, with a number of measures implemented since the mid-1990s. Through the new Centres of Innovation, the government subsidises high-risk collaborative R&D projects on social visions for the coming decade. If technology transfer through industry-science co-operation remains weak, universities and PRIs are active in patenting (Panel 1[p]). In 2012, Japan created the Programme for Creating Start-ups from Advanced Research and Technology (START) with USD 191 million (JPY 20 billion). START combines government funding and private-sector commercialisation know-how to support the launch of academic start-ups and leverage additional funding for public research.

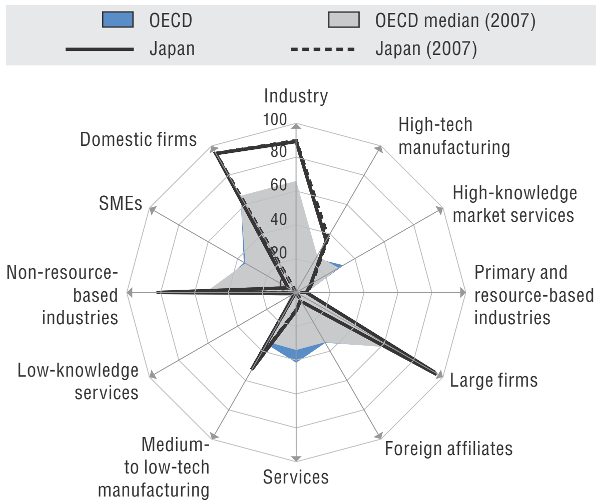
Clusters and smart specialisation: The Comprehensive STI Strategy and the Japan Revitalisation Strategy promote regional revitalisation by taking advantage of regional resources, developing regional infrastructures for innovation, particularly for transfer between universities and industry, and providing greater autonomy in the management of regional projects. Capitalising on prior cluster initiatives, Japan adopted a new Industrial Cluster Plan in 2014 with comprehensive initiatives to revitalise Japanese industry.

Globalisation: Japan remains weakly linked to international S&T co-operation networks (Panel 1[q, r]) and attracts few international R&D investments by firms (Panel 2). The Act for Promotion of Japan as an Asian Business Centre introduced corporate tax breaks, acceleration of patent examinations, reduction of patent fees, and shorter examination times for residence permits to encourage the establishment of foreign R&D centres and headquarters in Japan.

Skills for innovation: Japan has a sound skills foundation with a large pool of university graduates (Panel 1[t]) and high scores on international assessments of adults in technology problem-solving and of students in science (Panel 1[u, v]). However, there are relatively few doctoral graduates in science and engineering (Panel 1[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 therefore sought to improve the attractiveness of research careers and to build a broader science culture. The 4th S&T Basic Plan aims to enhance support for doctoral students, improve the career paths of researchers, and promote the active involvement of female researchers. It also aims to raise interest in and awareness of science among youth and society by promoting S&T communication activities by researchers, various S&T-related activities at science and regular museums, and the population's S&T literacy.

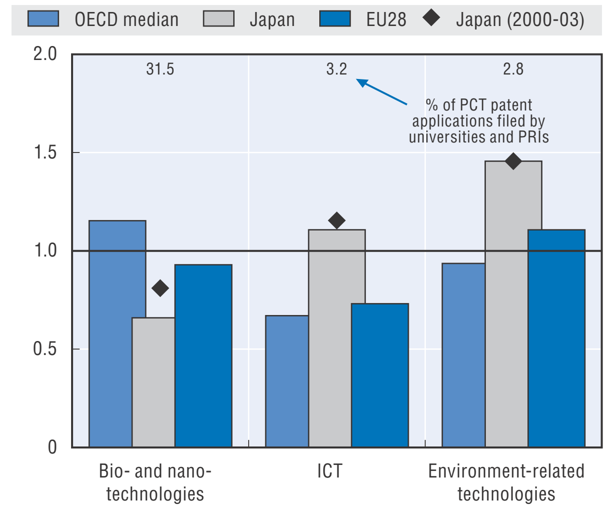
Panel 2. Structural composition of BERD, 2011

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

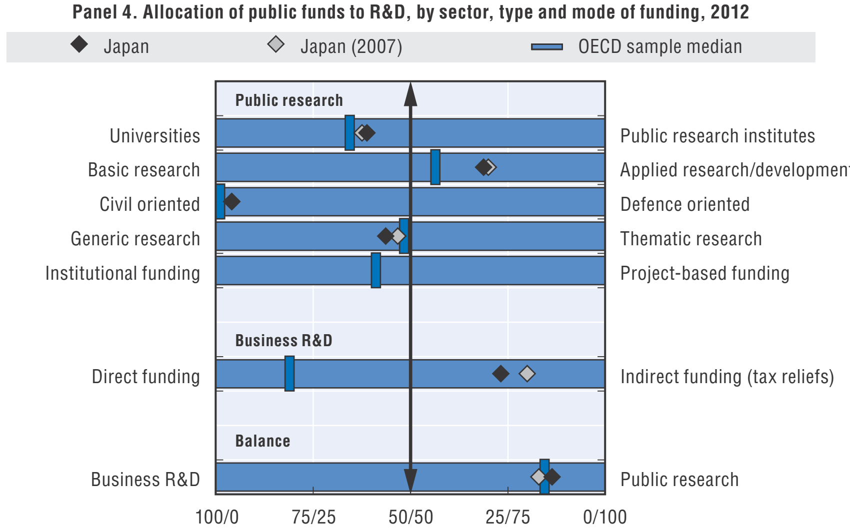


Panel 3. Revealed technology advantage in selected fields, 2009-11

Index based on PCT patent applications



Panel 4. Allocation of public funds to R&D, by sector, type and mode of funding, 2012



Note: Policy information comes from country responses to the OECD STI Outlook policy questionnaires 2014 and 2012. Japan's responses are available in the *OECD STI Outlook Policy Database*, edition 2014 at *http://qdd.oecd.org/Table.aspx?Query=E699EE6C-62BB-45F2-942B-48BF9EE892F3*.

Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888933152256

KOREA

Strong development in ICT and electronics sectors has made Korea one of the fastest-growing OECD economies over the past decade. It weathered the global crisis better than most OECD and non-OECD economies, and it is the world's most R&D-intensive country, with GERD at 4.36% of GDP in 2012. However, Korea faces 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 new government's road to economic prosperity and public wellbeing with the High Five Strategy to address long-term challenges.

Hot issue 1: Innovation to contribute to structural adjustment and a new approach to growth. Economic convergence with the advanced OECD countries has been progressively achieved, and consequently productivity growth slows and the potential for growth lessens. The High Five Strategy means to identify and support new industries, while the Creative Economy initiative (2013) sets the agenda for strengthening Korea's mid- and long-term creative capability.

Hot issue 2: Innovation to contribute to sustainable/green growth. Korea has been at the forefront of green growth initiatives and aims to be a hub for global green growth. The Green Climate Fund (GCF), started in 2013, encourages R&D, green technology development and green education. The Creative Economy initiative emphasises the role of innovation in addressing social challenges such as Internet privacy. Various R&D programmes for social problem solving, such as sustainable cities, have also been established.

Hot issue 3: Strengthening public R&D capacity and infrastructures. While public R&D expenditure is high, Korea still has few world-class universities and produces few high-impact publications by OECD standards (Panel 1[a, b, c]). One reason is that the public research system has historically been skewed towards applied and development-oriented research (Panel 4), much of which is performed in the PRIs (known as Government Research Institutes in Korea) that supply technology for industrial R&D. The 3rd S&T Basic Plan has allocated USD 109 billion (KRW 92.4 trillion) over the next five years to expand public R&D capacity, including national R&D facilities in strategic areas. At the same time, the government seeks to improve the efficiency of its R&D investment and has a comprehensive action plan for reforming the system for evaluating the performance of national R&D programmes.

Hot issue 4: Business innovation, entrepreneurship and SMEs. Large manufacturing conglomerates are the main performers of business R&D, with SMEs and young firms playing much smaller roles (Panel 2). The Creative Economy initiative focuses on building SMEs' innovative capacity, and the government plans to increase the share of its investments in R&D going to SMEs from 12.4% in 2011 to 18.0% in 2017. The 3rd S&T Basic Plan intends to build a favourable ecosystem for high-technology start-ups by strengthening technological assistance for SMEs through extension programmes and innovation vouchers and by strengthening support to entrepreneurship through the supply of venture capital.

Hot issue 5: Targeting priority areas/sectors. Korea has a strong RTA in ICTs (Panel 3) with almost half of its business R&D performed by computer, electronics and optical industries. Like its predecessors, the 3rd S&T Basic Plan seeks to help diversify the economy by orienting policy action towards a wider range of sectors and technologies, such as food and agriculture and medical services.

Highlights of the Korean STI system

STI policy governance: Under the new government, a ministerial overhaul and major changes in STI policy co-ordination arrangements were carried out in 2013. The Ministry of Science, ICT and Future Planning (MSIP) was established to support the implementation of the Creative Economy initiative and the Ministry of Trade, Industry and Energy (MOTIE) groups its trade functions with the R&D, industry and energy policy portfolio. In addition, a new National S&T Council under the Prime Minister's Office is the highest decision-making body on cross-agency STI policy issues.

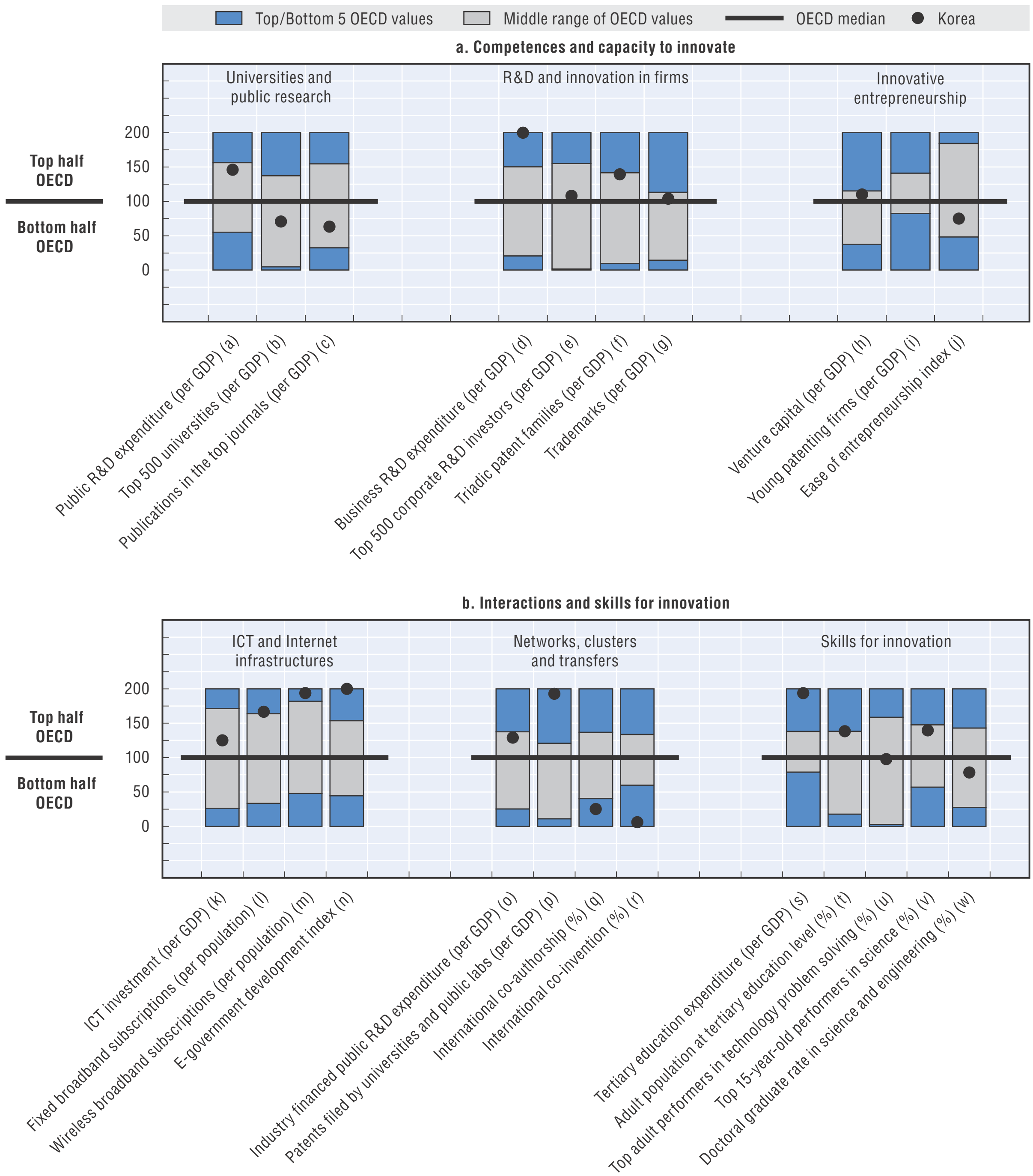
Technology transfer and commercialisation: Public research is mainly conducted in the PRIs, which have strong links with industry (Panel 1[o]). Universities and PRIs are also very active in patenting their research results (Panel 1[p]). Korea aims to establish a new eco-system for co-operation among PRIs, universities and industry to promote greater use of public R&D results for industrial and social purposes. It

Key figures, 2013

Economic and environmental performance	KOR	OECD	Gross domestic expenditure on R&D	KOR	OECD
Labour productivity			**GERD**		
GDP per hour worked, USD PPP, 2013	28.8	47.7	Million USD PPP, 2012	65 395	1 107 398
(annual growth rate, 2008-13)	(+2.6)	(+0.8)	As a % of total OECD, 2012	5.9	100
Green productivity			**GERD intensity and growth**		
GDP per unit of CO_2 emitted, USD, 2011	2.3	3.0	As a % of GDP, 2012	4.36	2.40
(annual growth rate, 2007-11)	(-0.9)	(+1.8)	(annual growth rate, 2007-12)	(+9.4)	(+2.0)
Green demand			**GERD publicly financed**		
NNI per unit of CO_2 emitted, USD, 2011	2.1	3.0	As a % of GDP, 2011	1.03	0.77
(annual growth rate, 2007-11)	(-0.7)	(+1.6)	(annual growth rate, 2007-11)	(+9.1)	(+2.8)

Figure 9.26. **Science and innovation in Korea**

Panel 1. Comparative performance of national science and innovation systems, 2014



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

includes a One-Stop Assistance Centre to help SMEs access the facilities and expertise of PRIs. The MSIP also has programmes to support exchanges of professors and students between universities and PRIs, and plans to establish 18 new joint industry-university-PRI R&D centres by 2017. In addition, the 3rd S&T Basic Plan encourages greater shared use of S&T infrastructure to broaden access to S&T knowledge and information. PRIs are required to devote 15% of their total budget to support SMEs by 2017 (compared to 7% in 2012) and 3% to transfer technology to SMEs and support human resources (compared to 1.76% in 2012).

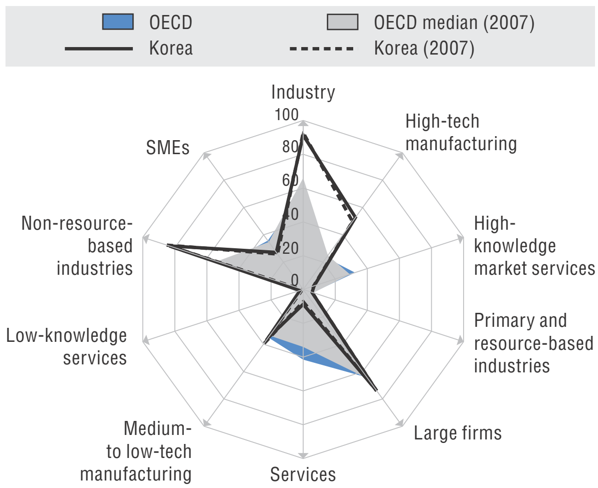
Clusters and smart specialisation: The Seoul Metropolitan Area is the focus of much S&T and innovation activity, and this has led to unbalanced regional growth. The government has therefore created special R&D districts, such as Daedeuk, Gwangju, Daegu and Busan, each with its own technological orientation, to promote regional industrial bases and local job creation. The Venture Investment Fund for special R&D districts was initiated in 2012 with USD 148 million (KRW 125 billion) to strengthen regional private investment.

Globalisation: Levels of international co-authorship and co-patenting are well below the OECD median (Panel 1[q, r]). A traditionally strong focus on applied research and technological development performed largely in PRIs partly explain low levels of international co-authorship. The low level of patent applications with foreign co-inventors is partly due to Korea's conglomerate industrial structure, which tends to retain technology development within the group. In the past, there have been occasional instances of cross-border co-operation but no comprehensive strategy for international STI co-operation. The MSIP has therefore developed a Comprehensive Plan for STI Global Co-operation, which includes the formation of a global network of overseas STI outposts, expansion of S&T official development assistance (ODA), reinforcement of science diplomacy, promotion of international joint R&D, and sharing of large R&D facilities. The MSIP is also implementing measures to encourage international mobility of highly skilled labour.

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 (Panel 1[s]). However, the Korean education system has mixed results. For example, with a large share of tertiary-qualified adults, adults' technical problem-solving ability is just average (Panel 1[t, u]), and while 15-year olds perform well in science, the rate of doctorates in science and engineering is modest (Panel 1[v, w]). The MSIP has developed a Comprehensive Plan for the Scientifically Gifted and Talented (2013-17) to identify pupils with high potential and nurture them to be more creative. The Five-Year Plan for University Start-ups (2013-17) aims to improve entrepreneurship education in secondary schools and universities. Korea's demographic pattern indicates that the student population will decline from 2018. The National Scholarship programme, the Income Contingent Loan for low-income students, with a zero interest rate, and the 3rd Women S&E Promotion Basic Plan (2014-18) all aim to increase participation in higher education. The MSIP, along with other ministries, is 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 pre-employment of students.

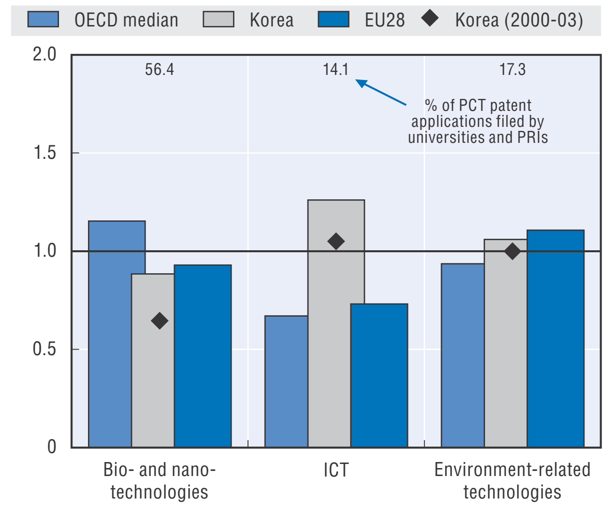
Panel 2. Structural composition of BERD, 2011

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

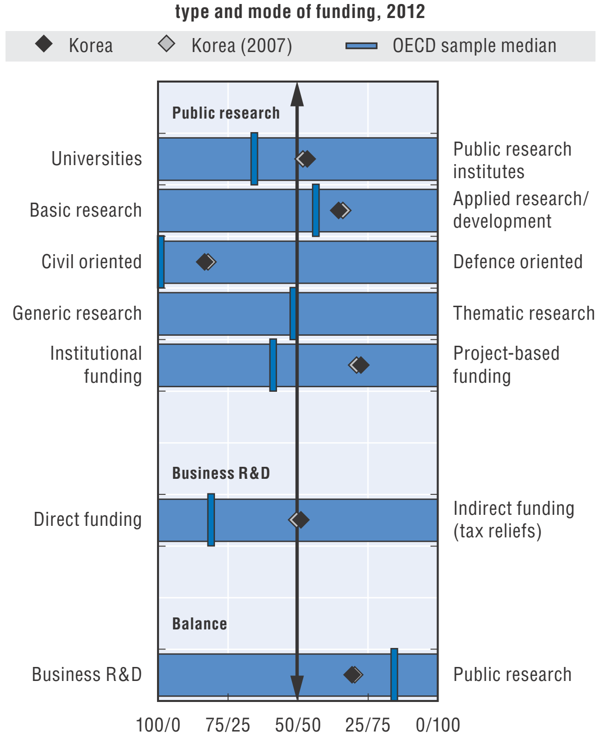


Panel 3. Revealed technology advantage in selected fields, 2009-11

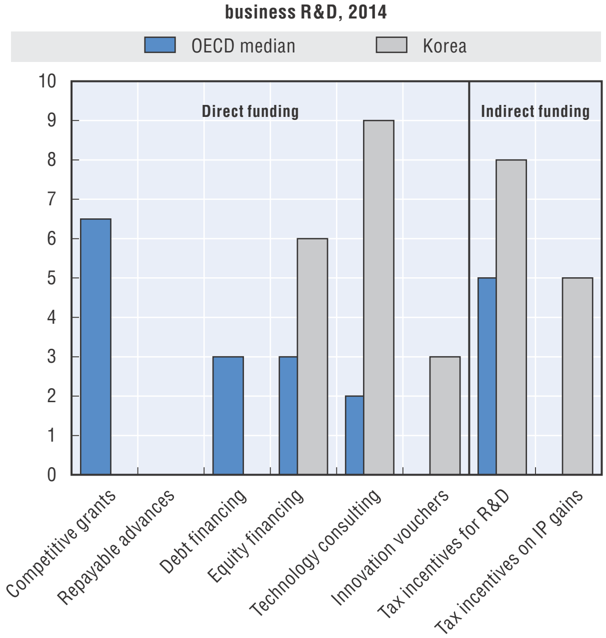
Index based on PCT patent applications



Panel 4. Allocation of public funds to R&D, by sector, type and mode of funding, 2012



Panel 5. Most relevant instruments of public funding of business R&D, 2014



Note: Policy information comes from country responses to the OECD STI Outlook policy questionnaires 2014 and 2012. Korea's responses are available in the *OECD STI Outlook Policy Database*, edition 2014 at *http://qdd.oecd.org/Table.aspx?Query=48A2673C-A4DF-4CB8-BDD2-469148C09DFB*.

Source: See reader's guide and methodological annex.

StatLink *http://dx.doi.org/10.1787/888933152261*

LATVIA

Latvia is a small EU member state, whose economy has returned to positive growth since 2011 after having contracted between 2008 and 2010. It has undergone changes in many policy areas in recent years. It has several STI priorities.

Hot issue 1: Improving overall human resources, skills and capacity building. Latvia has a reasonably good human resource base in terms of the tertiary-educated adult population, and its expenditure on tertiary education is at the OECD median (Panel 1[v, t]). However, brain drain and the ageing of the STI workforce are important challenges. Improvements in human resources and capacity building are top priorities in Latvia's Guidelines for Science, Technology Development and Innovation (2014-20). They are also priorities in Latvia's Smart Specialisation Strategy. The EU Structural Funds have programmes for the improvement of human resources and capacity building in science. The EU-funded Attracting Human Resources to Science (2007-13) addressed researcher brain drain and sought to attract young scientists to PRIs. To deal with the ageing of the STI workforce, employment quotas for young scientists have been introduced in government programmes and projects. Major reforms of HEIs have been carried out to introduce a new model of accreditation, new funding models and the internationalisation of HEIs, and education programmes have been revised to meet needs and trends in the job market.

Hot issue 2: Encouraging innovation in firms and supporting entrepreneurship and SMEs. The Guidelines on National Industrial Policy (NIP) for 2014-20, approved in June 2013, identify innovation as a key pillar for improving competitiveness, productivity and exports. Initiatives include support for co-operation between industry and academia and commercialisation of research results, new product and technology development and the expansion of innovative and technology-oriented companies as well as new financial instruments (e.g. seed and venture capital) for innovative companies, especially SMEs at their different stages of growth. To improve Latvian industry's ability to innovate, the EU Structural Funds have supported programmes, including the innovation voucher programme launched in 2012, to attract private investment in R&D for new products and technologies and their commercialisation. Competence centres seek to increase the competitiveness of businesses and to facilitate research-industry co-operation on industrial R&D for new products and technology.

Hot issue 3: Reforming the public research system and strengthening public R&D capacity and infrastructure. Government expenditure on R&D, at 0.51% of GDP, is at the bottom of the OECD mid-range (Panel 1[a]). No Latvian universities rank among the world's leaders (Panel 1[b]). Large-scale reforms of HEIs and PRIs are under way to improve the quality and relevance of public R&D. As part of this process, research institutions and science and innovation system have been assessed by international experts, in co-operation with the Nordic Council of Ministers and NordForsk. EU Structural Funds have been allocated to strengthen the research infrastructure and human resources for public research. The Baltic inter-ministerial expert group on research infrastructure and the Baltic-Nordic co-operation on research infrastructure are regional platforms for co-operation and assistance.

Hot issue 4: Improving returns to and impact of science. Commercialisation of research results and technology transfer are considered to improve the returns and impact of science. To this end, six competence centres and nine state research centres foster industry-science co-operation, and technology transfer contact points have been established for the commercialisation of public research. The Law on Scientific Activity has been amended to ensure more efficient legal protection of public research results, their commercialisation and the transfer of knowledge.

Highlights of the Latvian STI system

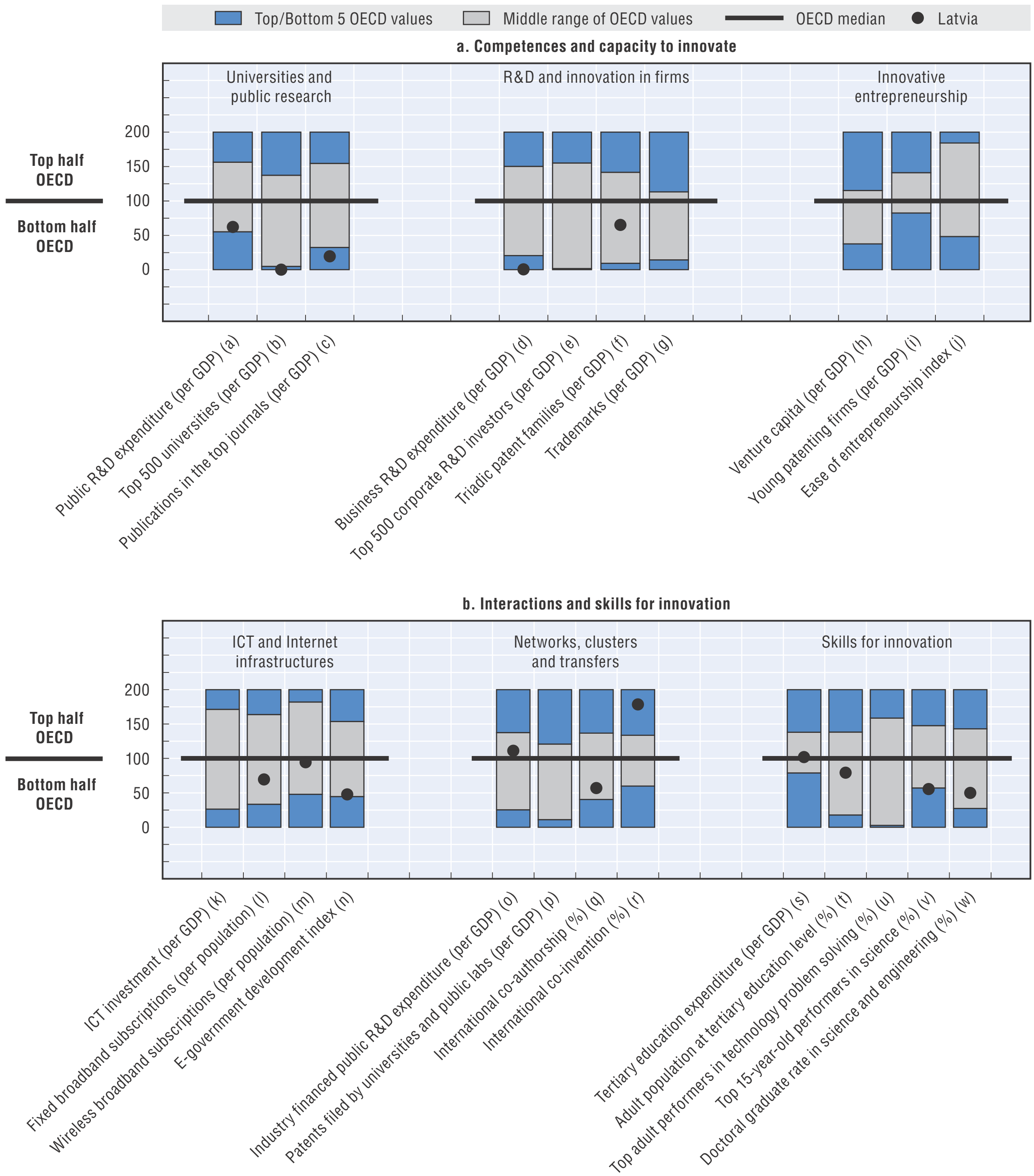
STI policy governance: Latvia has no high-level national council for STI policy. The Ministry of Education and Science and the Ministry of Economics share responsibility for innovation policy. A lack of human resources in the state administration and bureaucracy are considered barriers to policy co-ordination. Latvia participates in the joint Baltic political co-ordination expert group established in 2013. Research programmes are evaluated on completion of each programming period. Fundamental and applied research

Key figures, 2013

Economic and environmental performance	LVA	OECD	Gross domestic expenditure on R&D	LVA	OECD
Labour productivity			**GERD**		
GDP per hour worked, USD PPP, 2013	n.a.	47.7	Million USD PPP, 2011	274	1 107 398
(annual growth rate, 2008-13)	n.a.	(+0.8)	As a % of total OECD, 2011	0.0	100
Green productivity			**GERD intensity and growth**		
GDP per unit of CO_2 emitted, USD, 2011	4.0	3.0	As a % of GDP, 2012	0.66	2.40
(annual growth rate, 2007-11)	(-0.8)	(+1.8)	(annual growth rate, 2007-11)	(-0.6)	(+2.0)
Green demand			**GERD publicly financed**		
NNI per unit of CO_2 emitted, USD, 2011	4.7	3.0	As a % of GDP, 2012	0.17	0.77
(annual growth rate, 2007-11)	(+9.2)	(+1.6)	(annual growth rate, 2007-11)	(-17.5)	(+2.8)

Figure 9.27. **Science and innovation in Latvia**

Panel 1. Comparative performance of national science and innovation systems, 2014



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

grants are evaluated regularly. Market-oriented projects whose aim is innovative commercial products are assessed following the project's completion. According to the Law on Scientific Activity, PRIs are to be evaluated every six years. The latest research assessment exercise was performed by international experts in co-operation with the Nordic Council of Ministers and NordForsk in 2013. In order to facilitate the commercialisation of public research, a recent amendment to the Law on Scientific Activity assigns IPR on inventions from publicly funded research to the relevant scientific institutions.

Innovative entrepreneurship: The World Bank's Ease of Doing Business Index suggests that Latvia has a conducive business environment. Seed money, grants, loans and venture capital are available to help finance technology start-ups and fast-growing companies. In 2012, the Baltic Innovation Fund (BIF) was launched by the European Investment Fund in close co-operation with the Governments of Latvia, Lithuania and Estonia to boost equity investments in Baltic SMEs with high growth potential.

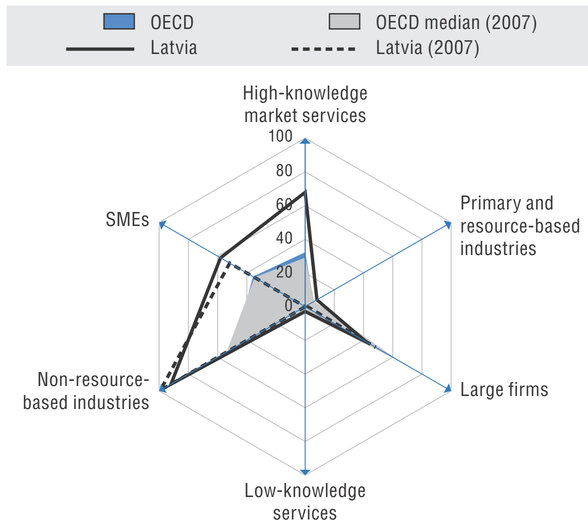
Clusters and smart specialisation: Latvia has participated in the EU effort to develop a Smart Specialisation Strategy and has involved several government ministries in partnership with industry, research institutions and trades unions. Since 2009 the industry-driven cluster initiatives have received support in order to promote collaboration between unrelated companies, research, educational and other institutions and to improve the competitiveness of enterprises, increase export volumes and promote innovation and development of new products.

ICT and Internet infrastructures: Relative to its income level, Latvia has advanced ICT infrastructures. Wireless broadband subscriptions are just below the OECD median, and the fixed broadband subscriptions and e-government development indexes are in the mid-range of OECD countries (Panel 1[m, l, n]).

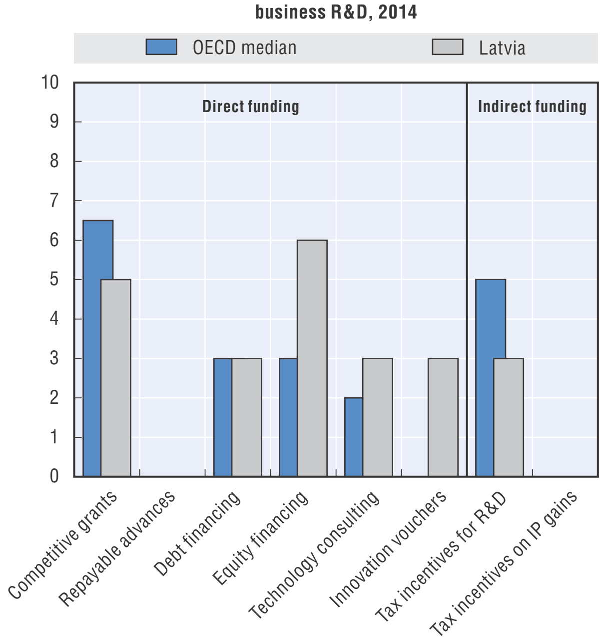
Recent developments in STI expenditures: GERD accounted for only 0.7% of GDP in 2011 and 0.66% in 2012 and has been declining in recent years. Publicly funded GERD has decreased even more dramatically, with the government budget for R&D down from approximately USD 120 million (LVL 36 million) in 2008 to USD 58.3 million (LVL 17.5 million) in 2011-13. The National Reform Programme for implementation of the EU Europe 2020 strategy sets a target for GERD of 1.5% of GDP by 2020.

Panel 2. Structural composition of BERD, 2011

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



Panel 3. Most relevant instruments of public funding of business R&D, 2014



Note: Policy information comes from country responses to the OECD STI Outlook policy questionnaire 2014. Latvia's response is available in the *OECD STI Outlook Policy Database*, edition 2014 at *http://qdd.oecd.org/Table.aspx?Query=CB8F5A08-514F-4474-BF57-5480EA02463C*.

Source: See reader's guide and methodological annex.

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LITHUANIA

Following a 15% plunge in GDP in 2009, the Lithuanian government launched broad economic reforms. Combined with spending cuts and tax rises, these led to a quick recovery in 2010. Since then Lithuania has been one of the fastest-growing EU economies, with GDP rising by 3.6% a year on average over 2010-13. It has launched a National Innovation Development Programme (NIDP) 2014-20 to support competitiveness and economic growth through innovation. Implementation of the programme is being prepared.

Hot issue 1: Improving the governance of the innovation system and policy. Creating a coherent R&D and innovation system is a long-term challenge and a strategic goal for NIDP 2014-20. Until recently, lack of co-ordination of R&D and innovation policy by the responsible ministries led to fragmented and incompatible policies and weakened outcomes. In 2013, the Strategic Council for Research, Development and Innovation, led by the prime minister, was formed to co-ordinate STI policy and to manage the setting of priorities. The Science Council has become the Research Council, which is actively involved in competitive research funding, and an Agency for Science, Innovation and Technology (MITA) was established to foster industry-science co-operation and to create a friendly environment for business innovation. The recent preparation for smart specialisation strategies (RIS3) is an example of improved governance, with enhanced evidence-based decision-making and the involvement of all stakeholders.

Hot issue 2: Encouraging innovation in firms and supporting entrepreneurship and SMEs. BERD is very low as a share of GERD (26.6%) and of GDP (0.24%). Lithuania has few large corporate R&D investors (Panel 1[e]). It ranks 17th on the World Bank's Ease of Doing Business Index (2014), ahead of many OECD economies. Since 2007 it has promoted private-sector R&D activities through the Intellect and Intellect+ programmes, with USD 299 million (LTL 479 million) over 2007-13. Since 2010 it has encouraged business-science co-operation and commercialisation of public research results through the innovation voucher programme with USD 4.4 million (LTL 7 million), and since 2012 it has strengthened technology transfer through MITA with USD 12.8 million (LTL 20.5 million). Public support for business R&D totalled USD 315.4 million (LTL 504.6 million) over 2007-13. Such instruments are expected to continue under NIDP 2014-20. The Entrepreneurship Promotion Programme 2014-20 is being prepared and will contain objectives for the development of innovative entrepreneurship by improving access to finance and implementing various initiatives.

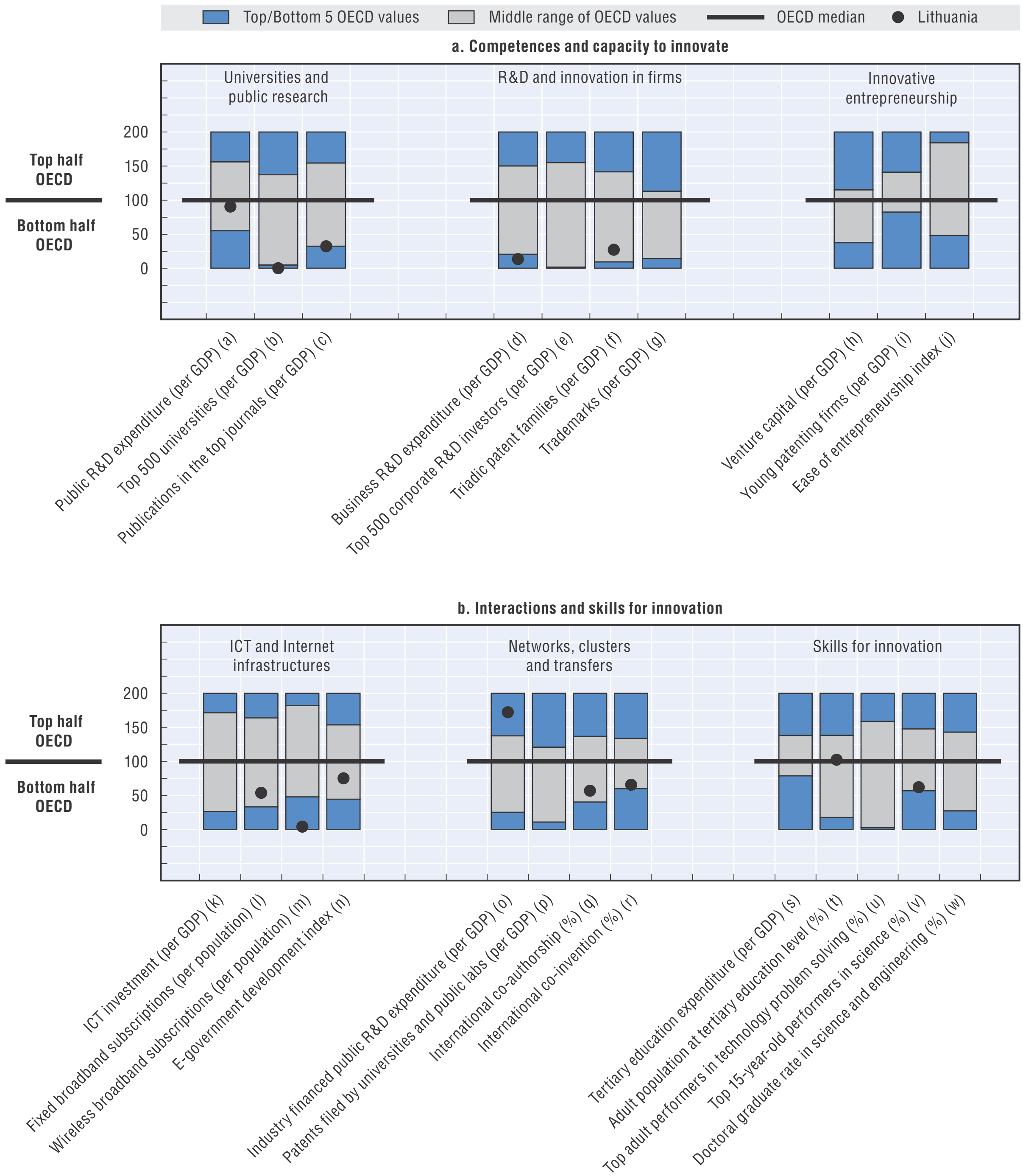
Hot issue 3: Addressing STI globalisation and increasing international co-operation. Lithuania's connection to global R&D and innovation networks is below the OECD median, as suggested by its international co-authorship and co-invention (Panel 1[q, r]). Since 2007, it has addressed international STI co-operation by promoting various types of clusters. In particular, MITA's promotion of the internationalisation of business-science partnerships, with USD 2.3 million (LTL 3.7 million) over 2007-13, led to the formation of ten clusters. The initiative that promotes the development of networks and co-operation in the Baltic Sea Region (BSR) focuses on the internationalisation of SMEs. Through the BSR Innovation Express Call in 2013, 28 new international collaboration projects were established,

Key figures, 2013

Economic and environmental performance	LTU	OECD	Gross domestic expenditure on R&D	LTU	OECD
Labour productivity			**GERD**		
GDP per hour worked, USD PPP, 2013	n.a.	47.7	Million USD PPP, 2011	598	1 107 398
(annual growth rate, 2008-13)	n.a.	(+0.8)	As a % of total OECD,	0.0	100
Green productivity			**GERD intensity and growth**		
GDP per unit of CO_2 emitted, USD, 2011	4.2	3.0	As a % of GDP, 2012	0.90	2.40
(annual growth rate, 2007-11)	(+1.6)	(+1.8)	(annual growth rate, 2007-11)	(+1.5)	(+2.0)
Green demand			**GERD publicly financed**		
NNI per unit of CO_2 emitted, USD, 2011	4.4	3.0	As a % of GDP, 2012	0.86	0.77
(annual growth rate, 2007-11)	(+4.6)	(+1.6)	(annual growth rate, 2007-11)	(-0.6)	(+2.8)

Figure 9.28. **Science and innovation in Lithuania**

Panel 1. Comparative performance of national science and innovation systems, 2014



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

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involving more than 900 SMEs. It attracted 47 applications from cluster organisations and business networks in the six funding partner countries. Four of these applications involved Lithuanian undertakings, all of which were approved.

Hot issue 4: Reforming and improving the public research system (including university research). Although Lithuania has few leading universities (Panel 1[b]), higher education institutions account for 53.7% of GERD and the government sector for 19.7%. In 2009, the Parliament adopted a Law on Higher Education and Research to reform and restructure the higher education and research system. Reforms have focused on improving quality, accessibility, competitiveness and efficiency. A shift towards programme-based competitive funding increased the share of competitive R&D funding to one-third of overall R&D funding. The reorganisation and consolidation of HEIs and PRIs introduced new governance mechanisms in universities and colleges and increased their accountability, and external and independent evaluations were introduced. IPR frameworks were developed for inventions made in HEIs and PRIs. Adopted in December 2012, the National Programme for the Development of Studies, Research and Experimental Development for 2013-20 outlines further objectives for developing higher education, research and innovation systems.

Hot issue 5: Strengthening public R&D capacity and infrastructure. Over 2007-13, the R&D Programme for Co-operation between Public R&D and the Business Sector – Integrated Research, Higher Education and Business Centres was implemented to improve R&D infrastructure and research capacities through the integration of R&D, education and business innovation. Five integrated science, education and business centres have been created, with a total investment of USD 670 million (LTL 1 099.7 million) in material science and electronics; biotechnology, environment and ICTs; bioenergy, forestry and food technologies; marine environment and technologies. Public R&D capacities have also been promoted by strengthening the skills of researchers, through the Researchers Career Programme with a total of USD 391.9 million (LTL 627.2 million) over 2007-13.

Highlights of the Lithuanian STI system

New sources of growth: In 2013, the Strategic Council for Research, Development and Innovation identified six priority areas: energy and sustainable environment; inclusive and creative society; agro-innovation and food technology; new materials and technologies; health and biotechnology; transport, logistics and ICTs. The Programme on the Implementation of the Priority Areas of Research and Development and Innovation (Smart Specialisation) was adopted in 2014, with 20 R&D and innovation priorities.

New challenges: Several national programmes focus on green innovation. These include the Lithuanian National Strategy for Sustainable Development and the Green Industry Innovation Programme (funded by the Norwegian Financial Mechanisms 2009-14). In 2013, the Ministry of Education and Science launched new national research programmes on social challenges: *Modernity in Lithuania*; Welfare society; Towards future technologies; Healthy ageing; and Sustainability of agro, forest and water ecosystems.

Clusters and smart specialisation: Two major programmes implemented during 2007-13, InnoCluster LT and InnoCluster LT+, focused on the promotion of clusters. With USD 48.7 million (LTL 78 million) over 2007-13, these programmes created 30 clusters and invested in R&D infrastructure. The government launched the process of identifying smart specialisation priorities in 2012, involving key stakeholders; they will involve the above-mentioned six priority areas. A project launched in 2013 also aims at fostering the internationalisation of SMEs, clusters and science partnerships and networking activities (Klaster.LT).

Globalisation: The Ministry of Education and Science has developed an Action Plan for Promoting the International Dimension in Higher Education for 2013-16. The Research Council of Lithuania supports application for and participation in EU Framework Programmes and has developed scientific exchange programmes with EU members and Switzerland. The Ministry of Economy has several programmes to promote the internationalisation of SMEs and clusters, such as initiatives in co-operation with Norway, Israel and the Baltic Sea Region countries.

Skills for innovation: Lithuanian has a well-educated population: 31% of adults have completed higher education and 15-year-olds perform reasonably well in science, with a Pisa score between the United States and Hungary. The 2012-16 national priorities include a strong focus on the development of mathematics and informatics skills and curricula. Various programmes support researchers' career development, promote top-performing international researchers, encourage researcher and student mobility, develop skills training and the hiring of skilled personnel in firms, and disseminate knowledge about science and technology among students. Several new projects for the promotion of innovative start-ups and spin-offs have recently been launched by the Agency for Science, Innovation and Technology. They include the new technological entrepreneurship projects Innovative Business Promotion and Technostart, which promote the commercialisation of research results and create opportunities for young researchers to develop their ideas and establish new technological businesses in Lithuania. The projects bring together the largest Lithuanian universities, S&T parks, and other research institutions

Recent developments in STI expenditures: GERD increased over the last five years to USD 640.6 million (LTL 1 025.5 million) and accounted for 0.9% of GDP in 2012. Most of the increase came from funding from abroad, largely from the EU. Government spending on R&D in 2012 was USD 255.6 million (LTL 408.9 million), a 6% increase from 2009. The government's goal is GERD at 1.9 % of GDP by 2020.

LUXEMBOURG

Luxembourg is a small open economy with one of the world's highest income per capita. In recent years, the government has invested heavily in building an advanced science base, virtually from scratch, and is now looking to consolidate these investments, with a strong focus on the efficiency and effectiveness of the science base and the roles it can play in supporting national innovation performance and structural change of the Luxembourg economy.

Hot issue 1: Strengthening public R&D capacity and infrastructure. The government's R&D budget has continued to increase, with total government budget appropriations or outlays for R&D (GBAORD) climbing from USD 72 million (EUR 60 million) in 2004 to USD 318 million (EUR 264 million) in 2013 (Panel 2). The number of researchers in the public sector has also grown substantially (Panel 3). These large increases reflect the government's intention to expand the research system in order to develop and diversify the economy. The rate of budget increase has slowed markedly in the last couple of years, however, a trend that can be expected to continue as the research system enters a phase of consolidation. Two draft laws, currently under consideration by the legislature, aim to further strengthen and harmonise the research system. One law focuses on reforms of Luxembourg's only research council, the *Fonds National de la Recherche* (FNR) to allow it to fund research in a wider variety of types of organisations. The second proposes modifications to the public research institutes, the *Centres de Recherche Public* (CRPs), specifically the merger of CRP-Gabriel Lippmann and CRP-Henri Tudor and the incorporation of the Integrated BioBank into CRP-Santé. An ambitious infrastructure project, the *Cité des Sciences, de la Recherche et de l'Innovation* at Belval, will group most of Luxembourg's public research (the University of Luxembourg and CRPs) in one campus by 2015, with facilities for public-private partnerships and an incubator for start-ups. Ultimately, the campus will have 7 000 students and 3 000 teaching staff and researchers.

Hot issue 2: Targeting priority areas/sectors. With only a few thousand scientists across the public and private sectors (Panel 3), Luxembourg has to focus on areas in which it can have international impact. The FNR therefore continues to concentrate much of its funding on a limited number of priority domains identified in an earlier foresight exercise. The priorities of the university, an increasingly important player in the system (Panel 4), are also important in shaping national priorities. They include systems biomedicine and security and reliability of ICT systems, which already have relatively large interdisciplinary centres. Other university priorities are international finance and European and business law, which relate to Luxembourg's role as host of financial institutions, corporate headquarters and European institutions. The government also has special action plans on logistics, health care and sustainable development.

Hot issue 3: Improving overall human resources, skills and capacity building. The proportion of the adult population with tertiary-level education is above the OECD median (Panel 1[t]). However, there is widespread perception that young people are not very interested in scientific careers. Measures such as Go for Science and ProScience seek to raise awareness of science among young people and to attract them to scientific careers. The FNR's *Aides a la Formation-Recherche* (AFR) programme aims to make scientific careers more attractive by offering better work contracts, working conditions and training opportunities to PhD and postdoctoral students. The government is considering professionalising the doctorate by setting up a series of doctoral schools to improve the professional skills of doctorate candidates in the coming years. The FNR also provides institutions with funding to attract high-level senior researchers and exceptional young researchers from abroad.

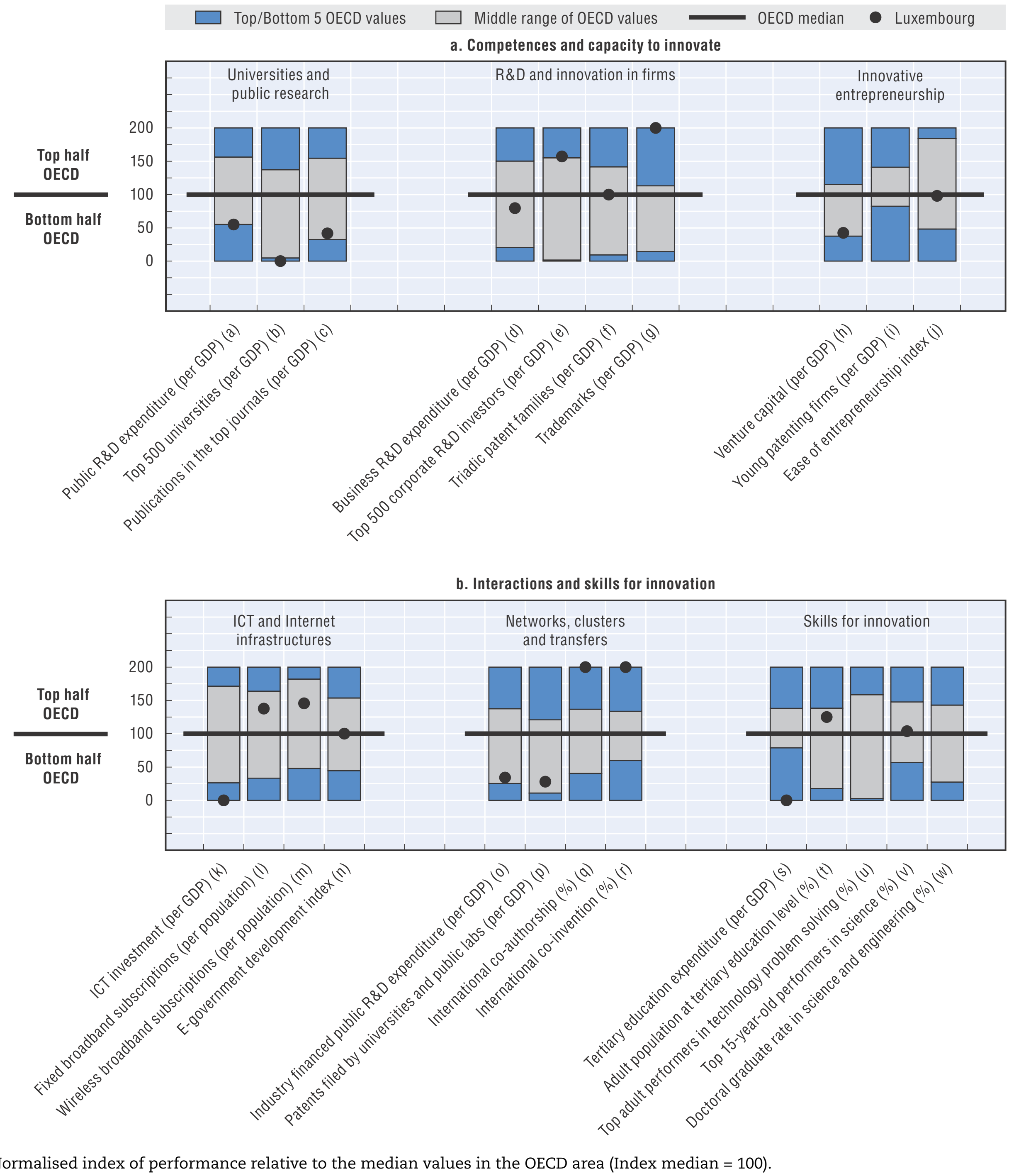
Hot issue 4: Improving returns and impact of science. Public research funding is tied to performance contracts between the government and research performers (the CRPs and the university) and the funding agency FNR as well as the innovation promotion agency Luxinnovation. For research performers, numbers of publications, doctorates, patents and spin-offs are among the main indicators used, along with targets for securing external funding. Regular evaluations of departments have also been introduced. New measures to support exploitation of research include the joint evaluation of thematic research project proposals by FNR and Luxinnovation and FNR's Proof of Concept pilot programme,

Key figures, 2013

Economic and environmental performance	LUX	OECD	Gross domestic expenditure on R&D	LUX	OECD
Labour productivity			**GERD**		
GDP per hour worked, USD PPP, 2013	85.1	47.7	Million USD PPP, 2012	692	1 107 398
(annual growth rate, 2008-13)	(-0.8)	(+0.8)	As a % of total OECD, 2012	0.1	100
Green productivity			**GERD intensity and growth**		
GDP per unit of CO_2 emitted, USD, 2011	3.4	3.0	As a % of GDP, 2012	1.46	2.40
(annual growth rate, 2007-11)	(+3.2)	(+1.8)	(annual growth rate, 2007-12)	(-1.9)	(+2.0)
Green demand			**GERD publicly financed**		
NNI per unit of CO_2 emitted, USD, 2011	2.3	3.0	As a % of GDP, 2011	0.44	0.77
(annual growth rate, 2007-11)	(-0.5)	(+1.6)	(annual growth rate, 2007-12)	(+8.5)	(+2.8)

Figure 9.29. **Science and innovation in Luxembourg**

Panel 1. Comparative performance of national science and innovation systems, 2014



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

which supports excellent research projects that seek to attract potential investors.

Highlights of the Luxembourg STI system

Innovation in firms: Relative to its size, Luxembourg hosts the headquarters of the largest number of top corporate R&D investors among OECD countries (Panel 1[e]). It files more trademarks (Panel 1[g]) than triadic patents (Panel 1[f]). Business is the largest performer of R&D (Panel 4), although BERD has fallen since the financial crisis and has yet to recover (Panel 5). The reasons for the decline are currently under investigation. A law on state aid for R&D, implemented in 2009, extended the scope of policy intervention. Measures include special subsidies for SMEs and innovative start-ups and schemes to promote knowledge flows between academia and industry.

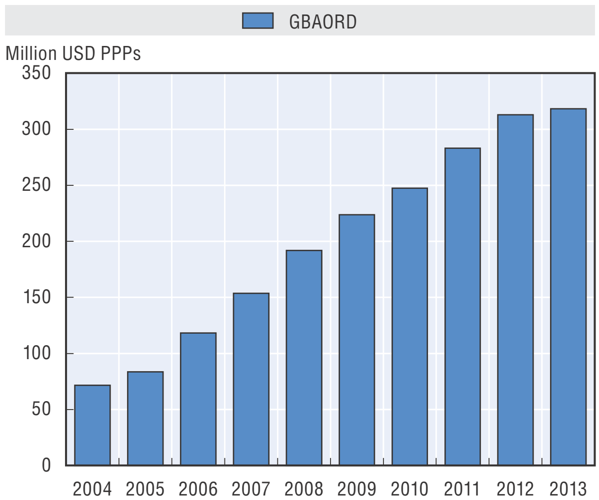
Innovative entrepreneurship: Luxinnovation is the main agency supporting innovative entrepreneurship, chiefly through advisory services, network building and information campaigns. Luxembourg has recently consolidated its various incubator structures in a single entity, Technoport S.A., whose mission is to facilitate the setup of start-ups and spin-offs. It offers a new physical incubator at the *Cité des Sciences, de la Recherche et de l'Innovation*, and aims to become an important relay between the university, the CRPs and the wider economy. It can also provide temporary premises for foreign companies planning to begin operations in Luxembourg. The installation of a fabrication laboratory has increased the diversity of the facilities. In addition, work has started on creating two new incubators in areas deemed national priorities, health technology and eco-technology.

Globalisation: Luxembourg has made international research co-operation a priority, and this is reflected in high shares of international co-authorship (Panel 1[q]) and international co-invention (Panel 1[r]). The government places considerable emphasis on strong participation in the EU's Horizon 2020, particularly as levels of national funding are set to stabilise over the next few years. It has also signed many bilateral agreements. Over 2011-13, bilateral programmes of the FNR and foreign funding agencies supported 33 projects with funding of USD 13.3 million (EUR 11 million).

Clusters and smart specialisation: The Luxembourg Cluster Initiative has six theme-based clusters: materials, ICTs, aeronautics and space, health care and biotechnology, eco-innovation, and automotive components. In 2013, the clusters, in collaboration with the Ministry of the Economy, set up a new working framework based on five priority areas: business development, supporting flagship projects, improving brand image for the sector, intensifying promotion and prospecting, and developing the internationalisation of the initiative. Specific quantitative objectives have been set for each cluster.

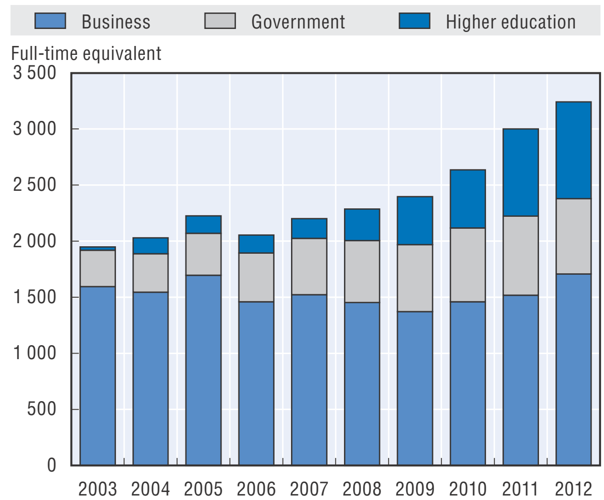
ICT and Internet infrastructures: The national ICT infrastructure is well developed (Panel 1[l, m]), an important location factor for many leading international ICT companies. ICT expertise underpins the sustainable development of the financial, media, environment, logistics, automotive and space industries, all of which are important in Luxembourg. The financial sector, for example, depends strongly on the fact that Luxembourg has become one of Europe's top locations for ICT infrastructures (e.g. in terms of data centres and low latency network connectivity) and offers specialised expertise to keep firms' data safe. Luxembourg is also investing heavily in ICT research in order to build scientific excellence. For example, the Interdisciplinary Centre for Security, Reliability and Trust at the University of Luxembourg aims to put the country on the world map in terms of high-quality research in secure, reliable and trustworthy ICT systems and services.

Panel 2. Total government budget appropriations or outlays for R&D (GBAORD), 2004-13

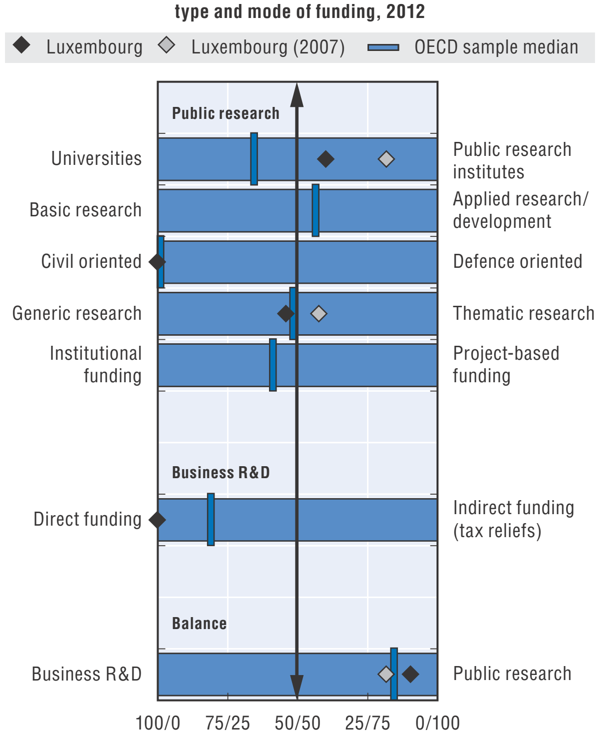


Panel 3. Number of researchers by sector of employment, 2003-12

Full-time equivalents

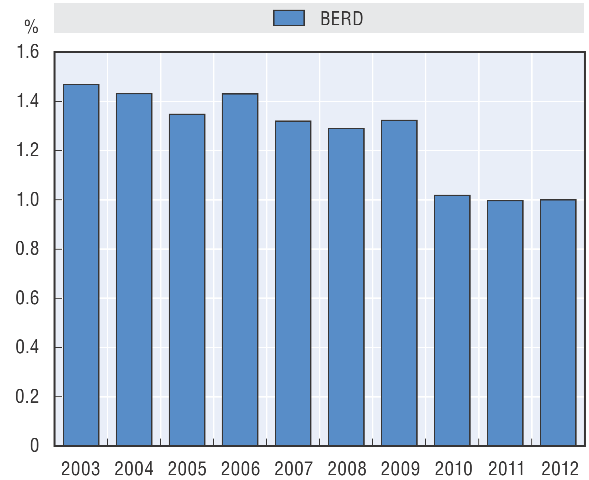


Panel 4. Allocation of public funds to R&D, by sector, type and mode of funding, 2012



Panel 5. BERD intensity, 2003-12

As a percentage of GDP



Note: Policy information comes from country responses to the OECD STI Outlook policy questionnaires 2012, and OECD Innovation Review of Luxembourg (2015, forthcoming).

Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888933152299

MALAYSIA

Malaysia is a dynamic emerging economy in Southeast Asia, with average growth at 4.1% between 2009 and 2012 and gross national income of USD 22 280 per capita in 2012. In 2013, the government announced the National Science, Technology and Innovation Policy (NSTIP) (2013-20), which provides strategic guidelines for STI policy and investment for Malaysia's transition to an innovation economy by 2020. The Prime Minister subsequently announced the Science for Action (S2A) for the implementation of the NSTIP, as one of the key strategic thrusts of the country's 11th Plan (2016-20).

Hot issue 1: Strengthening public R&D capacity and infrastructures. Malaysia's expenditure on public R&D, at 0.46% of GDP, is at the lower end of the OECD middle range (Panel 1[a]) and comparable to that of China (0.47%) and Russia (0.46%). Between 2001 and 2011, science and engineering articles produced by Malaysia increased by 16% a year, slightly faster than the increase of China's (15.6%). Going forward, the government envisages a public research sector that serves as a solid knowledge base and an effective diffusion channel within the national innovation system. To this end, the National Science and Research Council (NSRC) made several recommendations in 2013; to create a Research Management Agency under the NSRC to improve the management of public research; to establish an industry research nexus as a platform for public research and industry collaboration in order to improve the relevance and marketability of public research; to review, restructure and realign PRIs; and to enhance human capital and related funding and improve the research ecosystem and culture. Public spending on R&D continue to increase, with USD 428.6 million (MYR 600 million) allocated to five research universities in the 2013 budget for high-impact research in strategic fields such as nanotechnology, automotive technology, biotechnology and aerospace.

Hot issue 2: Improving overall human resources, skills and capacity building. While Malaysia spends a large share of GDP on higher education (Panel 1[s]), there is room for improvement in overall investment in human capital and in the workforce's industrial skill development. In addition, Malaysia needs to develop, attract and retain the highly skilled to further strengthen the human resource base. In 2013, the Ministry of Education (MOE) launched the Malaysia Education Blueprint (2013-25), which aspires to improve the Malaysian education system in terms of access, quality, equity, unity and efficiency. One of its major thrusts is to strengthen STEM throughout the education system. To enhance the supply of high-end STI personnel, the blueprint sets a target of producing 60 000 Malaysian PhDs by 2025. To this end, the government launched the MyBrain15 programme, which offers three types of scholarships: MyMaster, MyPhD and Industrial PhD. Wide-ranging measures to enhance the innovative skills of the workforce, intensify STI brain gain and brain circulation, improve the talent management system and develop a dynamic career for researchers are also being implemented.

Hot issue 3: Encouraging innovation in firms and supporting entrepreneurship and SMEs. While Malaysia has achieved robust economic growth in the past half-century, moving from a primary sector to a multi-sector economy with high-technology manufacturing and services, the country's STI capabilities need to be further developed. The government's 10th Malaysia Plan (2011-15), which aims to make Malaysia an innovation-led economy, promotes the private sector as the main driver of growth through increased private-sector investment and commitment to STI. Several measures to promote industrial innovation, including fiscal and financial incentives, support to consortia and clusters, public-private partnerships, and the promotion of science-industry linkages and knowledge transfer have been introduced. The government has allocated R&D funds, e.g. the TechnoFund, ScienceFund, InnoFund, Technology Acquisition Fund (TAF) and others, to various agencies and ministries.

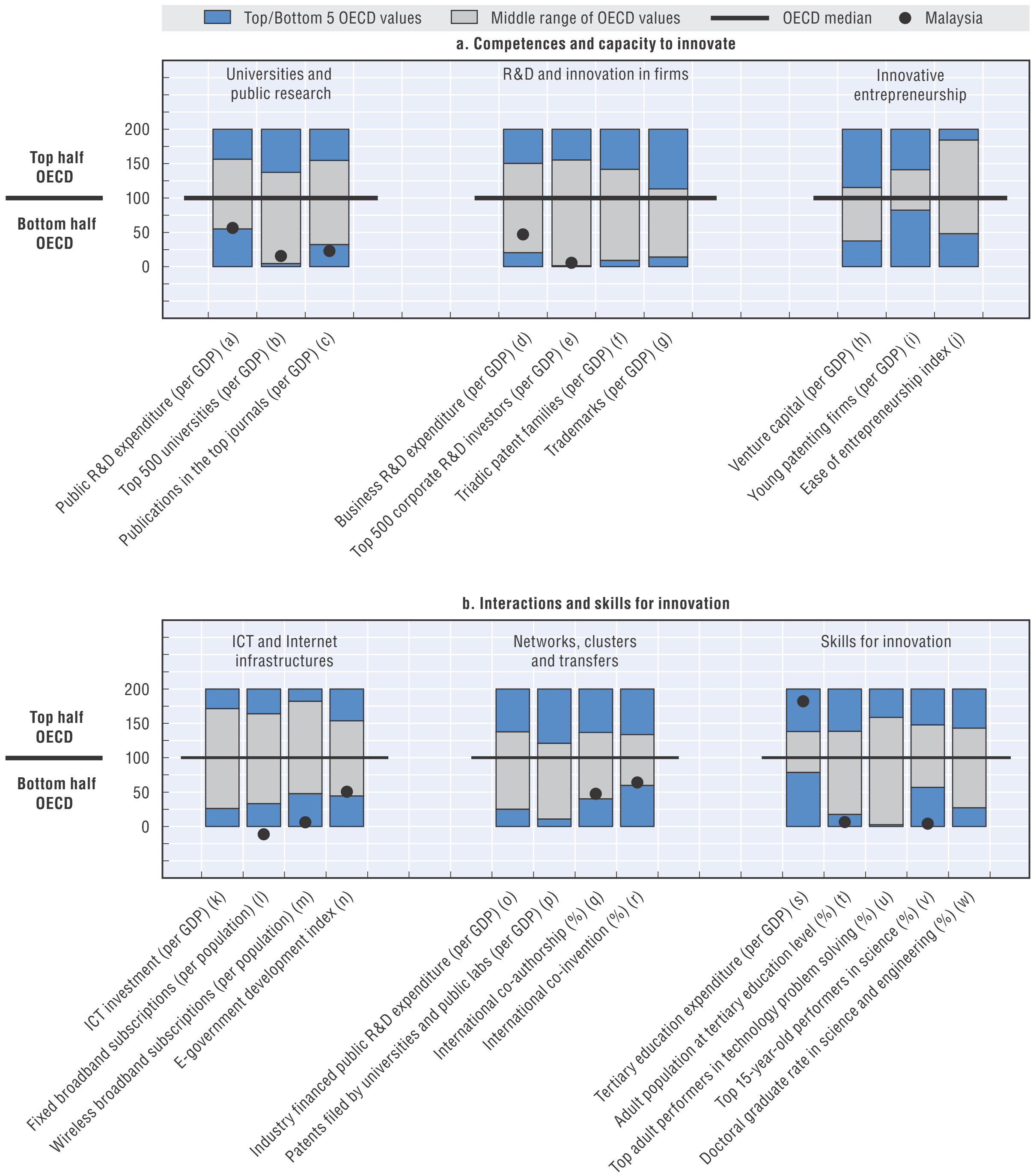
Hot issues 4: Improving the governance of the innovation system and policy. Malaysia has adopted a quadruple helix approach to improve interactions among government, academia, industry and society in order to implement the nation's STI policies, programmes and priorities more effectively. However, as many agencies continue to be engaged in STI policy making, funding and programming, a central body is needed to oversee and co-ordinate at the national level. One of the objectives of S2A is to strengthen public services and governance to ensure an ecosystem that will

Key figures, 2013

Economic and environmental performance	MYS	OECD	Gross domestic expenditure on R&D	MYS	OECD
Labour productivity			**GERD**		
GDP per hour worked, USD PPP, 2013	n.a.	47.7	Million USD PPP, 2011	4 953	1 107 398
(annual growth rate, 2008-13)	n.a.	(+0.8)	As a % of total OECD	n.a.	100
Green productivity			**GERD intensity and growth**		
GDP per unit of CO_2 emitted, USD, 2011	2.1	3.0	As a % of GDP, 2011	1.07	2.40
(annual growth rate, 2007-11)	(+0.4)	(+1.8)	(annual growth rate, 2008-11)	(+14.6)	(+2.0)
Green demand			**GERD publicly financed**		
NNI per unit of CO_2 emitted, USD, 2011	n.a.	3.0	As a % of GDP, 2011	0.47	0.77
(annual growth rate, 2007-11)	n.a.	(+1.6)	(annual growth rate, 2008-11)	(+28.7)	(+2.8)

Figure 9.30. **Science and innovation in Malaysia**

Panel 1. Comparative performance of national science and innovation systems, 2014



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

facilitate the development and uptake of S&T. The government recently established the National Science, Technology and Industry Council, which aims to rationalise the many science- and industry-based councils. Additionally, there are plans to establish a National Science and Research Board to co-ordinate the STI strategies of different agencies and align them with national strategies and priorities in addition to strengthening the management of STI programmes. Because the country's evaluation capabilities are weak, assessments of STI policies and programmes are not regularly undertaken.

Highlights of the Malaysian STI system

New challenges: The National Science and Research Council (NSRC) has established nine R&D priority areas: biodiversity, cybersecurity, energy security, environment and climate change, food security, medical and health care, plantation crops and commodities, transport and urbanisation, and water security. The Green Technology Financing Scheme (GTFS) was established in 2010 to accelerate the expansion of the green technology industry by improving access to bank credit financing. USD 2.5 billion (MYR 3.5 billion) in bank credit is available for use by 2015. Currently 127 projects are financed with a total of USD 1.26 billion (MYR 1.77 billion). In addition, several grassroots innovation schemes have been introduced in recent years to exploit the rich potential opportunities arising from the knowledge/practices of traditional communities. Under the NSTIP, an Innovation Inclusive Roadmap will be prepared to address the concerns of disadvantaged and low-income communities.

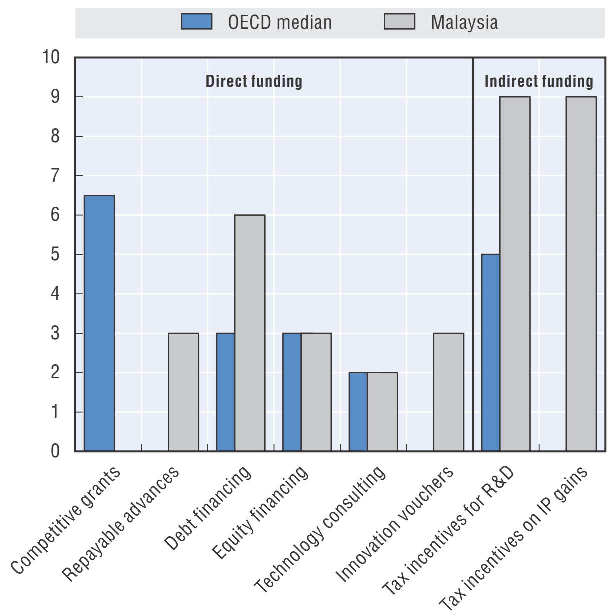
New sources of growth: The New Economic Model, unveiled in 2010, selected 12 national key economic areas (NKEAS), chosen on the basis of their potential to raise income and promote Malaysia's global competitiveness over the coming decade, such as: oil, gas and energy; palm oil and rubber; business services; electronic and electrical; education; and health care. Policy interventions are mainly implemented in the spirit of public-private partnerships, with public agencies mandated to provide eco-systems that are conducive to innovation and commercialisation, while business entities are expected to foster business and entrepreneurial agendas.

Innovative entrepreneurship: Industrial innovation has been limited and confined to the more dynamic export-oriented firms. Fewer than 10% of SMEs engage in R&D although they constitute almost 95% of manufacturing establishments. To help build a more entrepreneurial culture, courses on basic entrepreneurship skills have been made compulsory in all undergraduate programmes. Launched recently, the Malaysian Global Innovation and Creativity Centre (MaGIC) initiative with USD 35.7 million (MYR 50 million), helps domestic and international entrepreneurs to start and grow their businesses in Malaysia.

Technology transfer and commercialisation: Malaysia's R&D landscape includes PRIs and research-based universities. All public research universities are required to play a role in addressing societal welfare and/or commercialisation of research. The ScienceFund, InnoFund and TechnoFund, which are under the Ministry of Science, Technology and Innovation (MOSTI), promote the commercialisation potential of public-funded R&D outputs. Under the 10th Malaysia Plan, the MOE has launched the Knowledge Transfer Programme to facilitate the transfer of expertise and research findings through projects undertaken jointly by academia, industry and the community. To date, a total of 254 projects funded with some USD 25.7 million (MYR 36 million) have been launched with industry contributing about a quarter of the sum.

Globalisation: Chaired by the prime minister and formed by global industry leaders and renowned international experts, the Global Science and Innovation Advisory Council (GSIAC) is being set up as a sounding board for Malaysia's STI efforts. Key programmes initiated through this platform include the Malaysian Biomass Initiative, Smart Communities, and Human Capital Building. Existing programmes have been improved through the adoption of globally recognised best practices. International strategic collaborations were also forged, including the STEM Program (MOE and UKM), the Nobelist Mindset (PermataPintar™) and My Body is Fit and Fabulous (Ministry of Health). Malaysia has shared its STI development experience with developing countries and has contributed through financial and other support to international organisations such as the Commonwealth Partnership for Technology Management (CPTM), the Organization of Islamic Conference (OIC), and the International Science, Technology Innovation Centre for South-South Cooperation under the auspices of UNESCO (ISTIC), among others.

Panel 2. Most relevant instruments of public funding of business R&D, 2014



Note: Policy information comes from country responses to the OECD STI Outlook policy questionnaires 2014. Malaysia's response is available in the *OECD STI Outlook Policy Database*, edition 2014 at *http://qdd.oecd.org/Table.aspx?Query=F740E8F7-02C4-4A72-B953-9C5A65E8F709*.
Source: See reader's guide and methodological annex.

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MEXICO

Mexico, Latin America's second largest economy, has grown by 3.5% in real terms over the last four years. However, for long-term growth, productivity levels must rise and export markets be more diversified. To this end, the government's National Development Plan 2013-18 seeks to set the building blocks for a knowledge economy.

Hot issue 1: Improving the governance of the innovation system and policy. The new government, which took office in 2012, has introduced changes in governance. In April 2013, it created the Office of Co-ordination of Science, Technology and Innovation. Located in the office of the President, its role is to improve the co-ordination of STI policies and implement the National Development Plan. In 2013, Mexico's General Council for Scientific Research, Technological Development and Innovation recognised the Council for Science and Technology (CONACYT) as the principal body in charge of co-ordinating Mexico's STI system.

Hot issue 2: Improving the supply of high-end HRST and researchers. Public expenditure on higher education as a share of GDP is just below the OECD median (Panel 1[s]). However, a number of indicators highlight the need to improve the scale and quality of the education system (Panel 1[t, v, w]). CONACYT has therefore made improving the quality of HRST a priority. More resources have been mobilised for government-sponsored fellowships. Recognising the importance of high-quality graduate programmes, CONACYT joined in 1991 with the Secretary of Education to create the National Programme of Quality Graduate Programmes (PNPC). The programme seeks to improve the quality of the graduate programmes offered by HEIs and PRIs through a rigorous accreditation process based on international standards. The number of doctoral programmes participating in the PNPC increased from 427 in 2011 to 527 in 2013.

Hot issue 3: Innovation to address social challenges (including inclusiveness). In 2013 CONACYT launched a research grant scheme, Scientific Development Projects to Address National Problems, to deal with social challenges, such as climate change, sustainable development, health and food security. In the same year, it joined with the Ministry of Energy to create a sectoral fund, CONACYT-SENER, for sustainable energy. The fund supports STI solutions in the areas of energy efficiency, renewable energy, clean technologies and diversification of energy sources.

Hot issue 4: Industry-science linkages. Several policies to improve linkages include the Innovation Incentives Programme, which fosters science-industry linkages by offering higher co-funding participation rates for co-operative projects (see further the section on technology transfer and commercialisation).

Hot issue 5: Strengthening public R&D capacity and infrastructures. In 2013, two strategic initiatives were set up for implementation in 2014. One, *Cátedras* CONACYT (CONACYT Chairs), will create 574 new research positions in public universities and PRIs. The goal is to increase the share of young researchers in public research. The other is the National System of Researchers (SNI), which rewards excellence in research; it will be extended to researchers in private universities. The government also seeks to strengthen Mexico's scientific and technological infrastructure and has significantly increased funding from USD 37.2 million (MXP 285 million) in 2011 to USD 140 million (MXP 1 097 million) in 2013 in real terms.

Highlights of the Mexican STI system

Innovation in firms: As in other Latin American countries, Mexico's ratio of BERD to GDP is well below the OECD median (Panel 1[d]). CONACYT, which manages around 40% of the public STI budget, seeks to encourage business R&D and innovation. Its Innovation Incentives Programme has proved to be effective in stimulating business innovation, particularly in SMEs. The programme's overall budget increased from USD 223 million (MXP 1 663 million) in 2009 to an estimated USD 500 million (MXP 4 000 million) in 2014.

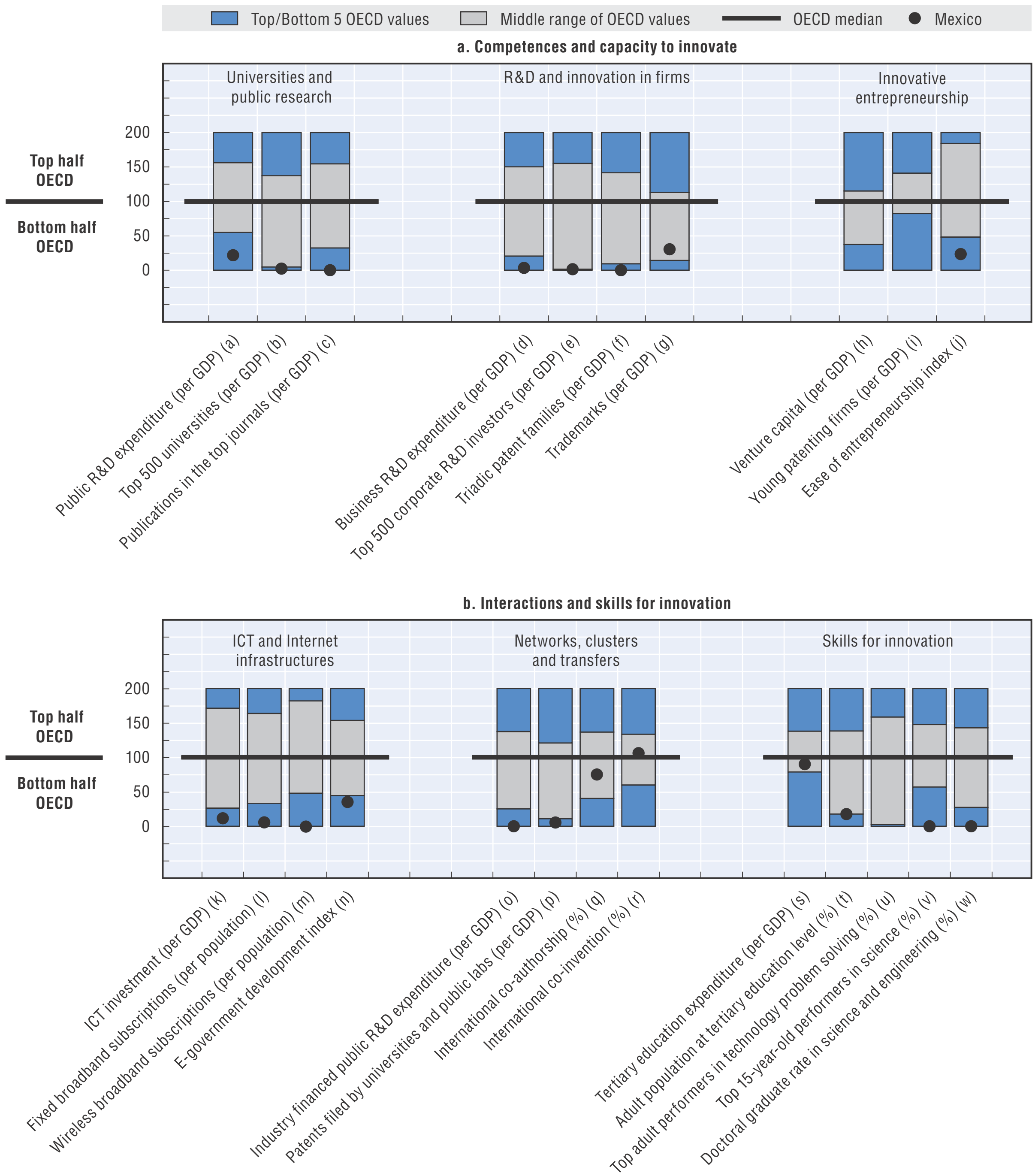
Technology transfer and commercialisation: CONACYT's Innovation Incentives Programme provides financial incentives for innovation, with an emphasis on co-operation between PRIs/HEIs and industry and on technology transfer. Its INNOVAPYME fund, which supports the innovation activities of micro firms and SMEs, provides 50% of total project expenditures if the firm collaborates with an HEI or PRI but only 35% in the absence of co-operation. Expendi-

Key figures, 2013

Economic and environmental performance	MEX	OECD	Gross domestic expenditure on R&D	MEX	OECD
Labour productivity			**GERD**		
GDP per hour worked, USD PPP, 2013	19.5	47.7	Million USD PPP, 2011	8 058	1 107 398
(annual growth rate, 2008-13)	(-0.3)	(+0.8)	As a % of total OECD, 2011	0.8	100
Green productivity			**GERD intensity and growth**		
GDP per unit of CO_2 emitted, USD, 2011	3.3	3.0	As a % of GDP, 2011	0.43	2.40
(annual growth rate, 2007-11)	(-0.7)	(+1.8)	(annual growth rate, 2007-11)	(+5.1)	(+2.0)
Green demand			**GERD publicly financed**		
NNI per unit of CO_2 emitted, USD, 2011	3.9	3.0	As a % of GDP, 2011	0.26	0.77
(annual growth rate, 2007-11)	(-0.4)	(+1.6)	(annual growth rate, 2007-11)	(+8.4)	(+2.8)

Figure 9.31. **Science and innovation in Mexico**

Panel 1. Comparative performance of national science and innovation systems, 2014



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

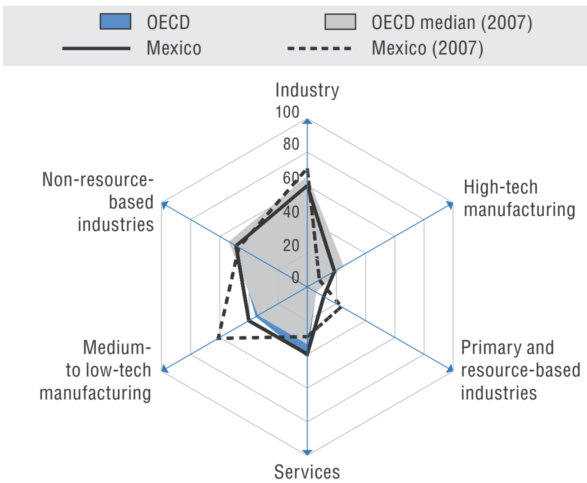
tures of collaborating HEIs or PRIs are financed at 90%. Its INNOVATEC fund, which supports large firms, provides 30% of total expenditures for joint projects in collaboration with HEIs or PRIs, but only 22% without collaboration. The collaborating HEIs or PRIs are financed at 70%. PROINNOVA funds product development based on frontier scientific research for up to 70% of the expenditures of firms and 90% of those of HEIs or PRIs. In order to foster technology transfer and the commercialisation of public research, the Ministry of Economy and CONACYT have provided support for the creation and improvement of knowledge transfer offices (KTOs). Legislative changes have made it possible for PRIs to establish the conditions for using the IP generated by their employees and to appropriate the economic benefits. The government also supports KTOs as enablers of science-industry relationships through consulting services and support for technology licensing and start-ups.

Clusters and smart specialisation: CONACYT has two main budget lines to support regional development through innovation: the Mixed Funds (FOMIX) and the Institutional Fund for the Regional Development of Science, Technology and Innovation (FORDECYT). The former, set up by the federal government as joint CONACYT-state funds, promotes applied research at state and municipal levels. The latter was created in 2009 to complement FOMIX by supporting STI projects in universities, research centres and companies to help integrate excluded regions in the national innovation system. Estimations indicate that the two funds amounted to USD 14 million (MXP 1 150 million) in 2013, an amount that is officially projected to rise by 30% in 2014. The operation of FOMIX has changed in order to differentiate public support. Formerly, CONACYT contributed one part of the funding and the state counterpart provided an equivalent amount. Under the new scheme, the ratio is 3 to 1 in some cases (states from the lowest tier), 2 to 1 in others (middle tier) and 1 to 1 in the best-performing states.

Globalisation: Mexico's international co-authorship and co-invention rates are close to OECD levels (Panel 1[q, r]), indicating a well-developed international network for STI collaboration, partly due to the educated Mexican diaspora. CONACYT's international scholarships programme for graduate studies helps promote international linkages among researchers, as do efforts aimed at improving the quality of its education system.

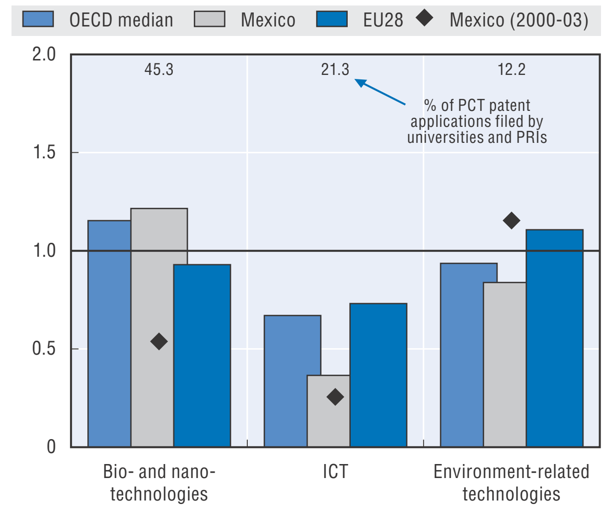
Panel 2. Structural composition of BERD, 2011

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

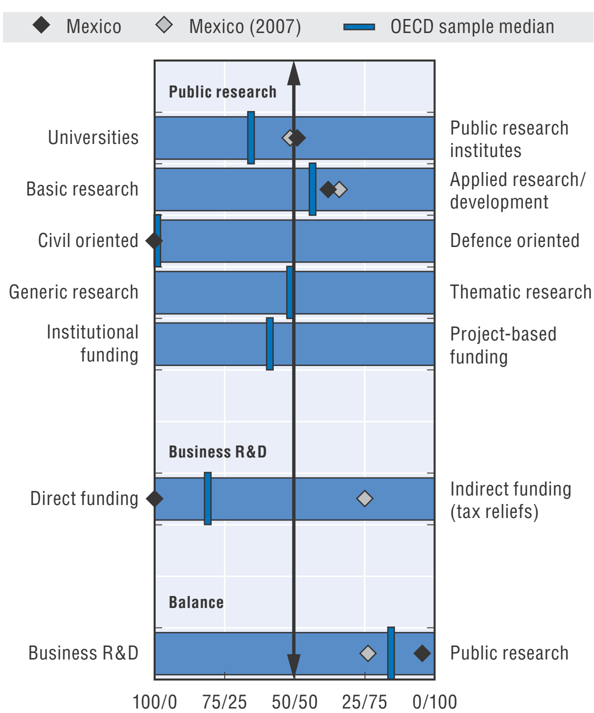


Panel 3. Revealed technology advantage in selected fields, 2009-11

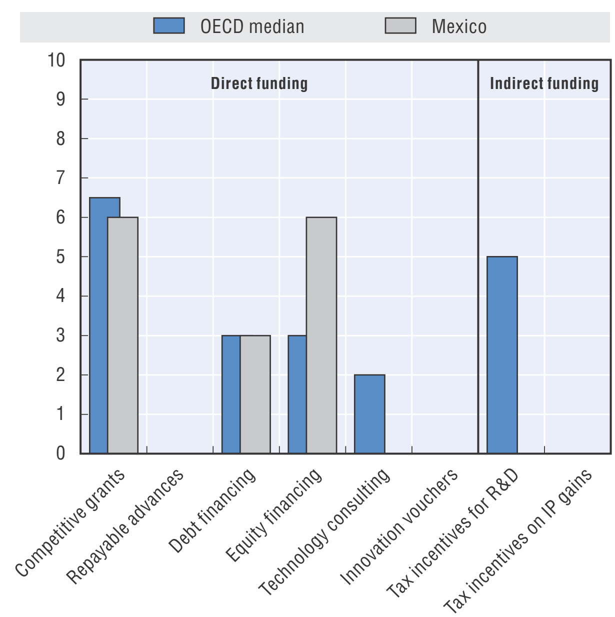
Index based on PCT patent applications



Panel 4. Allocation of public funds to R&D, by sector, type and mode of funding, 2012



Panel 5. Most relevant instruments of public funding of business R&D, 2014



Note: Policy information comes from country responses to the OECD STI Outlook policy questionnaires 2014 and 2012. Mexico's responses are available in the *OECD STI Outlook Policy Database*, edition 2014 at *http://qdd.oecd.org/Table.aspx?Query=BF209DC2-F4F4-41CE-8CB9-A4AA7ADE0ACA*.

Source: See reader's guide and methodological annex.

StatLink *http://dx.doi.org/10.1787/888933152310*

THE NETHERLANDS

The Netherlands is one of the world's most advanced economies, its long-term development underpinned by entrepreneurship and innovation. The economy has not fully recovered from the crisis, however. Dutch exporters have benefited less than others from an expansion into emerging markets. While levels of productivity are high, productivity growth has been rather weak. Strengthening investment in knowledge and innovation is a key to future growth and competitiveness and is necessary to address social challenges. The top sectors approach, a new form of industrial policy announced in 2011, focuses public resources on specific sectors and fosters co-ordination of activities in these areas by businesses, knowledge institutions and government.

Hot issue 1: Improving the framework conditions for innovation and competitiveness. The Netherlands scores high on indicators of overall framework conditions (Panel 1[j, n]) and skills for innovation (Panel 1[s, u, v]). Some indicators of private investment in R&D and innovation, however, are closer to the OECD median than to leading innovators (Panel 1[d, h, k]). The government has set targets to reduce administrative burdens and compliance costs for enterprises and improve transparency and provision of public services. It is concerned about sector-specific regulatory obstacles in the top sectors. The Netherlands Enterprise Agency (RVO), established in 2014 following a merger of agencies, offers help with EU and national grants, finding international business partners and know-how and facilitates compliance with laws and regulations.

Hot issue 2: Strengthening public R&D capacity and infrastructure. Public R&D expenditure has a high share of GDP (Panel 1[a]). Dutch universities are well placed in global rankings, and science has a strong global impact (Panel 1[b, c]). Universities and PRIs attract a high share of industry funding for their R&D (Panel 1[o]). While project-based funding has increased in importance, most public R&D funding is disbursed as institutional block funding (Panel 4), of which general university funds (GUF) represent approximately two-thirds. The government's vision for applied research foresees improved efficiency and effectiveness through greater national coherence and a tighter link between funding and quality and impact, particularly in the context of the top sectors.

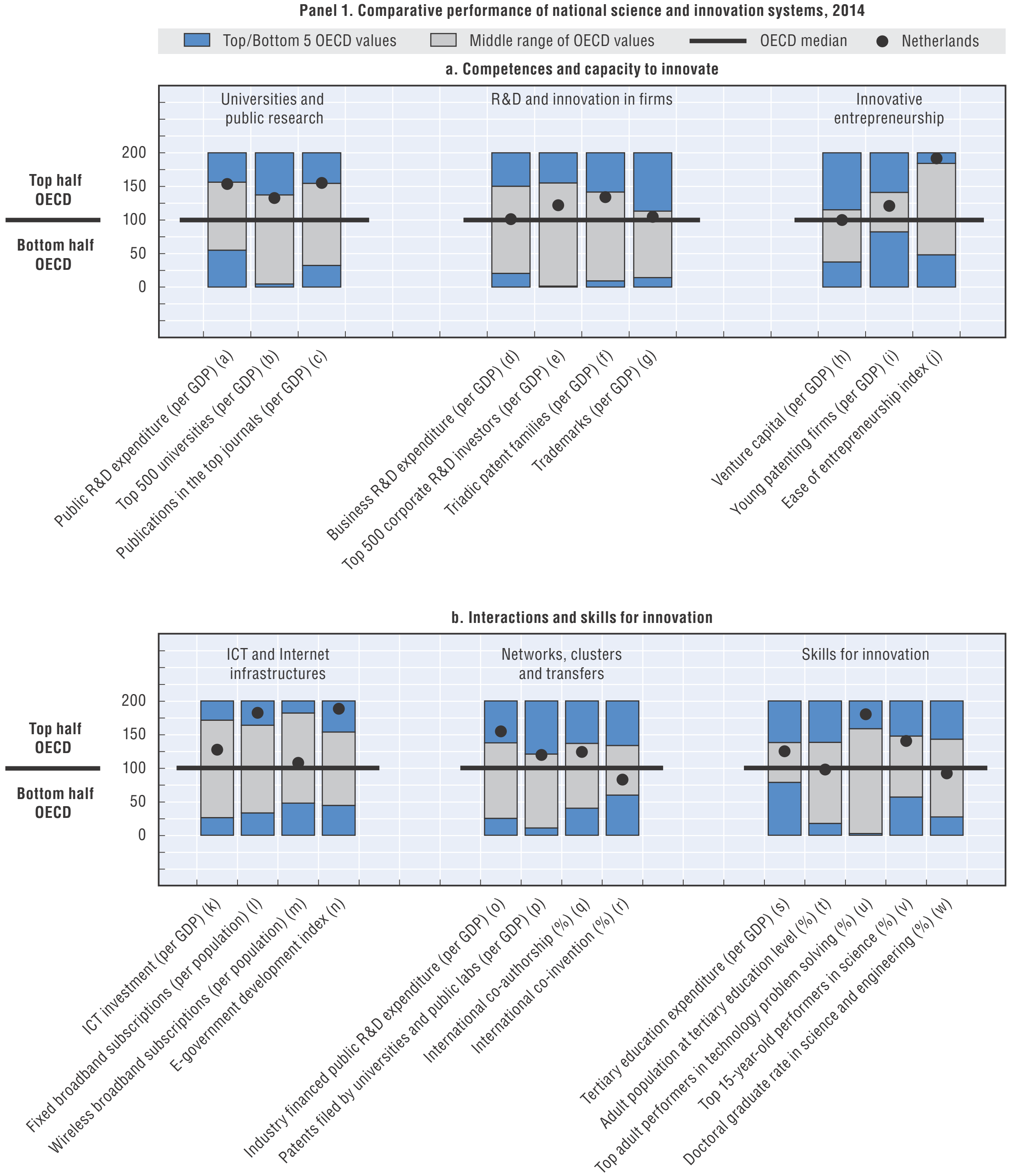
Hot issue 3: Encouraging innovation in firms and supporting entrepreneurship and SMEs. Business R&D expenditure is at the OECD median (Panel 1[d]), owing in part to structural features of the Dutch economy. Yet, the Netherlands performs above the OECD median in patenting (Panel 1[f]), owing in part to large corporate R&D spenders (Panel 1[e]). Support for business innovation is part of enterprise policy, with instruments for public-private partnerships in the top sectors and generic support for all businesses. Tax incentives are the primary means of financial support for business R&D (Panel 4). The largest innovation policy instrument is the R&D payroll tax allowance (WBSO), which is very beneficial for SMEs; it was complemented in 2012 by a tax allowance for investment in R&D. Together, they amounted in 2013 to over USD 1.2 billion (EUR 1 billion). Based on experience so far and to better reflect social challenges, efforts are made to simplify and harmonise top-sector instruments: the Top Consortia for Knowledge and Innovation (TKI) and the SME Innovation Support Top Sectors (MIT) scheme. The MIT scheme, introduced in 2013 with a budget of USD 24.1 million (EUR 20 million), promotes SMEs' participation in top-sector exploitation initiatives, through collaborative R&D projects, feasibility studies, innovation vouchers, hiring of experts, networking and coaching. The TKI allowance, with USD 100 million (EUR 83 million) in 2013, promotes public-private R&D consortia in top sectors. Efforts are under way to strengthen the representation of SMEs in the top sectors.

Hot issue 4: Targeting priority areas/sectors. Nine top sectors have been chosen for preferential support: agri&food, horticulture and propagating stock, high-technology systems and materials, energy, logistics, creative industry, life sciences, chemicals and water. Knowledge institutions, companies and the government co-operate to strengthen the competitiveness of top sectors and address social challenges. While research and innovation dominate top-sector programming, there is also concerted action concerning STEM-educated human resources. Dedicated funding for top-sector instruments is only some USD 128 million (EUR 106 million) a year, but considerable amounts of public research (of which about

Key figures, 2013

Economic and environmental performance	NLD	OECD	Gross domestic expenditure on R&D	NLD	OECD
Labour productivity			**GERD**		
GDP per hour worked, USD PPP, 2013	61.5	47.7	Million USD PPP, 2012	15 661	1 107 398
(annual growth rate, 2008-13)	(-0.2)	(+0.8)	As a % of total OECD, 2012	1.4	100
Green productivity			**GERD intensity and growth**		
GDP per unit of CO_2 emitted, USD, 2011	3.6	3.0	As a % of GDP, 2012	2.16	2.40
(annual growth rate, 2007-11)	(+1.4)	(+1.8)	(annual growth rate, 2007-12)	(+3.4)	(+2.0)
Green demand			**GERD publicly financed**		
NNI per unit of CO_2 emitted, USD, 2011	3.5	3.0	As a % of GDP, 2011	0.73	0.77
(annual growth rate, 2007-11)	(+0.7)	(+1.6)	(annual growth rate, 2007-11)	(+1.4)	(+2.8)

Figure 9.32. **Science and innovation in the Netherlands**



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

30% is privately financed) in universities and PRIs are being aligned with the approach, equal to about USD 1.2 billion (EUR 1 billion), excluding regional and EU funding.

Hot issue 5: Innovation to contribute to addressing societal challenges. The social challenges facing the Netherlands, including demographic change, energy supply and climate change, are an important factor in shaping top-sector agendas. Innovative responses to these challenges are strengthened by participation in the EU's Horizon 2020 programme, attention by the top sectors, and funding by the Netherlands Organisation for Scientific Research (NWO), which distributes a major share of competitive research funding to Dutch universities and other knowledge institutes.

Highlights of the Dutch STI system

Innovative entrepreneurship: The Netherlands ranks among the top countries on the OECD Ease of Entrepreneurship Index (Panel 1[j]). While early-stage entrepreneurial activity is strong, recent empirical OECD work finds barriers to subsequent growth. In recent years the scarcity of bank lending, combined with the limited role of venture capital in risk financing (Panel 1[h]), have been a limiting factor. In response, a number of policy instruments have special provisions for SMEs, including credit guarantees through the Qredits, MKB and GO facilities. The Seed Facility supports private equity firms investing in early stage start-up companies and the R&D credit goes to R&D projects.

Technology transfer and commercialisation: The government emphasises strengthening the commercialisation of public research (Valorisation Agenda of 2009). Dutch universities and knowledge institutes have strong links with the business sector, with a high share of industry funding for public research (Panel 1[o]). To foster commercialisation and technology transfer, the Valorisation Programme was introduced in 2011 with a budget of USD 76 million (EUR 63 million) to support 12 consortia over six years. Valorisation is now part of performance agreements with universities. Collaboration to exploit scientific research is a key objective of the top sectors.

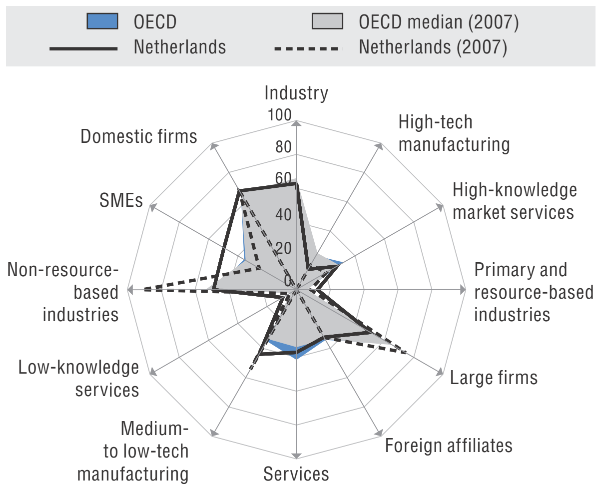
Clusters and smart specialisation: There is relatively little income inequality among Dutch regions owing in part to the poly-centricity of the Dutch economy. The aim of the Strong Regions initiative is to make the Randstad conurbation a leading sustainable, internationally competitive region, with an accessible and dynamic economy, high quality of life in an attractive living and working environment, and a climate-proof delta. To facilitate planning for the EU Structural Funds, Smart Specialisation Strategies have been drawn up for the North, East, West and South of the Netherlands, according to each region's comparative advantage.

Globalisation: The Netherlands is very open to international trade and investment. The science system, too, is highly internationalised, as reflected in international co-authorship (Panel 1[q]), although international co-invention is below the OECD median. Dutch participation in European Framework Programmes is above the European average. The Ministry of Education, Culture and Science and the Ministry of Economic Affairs have developed national strategies to promote the international dimension of STI policies and programmes.

Skills for innovation: The Dutch workforce is well educated and has strong innovation skills overall, and education is of high quality (Panel 1[u, v]), although adult tertiary education attainment and the rate of doctoral graduates in science and engineering could be improved (Panel 1[t, w]). Current policy efforts focus on maintaining quality in tertiary education and responding to emerging labour market needs. The top sectors' human capital agendas encourage co-ordination to identify and prepare for emerging skill needs. In 2013, the government launched the 2020 National Technology Pact, involving major stakeholders. Co-operation between HEIs, vocational secondary education and the business sector is a main aspect of the Pact, which aims to increase the number of technically trained people.

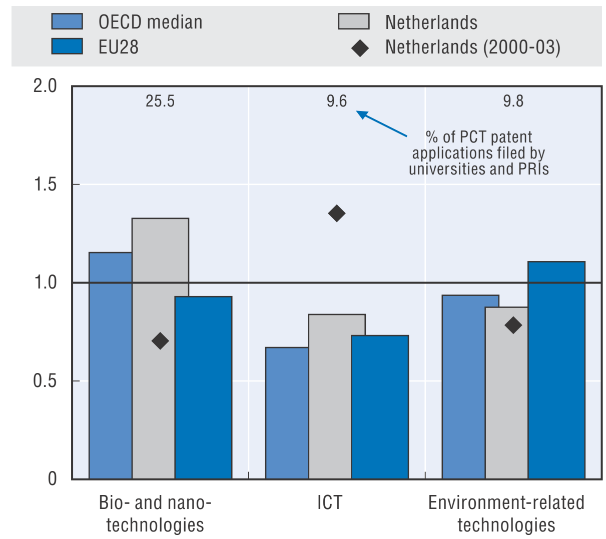
Panel 2. Structural composition of BERD, 2011

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

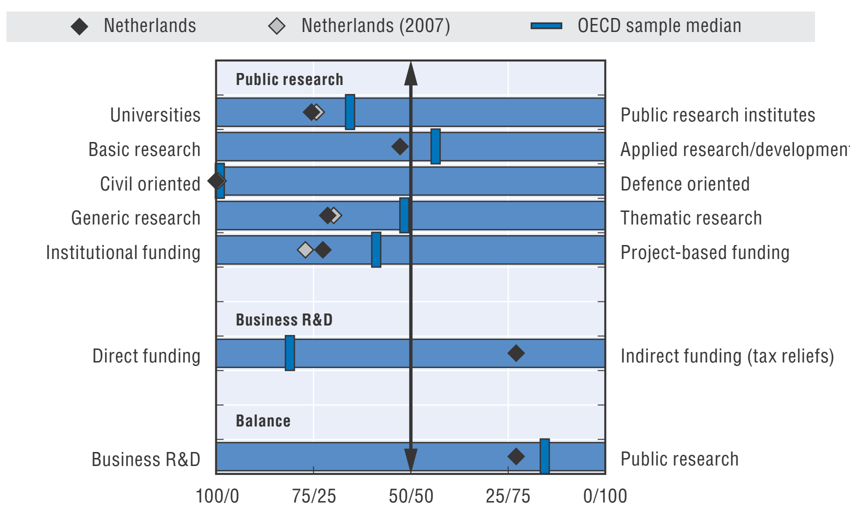


Panel 3. Revealed technology advantage in selected fields, 2009-11

Index based on PCT patent applications



Panel 4. Allocation of public funds to R&D, by sector, type and mode of funding, 2012



Note: Policy information comes from country responses to the OECD STI Outlook policy questionnaires 2014 and 2012. The Netherland's responses are available in the *OECD STI Outlook Policy Database*, edition 2014 at *http://qdd.oecd.org/Table.aspx?Query=C8D98511-C139-49BD-82AC-D6E6ADD45842*.
Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888933152321

NEW ZEALAND

New Zealand is an export-oriented economy that relies heavily on the primary sector. Its economy contracted sharply during the 2008-09 crisis when global demand collapsed, and substantial fiscal consolidation is under way to reduce public debt. After the 2010 Christchurch earthquake, investment in housing and public infrastructure boosted the recovery. The economy has subsequently grown strongly and is expected to continue to do so. Economic growth is a top priority, with science and innovation recognised as key drivers. This is reflected in a 60% increase in public investment in science and innovation since 2007-08. The government seeks a more diversified economy that combines growth in the primary sector with further investment in high-value manufacturing and services sectors. In spite of its small research system (GERD was only 1.27% of GDP in 2012), New Zealand has strengthened its technology advantage in bio- and nano-technologies, which is above both the OECD and the EU28 (Panel 3). The 2012 Business Growth Agenda focuses on export markets, innovation, infrastructure, skilled and safe workplaces, natural resources and capital markets.

Hot issue 1: Encouraging innovation in firms and supporting entrepreneurship and SMEs. Firms carry out very little R&D by OECD standards (Panel 1[d]). New Zealand faces special challenges for raising BERD (0.57% of GDP in 2011): an industrial structure that is not R&D-intensive, a business landscape characterised by a lack of large firms (SMEs performed 80% of BERD in 2009), a lack of large corporate R&D investors (Panel 1[e]), and difficult market prospects owing to New Zealand's small and scattered domestic markets and remote geographic location. The government is committed to creating the right business environment and incentives to encourage firms to double their R&D expenditure to above 1% of GDP. Callaghan Innovation, a new one-stop shop focused on supporting innovation, has USD 100 million (NZD 145 million) to support business R&D through three grants:

- R&D Growth Grants to increase R&D investment in businesses with a strong track record for R&D spending in New Zealand.
- R&D Project Grants to support greater investment in R&D in businesses with less established R&D programmes.
- R&D Student Grants to support undergraduate and postgraduate students to develop skills in a commercial research environment.

Hot issue 2: Strengthening public R&D capacity and infrastructures. New Zealand's public science system is based on universities and sectorally focused Crown Research Institutes (CRIs). In spite of relatively modest public expenditure on R&D (Panel 1[a]), the public research sector performs quite well, with five out of the world's top 500 universities and a strong ratio of scientific publications to GDP (Panel 1[b, c]). The National Science Challenges initiative, introduced in 2013, aims to strategically align and focus public research on large and complex issues by drawing scientists together across different institutions and disciplines. New investments have been made in large-scale research infrastructures, including advanced networks, genomics and high performance computing.

Hot issue 3: Improving returns to and impact of science. While industry and science maintain close ties through research contracts and co-operative R&D, commercialisation of public research results could be improved (Panel 1[o, p]). The government is committed to increasing the value New Zealand gains from its investments in public research, with commercialisation a major focus. The recently formed Ministry of Business, Innovation and Employment funds two tools to support commercialisation: the Pre-Seed Accelerator Fund (PSAF) which supports early-stage commercialisation activities and the Commercialisation Partner Network (CPN), which operates alongside the PSAF to turn science findings into commercially viable products. In addition, Callaghan Innovation aims to accelerate the commercialisation of innovation by firms in New Zealand.

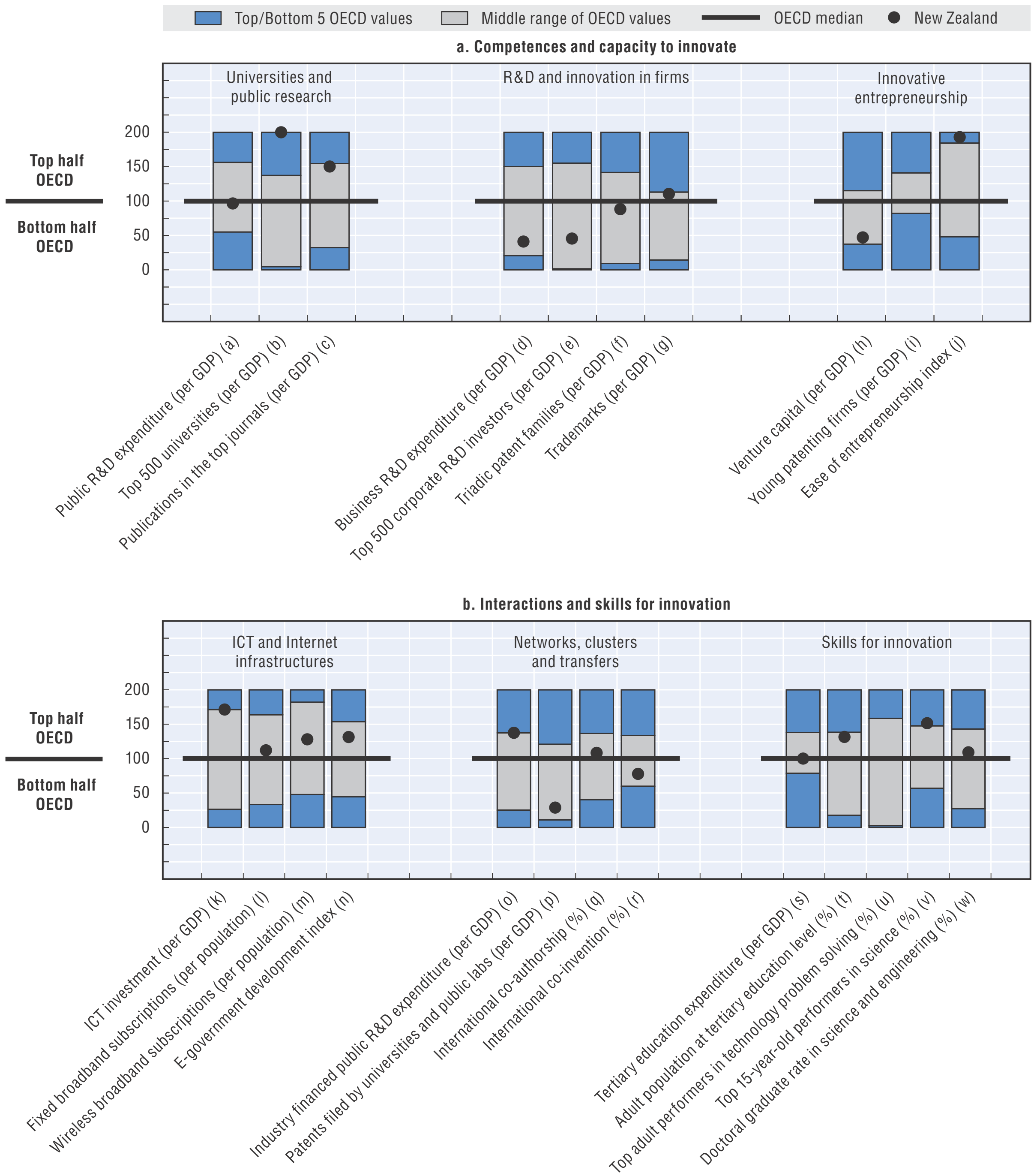
Hot issue 4: Reforming and improving the public research system (including university research). The government has recently made a number of significant investments in public science and research, including USD 91.4 million (NZD 133.5 million) over four years from 2013 for the National Science Challenges, and an additional USD 38.6 million (NZD 56.8 million) for contestable science funding for three years from 2015. The government recently released a draft National Statement of Science Investments (NSSI) for public consultation, which will help identify

Key figures, 2013

Economic and environmental performance	NZL	OECD	Gross domestic expenditure on R&D	NZL	OECD
Labour productivity			**GERD**		
GDP per hour worked, USD PPP, 2013	38.5	47.7	Million USD PPP, 2011	1 767	1 107 398
(annual growth rate, 2008-13)	(+1.2)	(+0.8)	As a % of total OECD, 2011	0.2	100
Green productivity			**GERD intensity and growth**		
GDP per unit of CO_2 emitted, USD, 2011	3.7	3.0	As a % of GDP, 2011	1.26	2.40
(annual growth rate, 2007-11)	(+3.5)	(+1.8)	(annual growth rate, 2007-11)	(+2.4)	(+2.0)
Green demand			**GERD publicly financed**		
NNI per unit of CO_2 emitted, USD, 2011	3.8	3.0	As a % of GDP, 2011	0.64	0.77
(annual growth rate, 2007-11)	(+3.8)	(+1.6)	(annual growth rate, 2007-11)	(+2.5)	(+2.8)

Figure 9.33. **Science and innovation in New Zealand**

Panel 1. Comparative performance of national science and innovation systems, 2014



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

future priorities to improve the value and effectiveness of the government's investment in science.

Hot issue 5: Improving framework conditions for innovation (including competitiveness). The Business Growth Agenda aims to improve the intellectual property (IP) regime in New Zealand and to increase the creation and use of IP. The 2013 Patents Act, which aligns national IP arrangements with international best practices, is the most extensive reform of IPR since 1953. The creation of a single patent-examination regime with Australia will help simplify patent applications as well.

Highlights of the New Zealand's STI system

STI policy governance: In 2013 the Ministry of Science and Innovation was merged into the newly formed Ministry of Business, Innovation and Employment. The Ministry of Science and Innovation advised the government on science and innovation and policy, oversaw its investment in science and innovation (including research infrastructure), and was responsible for supporting commercialisation and technology transfer. These core functions are now carried out by the MBIE's Science, Skills and Innovation Group. Callaghan Innovation was established in 2013 to accelerate the commercialisation of innovation by New Zealand firms. It provides several business innovation and support schemes within a single entity, and by providing a focal point for business R&D needs, helps to streamline STI policy delivery. Organisational changes have had an impact on STI policy evaluation, slowing the frequency of evaluations, increasing demand for impact-oriented evaluations and encouraging New Zealand to rebuild its evaluation system. More attention is being given to outcomes and a trend towards smaller and quicker evaluation exercises has been reinforced. Evaluation arrangements have been revised as well. New methods and data sources, e.g. public administrative data, are being introduced. Performance frameworks have been adapted to new funding mechanisms. Evaluation practices have been further institutionalised with the creation of an independent unit within the MBIE in charge of monitoring STI performance and STI evaluation.

Innovative entrepreneurship: New Zealand's administrative and regulatory framework is very favourable to entrepreneurship (Panel 1[j]). While it has a strong angel investment market, its venture capital industry is relatively weak (Panel 1[h]). The New Zealand Venture Investment Fund (NZVIF) was introduced in 2002 to help build a venture capital market. While the progress of NZVIF in catalysing venture capital markets has been promising, it was adversely affected in the mid-2000s by the global financial crisis. Recently, further efforts have been made to stimulate innovative entrepreneurship. The 2013 Technology Incubator Programme offers new repayable grants of up to USD 307 000 (NZD 450 000) to assist technology start-up companies and pre-incubation grants of up to USD 24 000 (NZD 35 000) to help prospective start-ups establish the commercial viability of their innovative ideas. Other activities include the Pre-Seed Accelerator Fund and Commercialisation Partner Network that support early-stage technology commercialisation activities.

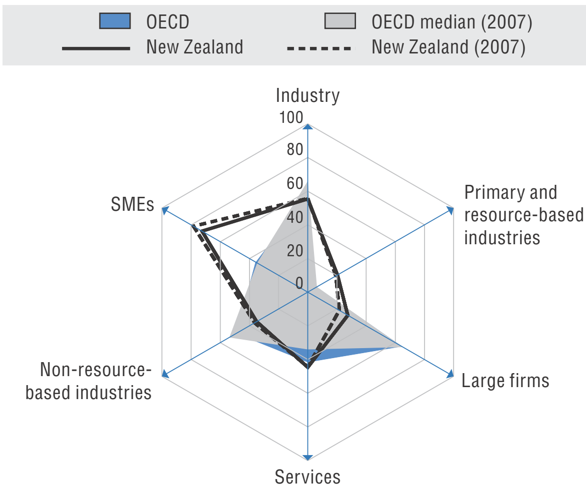
Clusters and smart specialisation: New Zealand's economy is continuing to broaden beyond its traditional base in primary industries. The government-industry Primary Growth Partnership, set up in 2012, drives the development of primary industries through market-driven science and innovation programmes along the value chain. The New Zealand Food Innovation Network supports the development of the food and beverage industry by providing S&T facilities and expertise. Other recent initiatives include the establishment of technology- and innovation-focused precincts in Auckland and Christchurch, and the Lincoln Hub, a specialist land-based innovation hub near Christchurch.

Globalisation: New Zealand is less integrated in global science and innovation networks than would be expected for a small, English-speaking country, as reflected in international co-authorship and co-patenting data (Panel 1[q, r]). The government is committed to building international linkages and strengthening international science and innovation relationships, with initiatives to identify and capitalise on mutually beneficial research and innovation opportunities with international partners.

Skills for innovation: New Zealand has a sound skills base, a large pool of university graduates, good student performance in science and a fair share of doctoral graduates in science and engineering (Panel 1[t, v, w]). The government's emphasis on increasing business R&D raises the issue of ensuring an appropriate innovation workforce. Science, engineering, and research-led learning has received USD 18 million (NZD 27 million) in funding and tuition subsidies have been raised. The Science and Society programme is a joint education-science plan to lift the profile of science, improve science literacy in society, and increase engagement in S&T, engineering and mathematics fields.

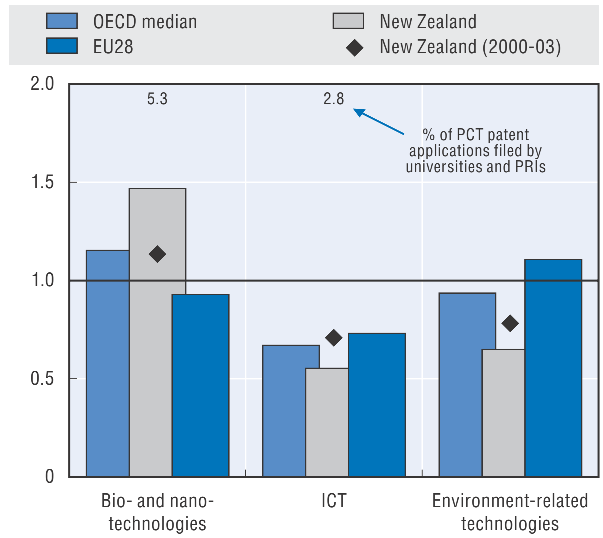
Panel 2. Structural composition of BERD, 2011

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

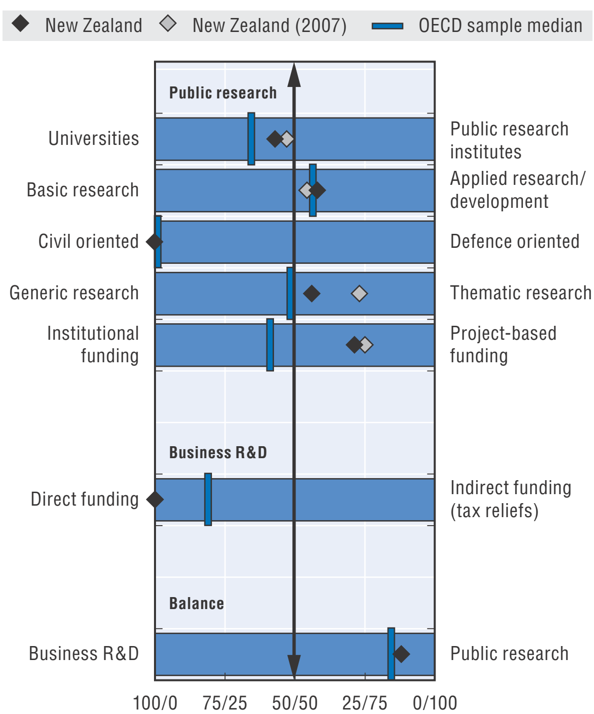


Panel 3. Revealed technology advantage in selected fields, 2009-11

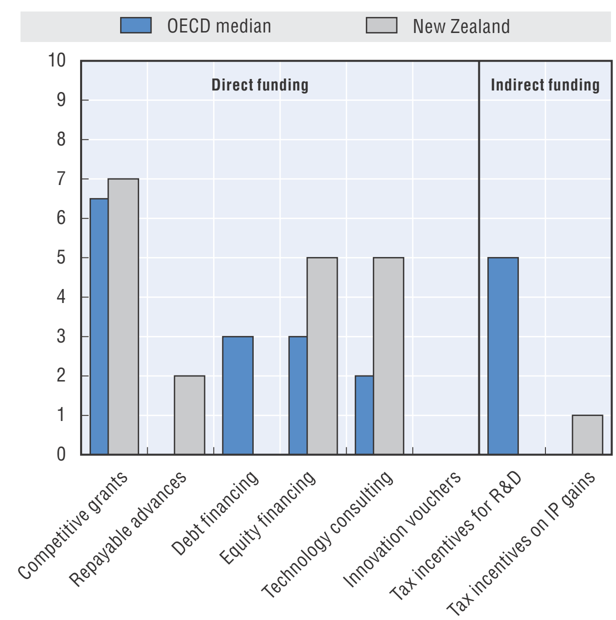
Index based on PCT patent applications



Panel 4. Allocation of public funds to R&D, by sector, type and mode of funding, 2012



Panel 5. Most relevant instruments of public funding of business R&D, 2014



Note: Policy information comes from country responses to the OECD STI Outlook policy questionnaires 2014 and 2012. New Zealand's responses are available in the *OECD STI Outlook Policy Database*, edition 2014 at *http://qdd.oecd.org/Table.aspx?Query=C8D98511-C139-49BD-82AC-D6E6ADD45842*.

Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888933152334

NORWAY

Norway has one of the world's highest incomes per capita, owing not only to its rich endowment and prudent management of natural resources but also to a high level of productivity. The new government that took office in October 2013 is preparing major new initiatives.

Hot issue 1: Improving the framework conditions for innovation (including competitiveness). To enhance industry competitiveness and diversify the Norwegian economy, the government aims to provide more favourable framework conditions for innovation. For example, it has taken steps to reduce the tax burden on businesses and personal incomes. In addition, the 2014 budget allocates more funds to existing instruments that support business R&D and innovation, such as the Open Innovation Arena (BIA), with an increase of USD 10 million (NOK 90 million) to USD 53 million (NOK 474 million), and the cluster programmes. In addition, an increase in project size and number of projects under the long-standing R&D tax credit scheme *Skattefunn* is expected following increases in allowable cost ceilings. This is expected to amount to an increase in tax expenditures of USD 28 million (NOK 250 million) to USD 204 million (NOK 1.8 billion). A productivity commission was appointed in 2014.

Hot issue 2: Improving overall human resources, skills and capacity building. Norway has a well-educated workforce, a relatively high share of the adult population with tertiary education, quite a high percentage of doctoral graduates in science and engineering, and the ratio of higher education expenditure to GDP is above the OECD median (Panel 1[t, w, s]). Norway aims to build a knowledge society by means of an ambitious education policy, increasing investment in R&D and building world-class research capabilities. The 2014 budget contains an allocation of USD 17 million (NOK 150 million) to improve higher education quality, and a new grant scheme of USD 3.7 million (NOK 33 million) for further education of teachers. In addition, total funding for vocational training has increased by USD 13 million (NOK 114 million) in 2014. A review of the institutional landscape of higher education is on-going. Its aim is to increase the quality of higher education and research.

Hot issue 3: Addressing challenges of STI globalisation and increasing international co-operation. Internationalisation remains an overall priority of the government's research and innovation policy. Norway is better integrated in the international network in scientific research than in innovation (Panel 1[q, r]). In May 2014, Norway joined the EU's Horizon 2020 programme with full membership as an associated country. A strategy that identifies clear objectives and priorities for research co-operation in the context of Horizon 2020 and the European Research Area was adopted in 2014. Since 2012, a dedicated STIM-EU Programme, with USD 6 million (NOK 55 million) in 2014, which supports the participation of Norwegian PRIs in the EU's 7th Framework Programme, has been part of a portfolio of measures to increase European research co-operation.

Hot issue 4: Improving the governance of the innovation system and policy. A White Paper, Long-Term Perspectives – Knowledge Provides Opportunity (2012-13), proposed a new approach to the formulation of national research policy to ensure clear priorities for long-term co-ordinated public investments in research and higher education. In response, the government is developing a ten-year plan for research and higher education, to be adopted in 2014 and updated every four years, that will set out strategic priorities and guidelines for public investment in STI and in research infrastructure, and for the expansion of education capacity over the long term.

Highlights of the Norwegian STI system

New challenges: Norway has a pronounced RTA in environment-related technologies that has decreased somewhat over the past decade (Panel 3). The Innovation Norway grant scheme for environmental technology (*Miljøteknologiordningen*) supports pilot and demonstration projects. Enova has started to make a strong effort on climate and energy technology.

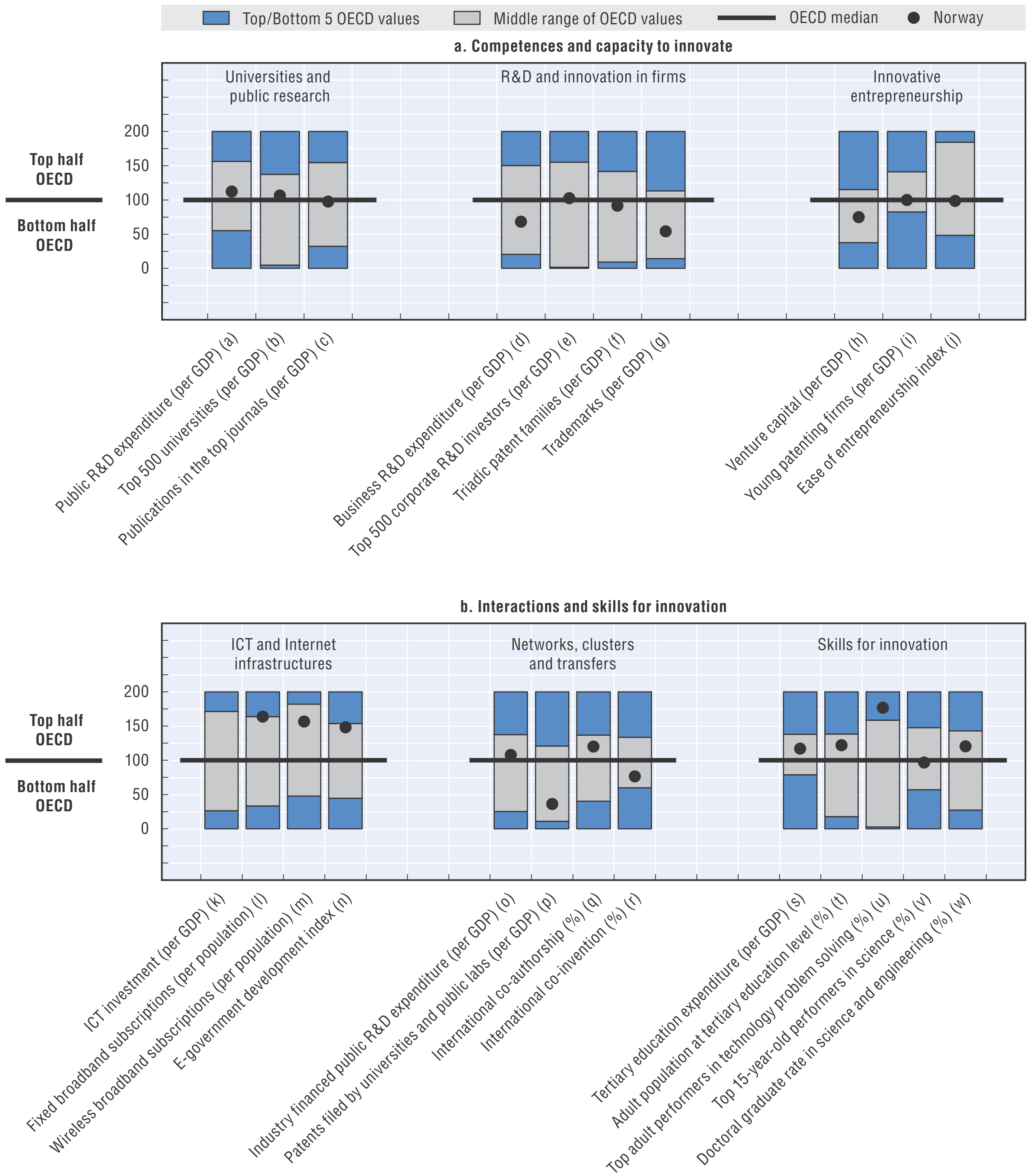
Universities and public research: With public R&D expenditure above the OECD median, Norway's public research performs reasonably well in terms of numbers of world class universities and academic publications, but less so in pat-

Key figures, 2013

Economic and environmental performance	NOR	OECD	Gross domestic expenditure on R&D	NOR	OECD
Labour productivity			**GERD**		
GDP per hour worked, USD PPP, 2013	89.0	47.7	Million USD PPP, 2012	5 482	1 107 398
(annual growth rate, 2008-13)	(+0.2)	(+0.8)	As a % of total OECD, 2012	0.5	100
Green productivity			**GERD intensity and growth**		
GDP per unit of CO_2 emitted, USD, 2011	6.3	3.0	As a % of GDP, 2012	1.65	2.40
(annual growth rate, 2007-11)	(+1.2)	(+1.8)	(annual growth rate, 2007-12)	(+2.0)	(+2.0)
Green demand			**GERD publicly financed**		
NNI per unit of CO_2 emitted, USD, 2011	6.9	3.0	As a % of GDP, 2011	0.78	0.77
(annual growth rate, 2007-11)	(-0.0)	(+1.6)	(annual growth rate, 2007-11)	(+2.5)	(+2.8)

Figure 9.34. **Science and innovation in Norway**

Panel 1. Comparative performance of national science and innovation systems, 2014



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

enting (Panel 1[a, b, c, p]). To increase the efficiency of public research, competitive funding has increased faster than institutional block funding during the last decade. Since 2013, the system for performance-based funding of PRIs has been simplified, with a streamlined set of indicators for measuring performance. As mentioned, the long-term national plan for research and higher education will set priorities and objectives to guide public investments in research and higher education for the next ten years.

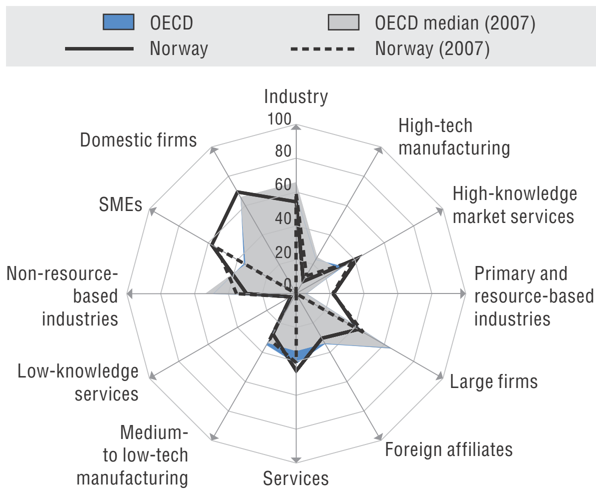
Innovation in firms: Norway's BERD is below the OECD median (Panel 1[d]), partly owing to structural features of the Norwegian economy. The Research Council of Norway (RCN) together with some specialised agencies provides government support for business R&D and innovation. Over 2011-13, public support for business R&D funded by industry-related ministries grew at the same rate as the overall government R&D budget. There are also some new programmes to support business innovation in specific technology areas (as mentioned above).

Innovative entrepreneurship: Norway's business environment for innovation, as indicated by the Ease of Entrepreneurship Index (Panel 1[j]) is around the OECD median, as is the performance of young patenting firms (Panel 1[i]). Established in 2012, the third generation of the Seed Fund Investment Programme for early-stage risk-capital investment is being phased in, to increase the supply of venture capital which is currently below the OECD median (Panel 1[h]). An SME strategy was presented in 2012, as part of a broader initiative to reduce costs for businesses by simplifying legislation and governmental services. The Action Plan for Entrepreneurship in Education (2009-14) aims to strengthen students' skills, perspectives, creativity and innovative thinking.

Technology transfer and commercialisation: The government intends to make the results of wholly or partially government-funded research publicly available for the benefit of both the research community and society. Since 2013, it has been taking measures to encourage and promote open access to results of publicly funded research, including promoting open-access publications with funding support. Open access costs, such as article processing charges, are to be covered by the RCN grants. An evaluation of the long-running technology transfer offices (TTO) programme started in 2014.

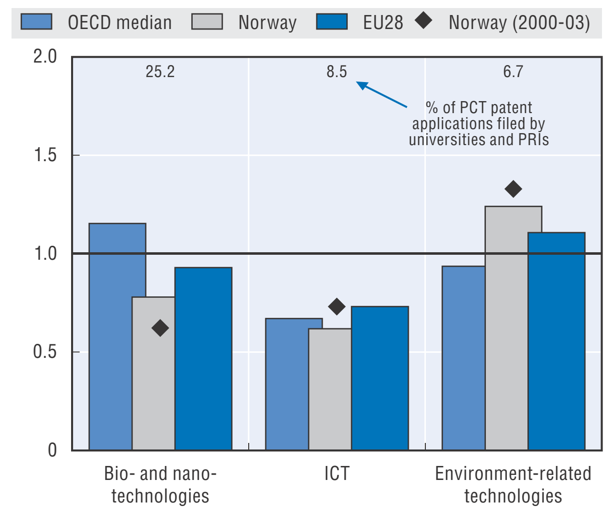
Panel 2. Structural composition of BERD, 2011

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

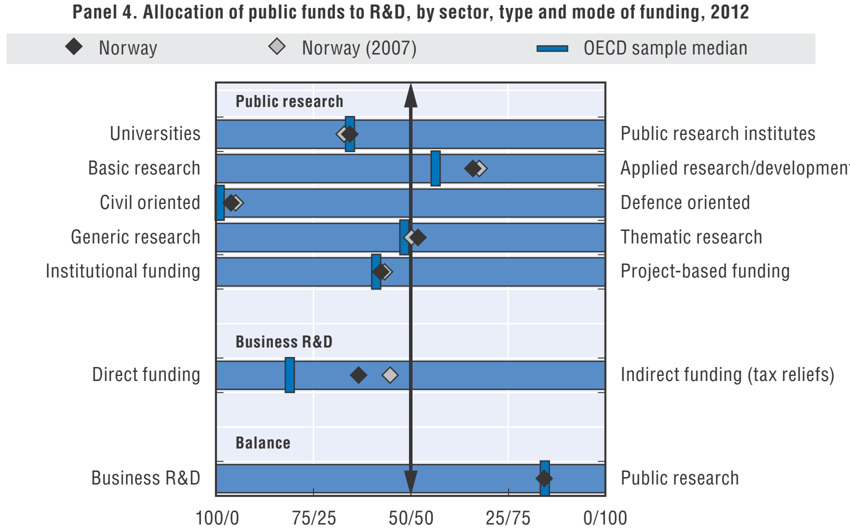


Panel 3. Revealed technology advantage in selected fields, 2009-11

Index based on PCT patent applications



Panel 4. Allocation of public funds to R&D, by sector, type and mode of funding, 2012



Note: Policy information comes from country responses to the OECD STI Outlook policy questionnaires 2014 and 2012. Norway's responses are available in the *OECD STI Outlook Policy Database*, edition 2014 at *http://qdd.oecd.org/Table.aspx?Query=C0DD3A8C-0B9B-4EB2-A56A-A252BA2D3B19*.

Source: See reader's guide and methodological annex.

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POLAND

Competitive supply helped the Polish economy outperform most EU countries during the recent economic crisis, but economic growth slowed in 2012-13. The Strategy for Innovation and Efficiency of the Economy – Dynamic Poland 2020 (2013-20), the Entrepreneurship Development Programme (EDP) and the National Research Programme (NRP) set the strategic direction for STI policy and implementation.

Hot issue 1: Innovating to contribute to structural adjustment and a new approach to growth. Although strong multi-factor productivity has boosted productivity and per capita income, Poland's labour productivity is still considerably below the OECD median. Only 60% of the working-age population are currently employed, compared to the OECD average of 65%. The 2014 OECD Economic Survey shows Poland's high potential to increase productivity by aligning product market regulations in network industries, retail distribution and professional services with the average of the three best-performing OECD countries. In addition to labour and product market reforms, Poland needs more investment in innovation to maintain growth. In line with the priorities of Horizon 2020, the NRP sets innovation for smart growth as one of the main objectives for the transition to the Polish knowledge- and innovation-based economy. Measures will therefore be taken to improve the legal and institutional environment for growth, to increase access to finance, and to promote intellectual capital investments and innovation and closer links between science and the economy.

Hot issue 2: Improving the design and implementation of STI policy. Poland has taken a new approach to innovation policy. It emphasises the importance of new forms of innovation, including new and innovative manufacturing technology, through new methods and greater interaction among innovation actors (e.g. open innovation, user-driven innovation). A holistic approach to policy design and implementation on related issues includes technological foresight, development of a low carbon economy, co-operation across regions and between businesses, government and other innovation stakeholders, and protection of industrial property rights.

Hot issue 3: Reforming and improving public research (including university research). In terms of public R&D expenditure and international publications (Panel 1[a, c]), Poland falls at the lower end of the mid-range of OECD countries. Industry-science relations are underdeveloped and university and PRI patenting is below the OECD median (Panel 1[o, p]). Major reforms to improve the efficiency and quality of PRIs and universities have been under way since 2010. Since 2012, additional resources are allocated on a competitive basis to promote high-quality research and teaching. PRIs and universities are encouraged to compete for the status of leading national research centre (KNOW), which gives access to additional funding for enhancing scientific and research potential, developing R&D personnel, creating attractive working conditions for research, building a strong and recognisable brand, and increasing researchers' remuneration and scholarships for PhD and undergraduate students. The centres are chosen in selected areas of knowledge through evaluations carried out by independent commissions with the participation of international experts. So far, after two rounds of competition, ten R&D units have received KNOW status.

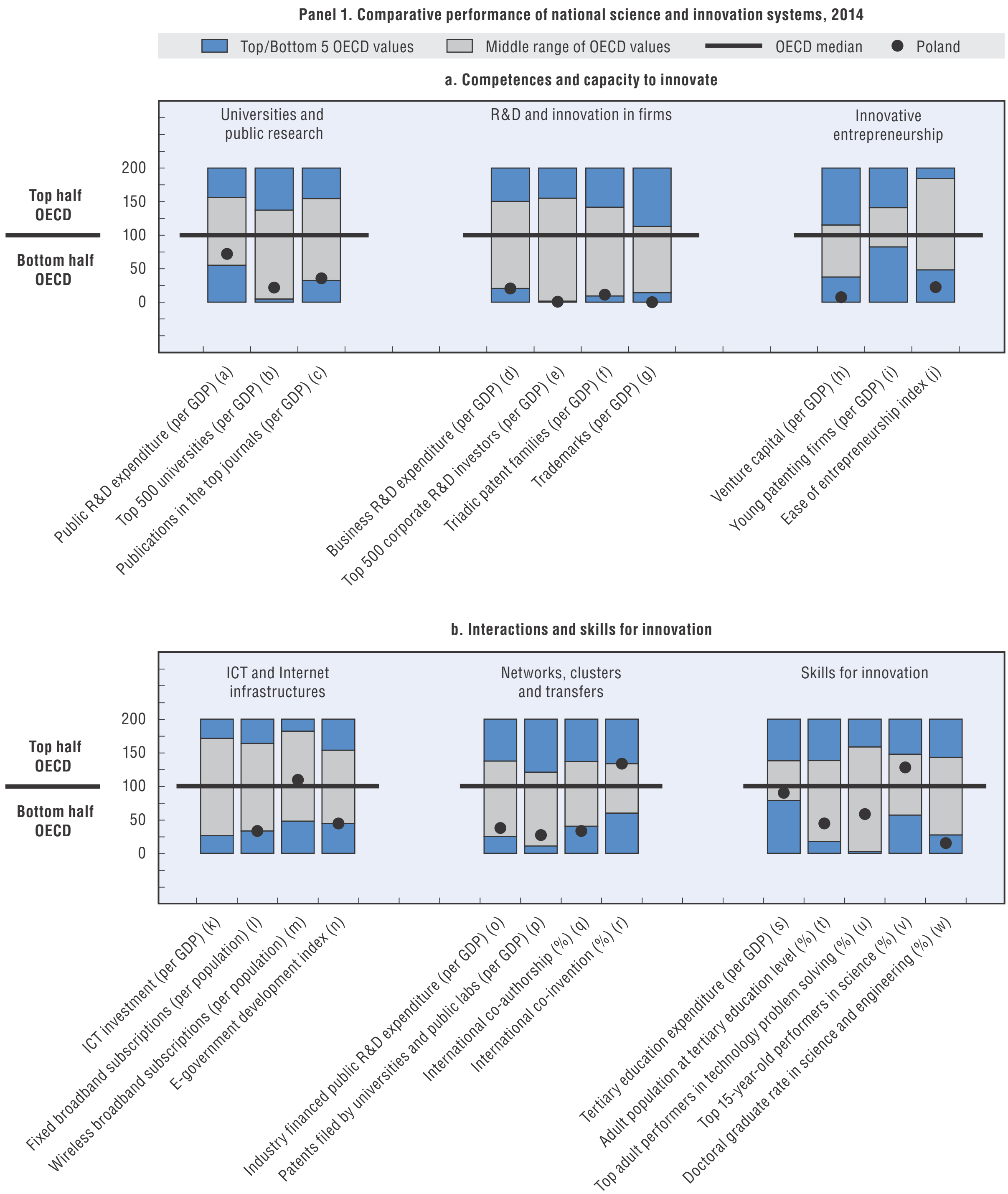
Hot issue 4: Strengthening public R&D capacity and infrastructures. To strengthen public research, Poland increased public R&D expenditure from 0.41% of GDP in 2008 to 0.56% in 2012. Furthermore, the NRP addressed the importance of improving and modernising R&D infrastructures and made several sources of funding available for this purpose. The Polish S&T Fund and the EU Structural Funds have increased financing for investments in research infrastructure. The KNOW also receive priority when they apply for funds to upgrade infrastructure. In August 2013 the EDP introduced the obligation to prepare a draft law on corporate income tax to support R&D.

Hot issue 5: Business innovation, entrepreneurship and SMEs. Polish enterprises, especially SMEs, show relatively little interest in R&D and innovation owing to the perceived technological and business risks and lack of recognition of the critical role of innovation for competitiveness. As a result, BERD was only 0.33% of GDP in 2012 (Panel 1[d]) and innovation output, as measured by the number of patents and

Key figures, 2013

Economic and environmental performance	POL	OECD	Gross domestic expenditure on R&D	POL	OECD
Labour productivity			**GERD**		
GDP per hour worked, USD PPP, 2013	28.7	47.7	Million USD PPP, 2012	7 899	1 107 398
(annual growth rate, 2008-13)	(+3.4)	(+0.8)	As a % of total OECD, 2012	0.7	100
Green productivity			**GERD intensity and growth**		
GDP per unit of CO_2 emitted, USD, 2011	2.3	3.0	As a % of GDP, 2012	0.90	2.40
(annual growth rate, 2007-11)	(+4.7)	(+1.8)	(annual growth rate, 2007-12)	(+13.4)	(+2.0)
Green demand			**GERD publicly financed**		
NNI per unit of CO_2 emitted, USD, 2011	2.4	3.0	As a % of GDP, 2012	0.49	0.77
(annual growth rate, 2007-11)	(+5.0)	(+1.6)	(annual growth rate, 2007-12)	(+11.5)	(+2.8)

Figure 9.35. **Science and innovation in Poland**



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

trademarks registered (panel 1[f, g]), is weak. To boost business innovation and to support entrepreneurship and SMEs, new instruments have been introduced and existing ones revised. The Development Projects (2012-15) under the Operational Programme Innovative Economy promote industrial research and development. In July 2013, the Loan Fund was launched to provide low-interest loans for private investments in innovative start-ups.

Highlights of the Polish STI system

New challenges: To address challenges such as health and environment, the government has introduced strategic R&D programmes such as: STRATEGMED (2013-18) for health and BIOSTRATEG (2014-19) for natural environment, agriculture and forestry. Polish industry relies heavily on coal as a source of energy, and the government supports research on renewables and the low emission economy through Blue Gas – Polish Shale Gas Programme (2012-17), and the GEKON programme (2013-16) on energy production technologies. The GREEN-EVO Programme also promotes Polish environmental technologies. New business-driven initiatives, such as the INNOLOT programme (2013-18) are supported by the government.

Technology transfer and commercialisation: To improve the commercialisation of research results, participants in the Development Projects (2012-15) initiative must sign the consortium agreement between research organisations and enterprises. The BRIdge VC (2013-17) programme supports commercialisation of public R&D results. Since 2013, the pilot Innovation Voucher projects support experienced entrepreneurs who collaborate with the research sector. OCEAN, a new research data centre, is funded by the National Centre for Research and Development (NCBiR). To be operational by the fourth quarter 2015, it will provide the e-infrastructure for storage of open data and facilities and expertise for big data analysis. A budget of about USD 36 million (EUR 20 million) has been allocated for 2014-15.

Clusters and smart specialisation: Poland has developed national and regional smart specialisation strategies through consultation with stakeholders and an entrepreneurial discovery process. The results of foresight exercises have also been used in these processes. While the government adopted the National Smart Specialisation document on 8 April 2014, areas of specialisations are still being identified in co-operation with stakeholders' working groups and with the Observatory of Economy. Entrepreneurial discovery is supported by the World Bank in order to improve the engagement of entrepreneurs in the formation of innovation policy and the identification of emerging specialisations.

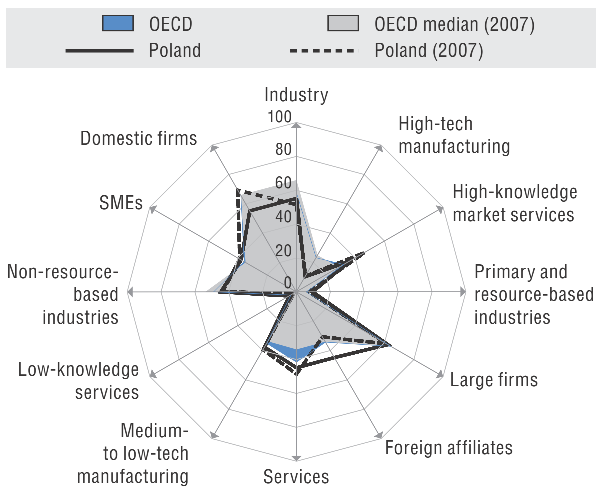
Globalisation: Polish innovators are well integrated in international innovation networks (Panel 1[r]), unlike their academia counterparts (Panel 1[q]). The MOBILITY PLUS initiative supports academic researchers who work abroad for periods of 6 to 36 months. 57 researchers benefited from the initiative in 2013. Greater openness to FDI on the business side would also increase knowledge spillovers.

Skills for innovation: Expenditure on higher education as a share of GDP is just below the OECD median (Panel 1[s]) and Polish 15-year-olds perform above the OECD median in science (Panel 1[v]). However, adults with tertiary qualifications, adults' technical problem-solving skills, and the share of PhD graduates in science and engineering are all far below the OECD median (Panel 1[t, u, w]). Programmes supporting skills development include the TOP 500 Innovators (2013-15) and the LIDER programme (2009-17), and entrepreneurship education has been made compulsory in Polish universities.

Recent developments in STI expenditures: In 2012, Poland's GERD stood at 0.9% of GDP, having grown by a robust 13.4% a year over 2007-12. The government seek to reach GERD of 1.7% of GDP by 2020. In 2012, industry funded a comparatively low 32.3% of GERD, up from 24.4% in 2010, and the government a high 51.3%, down from 60.9% in 2010. The share of GERD financed from abroad reached 13.3%, up from 5.4% in 2008, during the economic crisis.

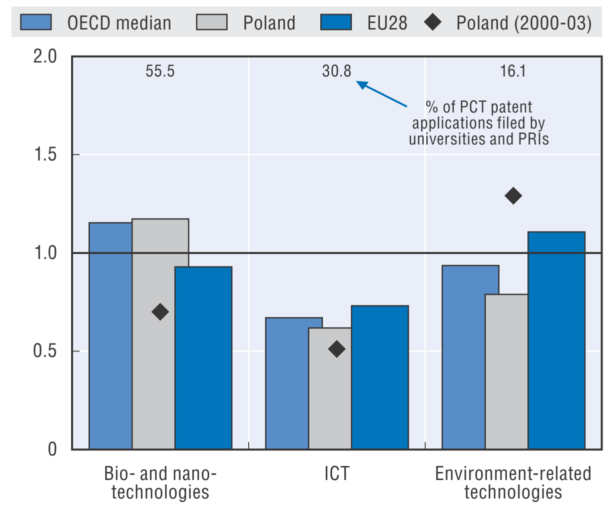
Panel 2. Structural composition of BERD, 2011

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

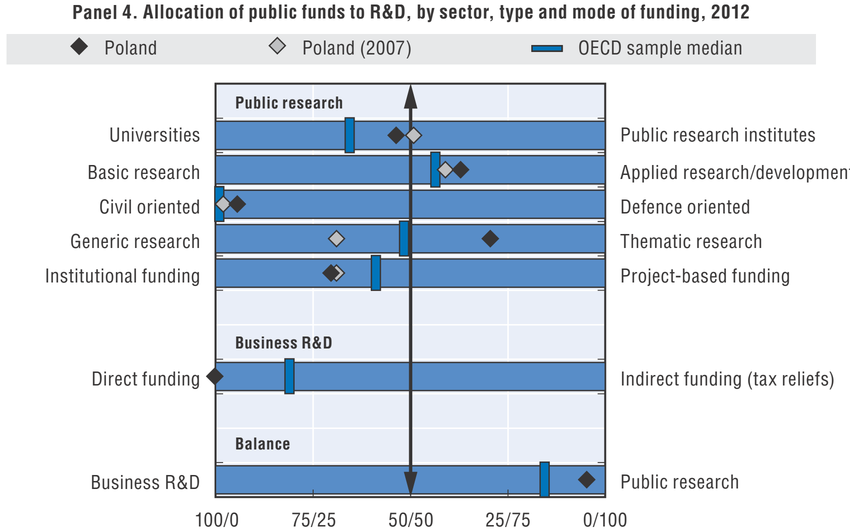


Panel 3. Revealed technology advantage in selected fields, 2009-11

Index based on PCT patent applications



Panel 4. Allocation of public funds to R&D, by sector, type and mode of funding, 2012



Note: Policy information comes from country responses to the OECD STI Outlook policy questionnaires 2014 and 2012 as well as the OECD Economic Survey of Poland 2014. Poland's responses are available in the *OECD STI Outlook Policy Database*, edition 2014 at *http://qdd.oecd.org/Table.aspx?Query=498B27DF-83F5-40D3-9E4E-B6CA4EEC64D6*.

Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888933152355

PORTUGAL

The Portuguese economy contracted in 2011-13 in the wake of the global financial crisis. However, GDP is forecast to grow in real terms in 2014. The government has taken significant action to restore the sustainability of public finances and restart growth. On-going reforms aim to improve product and labour market regulation, upgrade education and skills, and enhance innovation.

Hot issue 1: Reforming the public research system (including university research). Portugal's public R&D expenditure as a share of GDP is at the OECD median, but its shares of top 500 universities, and scientific publications over GDP exceed it (Panel 1[a, b, c]). Reform of the public research system has been an STI policy priority for a long time. The 2007-13 National Strategic Plan for Research and Innovation (NSPRI) emphasised co-operative innovation projects, fellowships and research contracts. Except in 2011, the public R&D budget increased steadily during the decade to 2013. Policy emphasis has recently shifted from expansion to excellence and effectiveness, and initiatives to support career development (e.g. the Investigator Programme and the PhD programmes) and build research infrastructures have been introduced. Academic PRIs will be evaluated to identify their research capabilities of strategic interest.

Hot issue 2: Commercialisation of public research results. Exploitation of public research results is a major bottleneck, as Portugal lacks a tradition of linking scientific research with innovation. Industry-financed public R&D is among the lowest among OECD countries (Panel 1[o]). In 2012, the University Technology Enterprise Network (UTEN), created in 2007, supported commercialisation of public research with a budget of USD 2.7 million (EUR 1.6 million). The national S&T funding agency, *Fundação para a Ciência e a Tecnologia* (FCT), through the Portuguese Technology Transfer Initiative of 2012, promotes knowledge diffusion from large European agencies (e.g. CERN, ESO, ESA) to Portuguese firms, with a focus on the space industry.

Hot issue 3: Encouraging innovation in firms and supporting entrepreneurship and SMEs. Portugal's business R&D expenditure and innovation output performance are below the OECD median (Panel 1[d, e, f, g]), owing to its specialisation in low- and medium-low-technology industries and to the small share of investment in R&D by large companies compared with other European countries. The government has three major initiatives to stimulate business R&D and support business innovation. SI I&DT, an R&D incentive, seeks to intensify BERD, increase firm competitiveness and foster co-operation among STI actors. *SI Inovação* targets the development of new goods, services and processes in export-oriented firms in strategic sectors. *SI Qualificação PME* aims to increase the competitiveness of SMEs through financing to enhance their productivity, flexibility and responsiveness to the global market. In 2013, the first two initiatives sponsored 847 projects with a budget of USD 1 258 million (EUR 755 million). However, BERD increased only from 0.6% to 0.7% of GDP between 2007 and 2012.

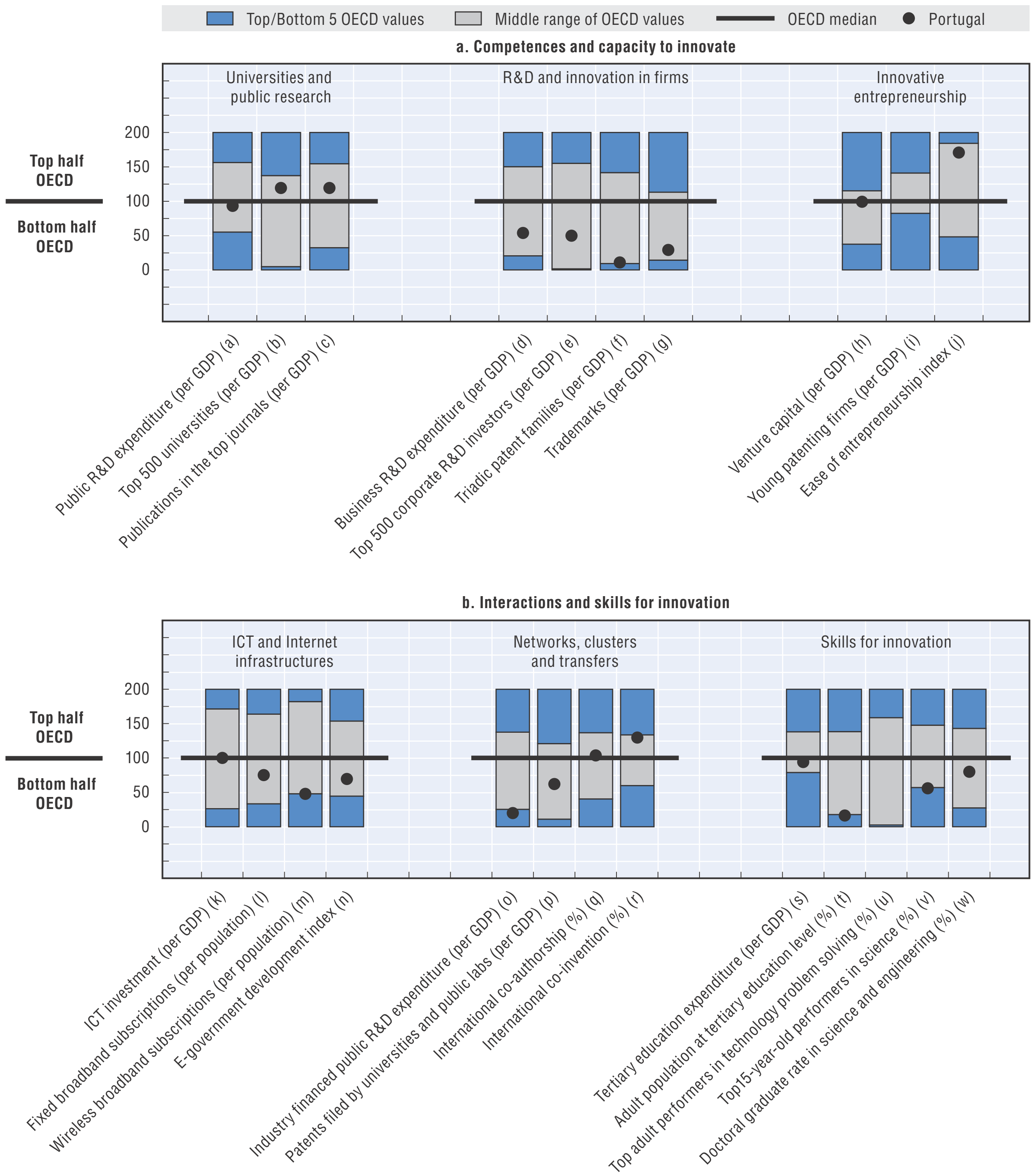
Hot issue 4: Improving overall human resources, skills and capacity building. Expenditures on tertiary education are at the OECD median, but the share of tertiary-educated adults is well below (Panel 1[s, t]). The government has taken steps to reorganise vocational and education training (VET) and is considering the creation of professional schools to match the skills supply better to industry needs. To improve the supply of high-level STI workforce, the FCT allocated an average of USD 251.7 million (EUR 151 million) a year during 2011-13 to fund PhD studies and postdoctoral training for an average of approximately 11 000 fellowships a year. The FCT is redesigning its support for human resources by reducing the emphasis on individual PhD fellowships and moving towards supporting PhD programmes as a whole and integrating training support into research and institutional grants. The FCT's Investigator Programme of 2012 supports the recruitment of talented scientific researchers to work in Portuguese research centres under five-year contracts. In 2012, 159 national and non-resident researchers were selected for funding and a further 209 were selected in 2013 through an international peer-review process. It has a goal of 1 000 researchers by 2016.

Key figures, 2013

Economic and environmental performance	PRT	OECD	Gross domestic expenditure on R&D	PRT	OECD
Labour productivity			**GERD**		
GDP per hour worked, USD PPP, 2013	31.4	47.7	Million USD PPP, 2012	4 081	1 107 398
(annual growth rate, 2008-13)	(+1.2)	(+0.8)	As a % of total OECD, 2012	0.4	100
Green productivity			**GERD intensity and growth**		
GDP per unit of CO_2 emitted, USD, 2011	4.8	3.0	As a % of GDP, 2012	1.50	2.40
(annual growth rate, 2007-11)	(+3.5)	(+1.8)	(annual growth rate, 2007-12)	(+3.9)	(+2.0)
Green demand			**GERD publicly financed**		
NNI per unit of CO_2 emitted, USD, 2011	4.5	3.0	As a % of GDP, 2011	0.73	0.77
(annual growth rate, 2007-11)	(+2.7)	(+1.6)	(annual growth rate, 2007-11)	(+7.9)	(+2.8)

Figure 9.36. **Science and innovation in Portugal**

Panel 1. Comparative performance of national science and innovation systems, 2014



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

Highlights of the Portuguese STI system

STI policy governance: Policy co-ordination was only institutionalised in 2011 with the creation of two high-level advisory councils for research and innovation, the National Council for Science and Technology (CNCT) and the National Council on Entrepreneurship and Innovation (CNEI), both chaired by the prime minister. The government is currently preparing a National Strategy for Research and Innovation (NSPRI) for 2014-20. It will introduce multi-level governance mechanisms at national and regional levels and co-ordinate research and innovation efforts around strategic areas/sectors and different innovation actors with a view to better translating research results into innovative goods, services and processes. A working group created in 2013 will co-ordinate the preparation of the new plan by the Ministry of Economy and the Ministry of Education and Science in collaboration with sectoral ministries and regional agencies.

New challenges: The National Strategy for Research and Innovation (2014-20) addresses social challenges such as ageing and climate change. The Exploratory Projects (2013-15) support blue-sky research in emerging fields with a budget of USD 12.4 million (EUR 8.5 million). They favour multidisciplinarity, industry involvement, co-funding and the participation of young researchers.

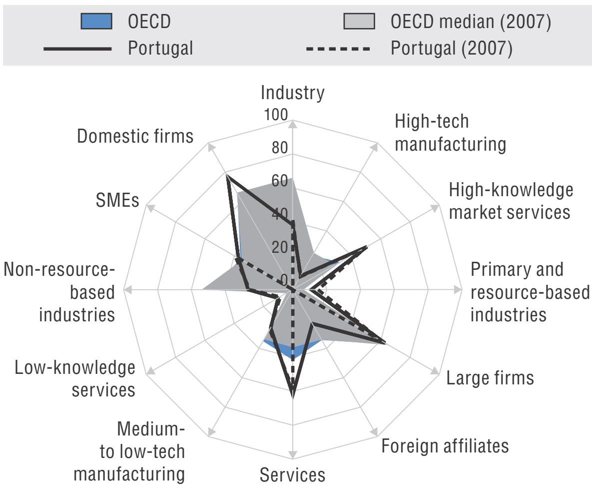
Innovative entrepreneurship: Portugal's business environment is very conducive to entrepreneurship, although provision of venture capital is at the median of OECD countries (Panel 1[j, h]). Various initiatives support business innovation, entrepreneurship and SMEs. The Financial Support to Company Growth (FINCRESCE) programme aims to improve financing conditions for firms with good innovative capabilities and risk profiles. The Strategic Initiative for Entrepreneurship and Innovation, approved in 2011, focuses on strengthening knowledge and capacities, reinforcing innovation and entrepreneurship, and promoting innovation financing. SIFIDE provides fixed and incremental tax credits for R&D and supports the hiring of doctoral-level graduates in companies. In 2013, the government launched INOVA, Creative Youngsters: Entrepreneurs for the 21st century programme to develop an environment that favours innovation and creativity in primary and secondary schools. The programme seeks to foster youngsters' analytical capabilities and the mind-sets needed to identify business opportunities, take risks and face competition.

ICT and Internet infrastructures: While Portugal's ICT investment as a share of GDP is at the OECD median (Panel 1[k]), levels of public and private use of ICT infrastructures lag behind (Panel 1[l, m]). During 2013-15, the above-mentioned Early Bird initiative gives priority to research in ICT and applications.

Globalisation: Portugal performs well on international co-patenting but less so on international co-authorship of S&T publications (Panel 1[r, q]). Measures are being designed to overcome barriers to better international co-operation, such as weak participation of SMEs and large companies in European initiatives and a lack of co-ordination among national actors to act jointly at the European and international level.

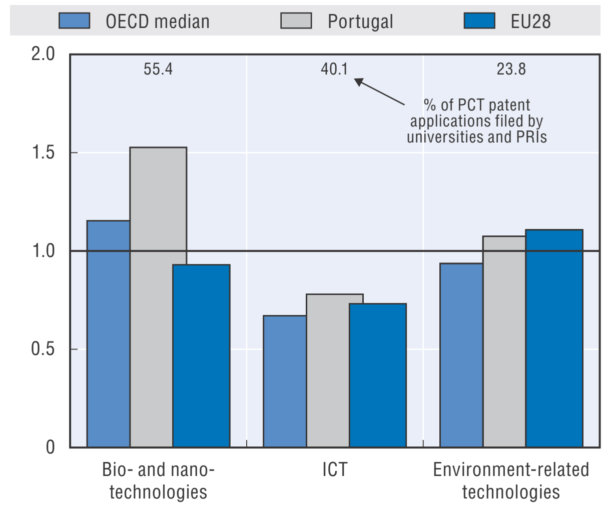
Panel 2. Structural composition of BERD, 2011

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

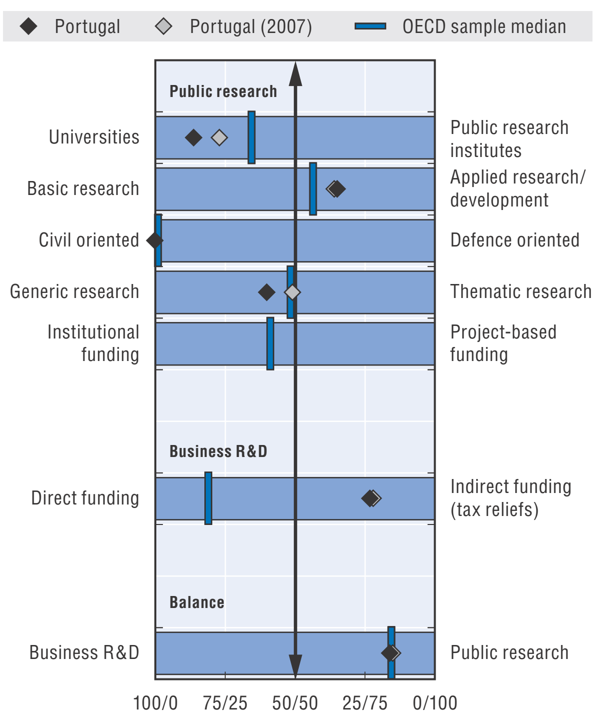


Panel 3. Revealed technology advantage in selected fields, 2009-11

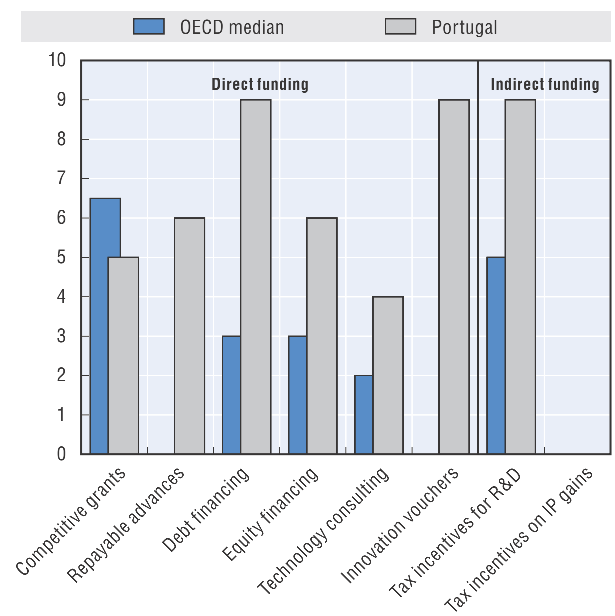
Index based on PCT patent applications



Panel 4. Allocation of public funds to R&D, by sector, type and mode of funding, 2012



Panel 5. Most relevant instruments of public funding of business R&D, 2014



Note: Policy information comes from country responses to the OECD STI Outlook policy questionnaires 2014 and 2012. The Portugal's responses are available in the *OECD STI Outlook Policy Database*, edition 2014 at *http://qdd.oecd.org/Table.aspx?Query=35B595A5-DB39-4CF0-AF50-479023EF49F9*.

Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888933152362

RUSSIAN FEDERATION

The Russian Federation has long-standing strengths in science and technology but they need to be better exploited in order to diversify the economy and reduce its reliance on natural resources. Presidential Decrees in 2012 set major goals for Russian STI policy, including increasing GERD to 1.77% of GDP by 2015.

Hot issue 1: Reforming and improving the public research system (including university 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. A new Federal Agency for Scientific Organisations was also established 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 performance assessment of public scientific organisations in the civil sector were also introduced in 2013 to improve accountability. In 2013 a new Russian Research Foundation was set up and distributed on a competitive basis USD 2.06 billion (RUB 48 billion) in the form of research grants during 2013-16.

Russia has few internationally renowned universities and its researchers publish little in high-impact international S&T journals (Panel 1[b, c]). Several important measures since 2010 seek to further develop research capabilities in universities. Most recently, a new competition for public institutional grants, known as Programme 5/100/2020, will provide USD 2 billion (RUB 40 billion) during 2014-16 to selected universities, which are expected to enter the world's top 200 by 2020. Five universities are expected to join the world's top 100 by the same date.

Hot issue 2: Improving returns and impact of science. During 2011-13, 34 technology platforms were established to bring together universities, research institutes and companies to share perspectives and co-operate on science and innovation. Changes have been made in the legislation for intellectual property (IP) exploitation. Decree No. 233 of 2012 assigns IPRs resulting from public research to the Russian Federation and establishes the principle of free transfer of IP to facilitate the transfer of public research results to industry and society. Amendments to federal law in 2013 made it easier for PRIs and universities to create business partnerships for transferring IP on the basis of a licence or commercialisation.

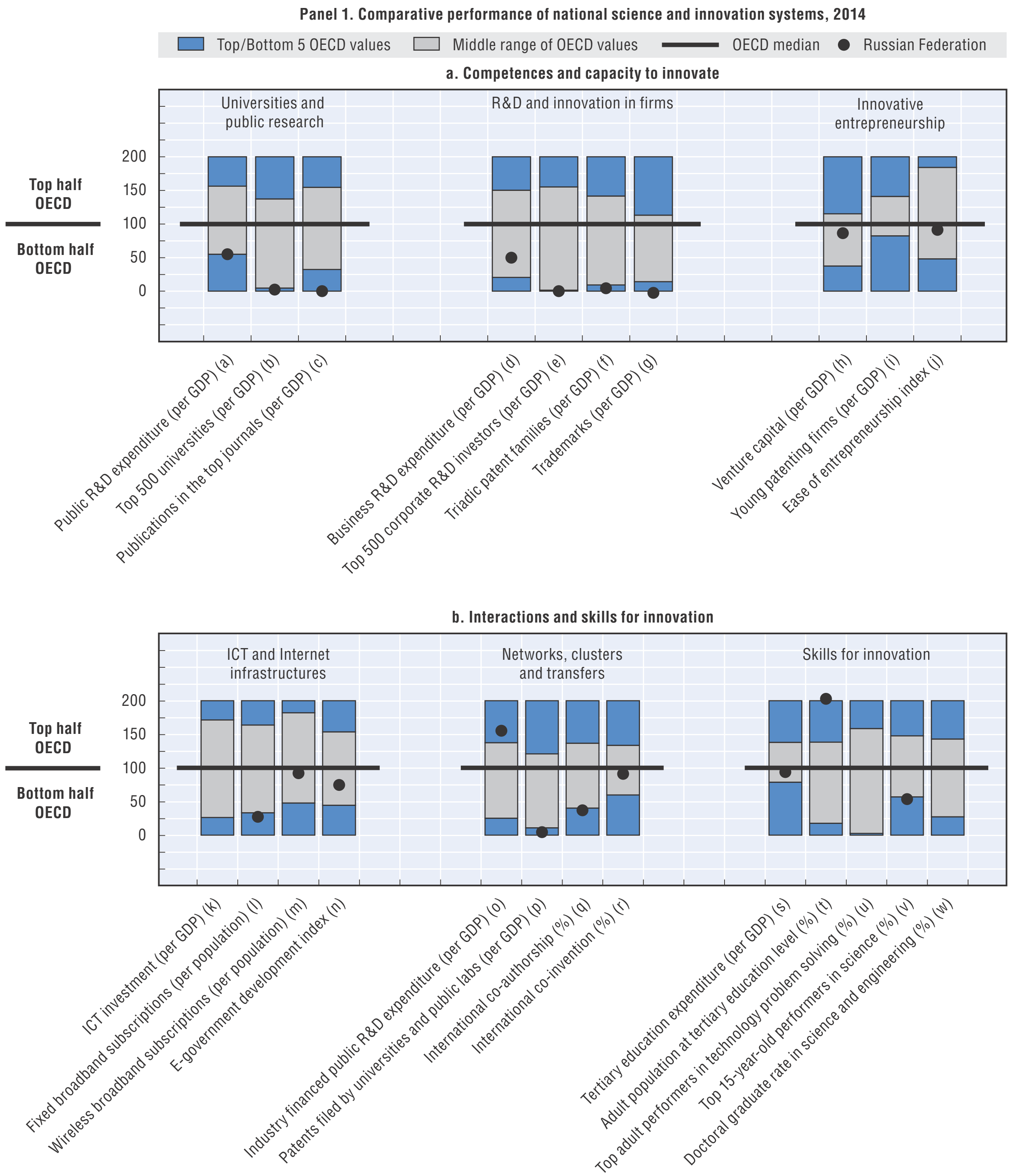
Hot issue 3: Improving the education system. The proportion of the tertiary-qualified population, at 53%, is well above that of any OECD country (Panel 1[t]). Yet, the performance of 15-year-olds in science is below the OECD median (Panel 1[v]). The government has introduced many measures to improve the efficiency of the education system and its ability to meet the skills needs of the country. For example, the 2012 Federal Law On Education in the Russian Federation has raised the standards for PhD qualification and made the process more transparent. Since 2012, the Presidential Programme for Advanced Training of Engineering Personnel has been implemented with total state financing of USD 38.8 million (RUB 750 million) over three years. The goal is to improve the qualification of engineers in Russia's strategic industries and to improve the structure of engineering education by organising training programmes in priority industry sectors (energy and resource efficiency, nuclear technologies, space, medicine, and ICT) and internships in leading research and engineering centres in Russia and abroad.

Hot issue 4: Encouraging innovation in firms and supporting entrepreneurship and SMEs. BERD accounted for 0.66% of GDP in 2012. The federal budget for state-owned enterprises (SoEs) or industrial R&D organisations accounts for the major share of Russian business R&D expenditures. On many measures, the innovation performance of Russian firms lags far behind counterparts in OECD countries (Panel 1[e, f, g]). Several government initiatives seek to stimulate innovative activities in the business sector. The Innovation Development Programme (IDP) targets the largest SoEs, charging them to develop innovation strategies and to co-operate with universities and research institutes. As a result, the R&D and innovation expenditures of the largest SoEs have increased in the last two years. The new Federal Law on Public Procurement (2013) provides specifically for the procurement of high-technology and innovative products. In 2012-13, a number of sectoral programmes were adopted to support priority sectors such as advanced manufacturing, aviation and shipbuilding. To

Key figures, 2013

Economic and environmental performance	RUS	OECD	Gross domestic expenditure on R&D	RUS	OECD
Labour productivity			**GERD**		
GDP per hour worked, USD PPP, 2013	23.9	47.7	Million USD PPP, 2012	37 854	1 107 398
(annual growth rate, 2008-13)	(+1.2)	(+0.8)	As a % of total OECD, 2012	3.4	100
Green productivity			**GERD intensity and growth**		
GDP per unit of CO_2 emitted, USD, 2011	1.3	3.0	As a % of GDP, 2012	1.12	2.40
(annual growth rate, 2007-11)	(+1.5)	(+1.8)	(annual growth rate, 2007-12)	(+2.0)	(+2.0)
Green demand			**GERD publicly financed**		
NNI per unit of CO_2 emitted, USD, 2011	1.8	3.0	As a % of GDP, 2012	0.77	0.77
(annual growth rate, 2007-11)	(+1.7)	(+1.6)	(annual growth rate, 2007-12)	(+3.5)	(+2.8)

Figure 9.37. **Science and innovation in the Russian Federation**



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

support SMEs, the SMEs Development Programme provides USD 8 billion (RUB 155 billion) over 2013-20 and other support measures.

Highlights of the Russian STI system

STI policy governance: The Presidential Council for Science and Education and the Presidential Council for Economic Modernisation and Innovative Development have been established to improve policy co-ordination on science and innovation. Two programmes, the Development of Science and Technology (DST) (2013-20) and Economic Development and Innovative Economy (2013-20), approved in 2013, are to organise and co-ordinate systematically all major federal budget-funded initiatives in science and innovation. In terms of strategic policy intelligence, foresight studies, e.g. in the framework of the Interdepartmental Commission on Technology Foresight, are increasingly used in the selection of national and sectoral STI priorities. The Long-term S&T Foresight Towards 2030, which identifies promising S&T areas, is a major input to strategic planning and policy formulation in the area. Evaluation of government programmes has also been reinforced.

ICT and Internet infrastructures: ICT infrastructures are comparatively weak, with 14.5 subscribers to fixed broadband networks per 100 inhabitants (Panel 1[l]). Public research infrastructure is expected to improve through several initiatives, including a Mega-Science Infrastructure Projects programme within the DST (2013-20) for the creation and development of very large research facilities. It provides competitive funding for infrastructures to both public and private research institutes and universities.

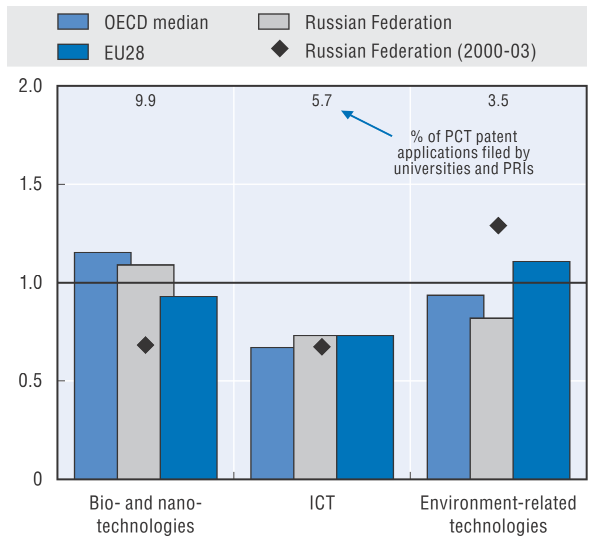
Clusters and smart specialisation: The government launched a new nationwide programme in 2012 to support pilot innovative clusters, and 25 were established in six strategic sectors: nuclear and radiation technology; aircraft and space vehicles manufacturing; shipbuilding; pharmaceutical, biotechnology and medical industries; new materials; chemicals and petrochemicals; and information technology and electronics. In 2013, a federal subsidy of USD 67 million (RUB 1.3 billion) was allocated to support the pilot clusters, and up to USD 154 million (RUB 3.1 billion) is expected to be available annually over 2014-16.

Globalisation: While international co-patenting is close to the OECD median, Russian science is much less well integrated internationally (Panel 1[r, q]). A number of administrative barriers hamper deeper and more efficient international STI co-operation, including visa issues and misalignment of funding procedures with foreign and international funding agencies. In 2013, the government announced two major STI funding programmes that include provisions that support international co-operation: R&D in Priority Fields of Russia's S&T Complex 2014-20 and R&D Personnel for Innovative Russia 2014-20.

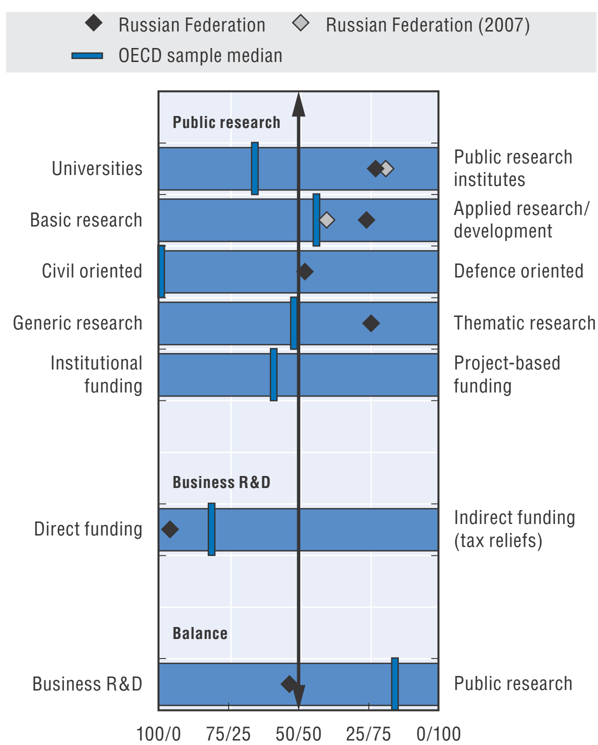
Recent developments in STI expenditures: GBAORD has increased considerably in the last five years. The Federal Budget Plan for 2014-15 predicts a slight decrease in budget appropriations for civil R&D in 2014. Nevertheless, government funding is predicted to remain the main source of GERD until 2030, despite important recent initiatives to stimulate business R&D and innovation. HERD is set to increase from 9% to 13.5% of GERD by 2018, reflecting the government's goal to enhance the research capacities of universities.

Panel 2. Revealed technology advantage in selected fields, 2009-11

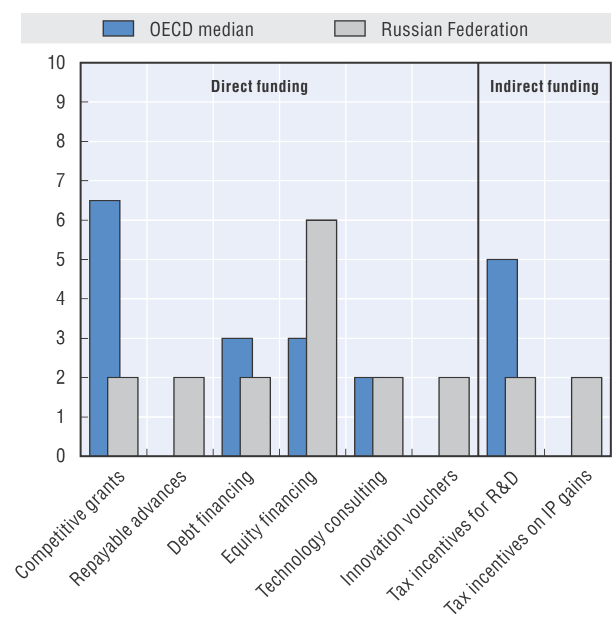
Index based on PCT patent applications



Panel 3. Allocation of public funds to R&D, by sector, type and mode of funding, 2012



Panel 4. Most relevant instruments of public funding of business R&D, 2014



Note: Policy information comes from country responses to the OECD STI Outlook policy questionnaires 2014 and 2012. The Russian Federation's responses are available in the *OECD STI Outlook Policy Database*, edition 2014 at *http://qdd.oecd.org/Table.aspx?Query=E7DE044B-7994-456D-B3D9-BBB3FF44EA0E*.

Source: See reader's guide and methodological annex.

StatLink *http://dx.doi.org/10.1787/888933152376*

SLOVAK REPUBLIC

The Slovak Republic is one of Europe's most dynamic economies. The economy is projected to grow, with high export demand boosting exports and investment. However, it has so far made limited progress towards an advanced STI system.

Hot issue 1: Improving the governance of innovation. The governance structure of the Slovak STI system changed little over the last decade, but important reforms are under way on the procedural side, in planning, decision making, organisation, management, monitoring and control in view of the implementation of the newly adopted Research and Innovation Strategy for Smart Specialisation of the Slovak Republic (RIS3 SK) (2014-20). Key changes in governance include: legislative changes, especially in the central state administration; amendments of the statue of the Government Council for Science, Technology and Innovation (GCSTI); creation of a GCSTI Standing Committee for the RIS3 SK; and creation of additional technology and research agencies. A first Action Plan to implement the RIS3 SK is being prepared by a working party chaired by the Slovak Government Office.

Hot issue 2: Encouraging innovation in firms and supporting entrepreneurship and SMEs. While the Ease of Entrepreneurship Index (Panel 1[j]) shows that the business environment has significantly improved, business R&D investment and innovation outputs are still among the lowest in the OECD area (Panel 1[d, f, g]). Competitive grants are the main public funding instrument, with USD 179 million (EUR 91 million) in 2012, a strong increase from USD 13 million in 2009 (EUR 6.6 million). Measures to encourage innovative entrepreneurship include: the JEREMIE Initiative, which provides SMEs with equity for seed, start-up and development phases as well as loan guarantees; Boosting the Innovation of Small and Medium Enterprises in Slovakia (BISMES), which provides analysis and information on funding available for SMEs; the Ministry of Economy's (MoE) Innovative Deed of the Year and Young Designer competitions, which aim to motivate young innovators. In addition, the Operational Programme Research and Development allocated some USD 1 351 million (EUR 689 million) over 2007-13 to support knowledge transfer and the building of an innovation culture in firms. A Risk Capital Programme has been operating since 2006.

Hot issue 3: Strengthening industry-science linkages. Links between science and industry are weak: the share of business-funded R&D in universities and government labs, an indicator of industry-science relations, is below the OECD median (Panel 1[o]). A strong policy element of the RIS3 SK aims to link academics and the business sector in university research parks. A network of national science centres will be built at the largest of these. They will focus on world-class research in biotechnology, biomedicine, IT, materials and energy. In addition, an independent National Technology Transfer Centre will serve as a central contact point for technology transfer.

Hot issue 4: Innovating to address social challenges (including inclusiveness). Eco-innovation is part of the country's innovation strategy and its strategy to address social and environmental challenges. Support for eco-innovation comes mainly from non-reimbursable grants from EU Structural Funds, which are administered by the Slovak Innovation and Energy Agency. The National Action Plan for Green Public Procurement (2011-15) aims to increase green procurement to 65% of all public procurement at the central government level and to 50% at the level of the self-governing regions and cities by 2015.

Hot issue 5: Addressing globalisation of STI and increasing international co-operation. In the Phoenix Strategy the government adopted a package of measures to improve researchers' mobility and attract and retain leading foreign researchers. Mobility centres, the National Scholarship Programme, and the EC EURAXESS portals offer opportunities to access global networks. In addition, the Slovak Republic's Research and Development Agency (SDRA) supports various international co-operation projects. In accordance with EU regulations, the government uses investment incentives to attract FDI and MNE, including in R&D activities.

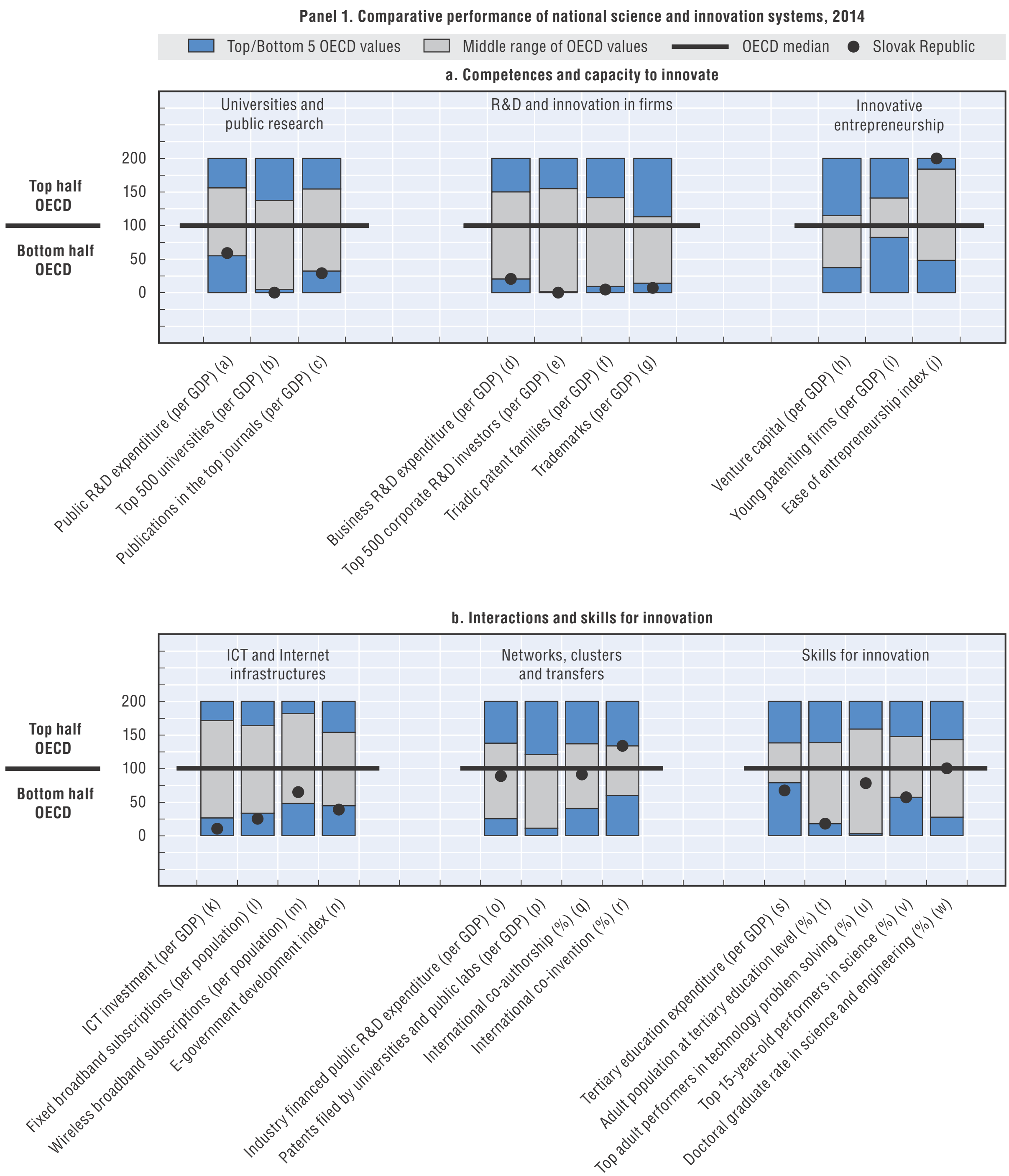
Highlights of the Slovak Republic's STI system

New sources of growth: Based on a SWOT analysis and on analysis of the future development of the Slovak economy, the RIS3 SK has identified areas of specialisation in traditional and fast-growing sectors. R&D priorities are: material science and nanotechnology, ICT, biomedicine and biotech-

Key figures, 2013

Economic and environmental performance	SVK	OECD	Gross domestic expenditure on R&D	SVK	OECD
Labour productivity			**GERD**		
GDP per hour worked, USD PPP, 2013	36.6	47.7	Million USD PPP, 2012	1 150	1 107 398
(annual growth rate, 2008-13)	(+1.8)	(+0.8)	As a % of total OECD, 2012	0.1	100
Green productivity			**GERD intensity and growth**		
GDP per unit of CO_2 emitted, USD, 2011	3.3	3.0	As a % of GDP, 2012	0.82	2.40
(annual growth rate, 2007-11)	(+5.9)	(+1.8)	(annual growth rate, 2007-12)	(+14.5)	(+2.0)
Green demand			**GERD publicly financed**		
NNI per unit of CO_2 emitted, USD, 2011	3.1	3.0	As a % of GDP, 2012	0.36	0.77
(annual growth rate, 2007-11)	(+5.8)	(+1.6)	(annual growth rate, 2007-12)	(+9.5)	(+2.8)

Figure 9.38. **Science and innovation in the Slovak Republic**



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

nology; technological priorities are manufacturing technologies, sustainable energy, environment and agriculture.

Universities and public research: Public R&D expenditures are below the OECD median at 0.48% of GDP (Panel 1[a]), as is scientific output (Panel 1[c]). Slovakian researchers are reasonably networked internationally (Panel 1[q]). Public research and higher education reforms will continue. Long-term institutional funding will be based on the results of periodical evaluations of universities and PRIs, expected to be modelled on the British Research Assessment Exercise. New rules for short-term institutional funding, which are subject to annual adjustment, will be specified in the revised Act on the State R&D Support Mechanism in 2014. A roadmap is being prepared to strengthen high-impact research at centres of excellence.

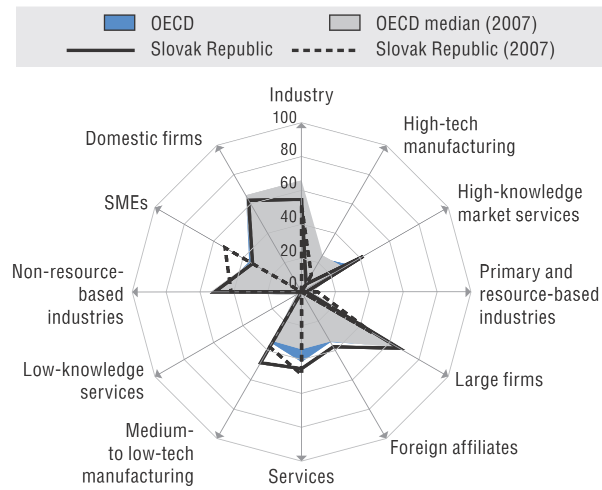
Clusters and smart specialisation: A Smart Strategy for the Bratislava Region was approved by the government in 2012. The RIS3 SK has been developed as a national smart specialisation in line with the EU Research and Innovation Strategies for Smart Specialisations Guideline.

Skills for innovation: In the Slovak Republic 18.6% of the adult population has tertiary education compared to 27% for the EU28, and adult performance in technology problem solving is below the OECD median (Panel 1[t, u]). The performance of 15-year-olds in sciences is below the OECD median (Panel 1[v]). One of the main priorities of the Phoenix Strategy is to popularise S&T among youth and the RIS3 SK includes measures to support mobility of human resources in science and innovation.

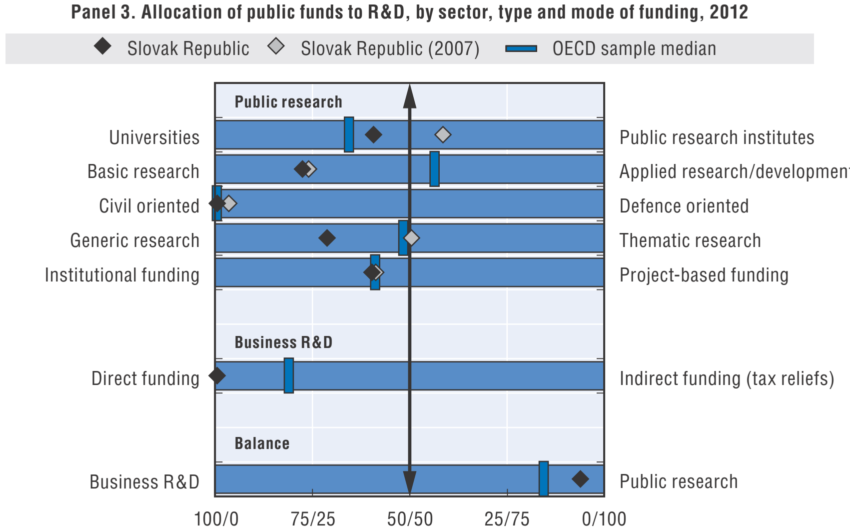
Recent developments in STI expenditures: In spite of the economic crisis, GERD rose from 0.46% of GDP in 2007 to 0.82% of GDP in 2012, by an average annual growth of 14.5% between 2007 and 2012. Government expenditure on R&D increased from 0.16% to 0.20% of GDP between 2008 and 2012, a trend expected to continue in the coming years. Having bottomed out at 0.18% of GDP in 2007, BERD increased to 0.34% of GDP in 2012. If current growth rates are maintained, it will be possible to reach GERD of 1.2% of GDP by 2020, a target set by the RIS3 SK.

Panel 2. Structural composition of BERD, 2011

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



Panel 3. Allocation of public funds to R&D, by sector, type and mode of funding, 2012



Note: Policy information comes from country responses to the OECD STI Outlook policy questionnaires 2014 and 2012. Slovak Republic's responses are available in the *OECD STI Outlook Policy Database*, edition 2014 at *http://qdd.oecd.org/Table.aspx?Query=6E4E6EC1-49FD-4034-A4FB-4137368297A8*.

Source: See reader's guide and methodological annex.

StatLink *http://dx.doi.org/10.1787/888933152384*

SLOVENIA

In less than two decades, Slovenia has become a market-based economy. It has integrated with world markets and has joined the EU, the European Monetary Union and the OECD. It leads central and eastern European transition countries in GDP per capita and on a range of innovation-related indicators.

Hot issue 1: Improving the design and implementation of STI policy. The Research and Innovation Strategy of Slovenia 2011-20 (RISS) and the National Higher Education Programme 2011-20 (NHEP) support close links between research, technology development, innovation and higher education. They also propose measures for necessary reforms of the national innovation system and measureable implementation targets. To implement these strategies, legal documents are being prepared. They include a new (or significantly amended) Research and Development Act as well as a Higher Education Act and a Smart Specialisation Strategy (SSS). Priorities set out in the strategic documents are supported by the national budget and EU Structural Funds. In 2012, the government's budget for R&D (GBAORD) amounted to EUR 190 million, accounting for 0.54% of GDP. It remained unchanged in 2013. For 2012-13, the government also received USD 216 million (EUR 130 million) from the EU Structural and Social Funds for R&D to implement the strategies.

Hot issue 2: Improving the framework conditions for innovation (including competitiveness). The Slovenian government endeavours to create a legislative environment conducive to innovation and to strengthen incentives for innovation, notably by implementing and supporting the protection and management of IPR. This is considered necessary for accumulating innovation capabilities in companies, promoting innovation in services and encouraging the international orientation of business R&D.

Hot issue 3: Encouraging innovation in firms and supporting entrepreneurship and SMEs. BERD as a share of GDP is above the OECD median (Panel 1[d]). It reached 1.99% in 2012, up from 1.83% in 2011. Overall, BERD has expanded rapidly in recent years, in spite of the recession and a slow recovery. Much of it is concentrated in a small number of firms, with two pharmaceutical firms accounting for a large share. The services sector performs less R&D than in other OECD countries (Panel 2). Triadic patents filed and trademark applications fall short of the OECD median (Panel 1[f, g]). Venture capital per GDP is at the bottom of the OECD middle range (Panel 1[h]). To foster business R&D and innovation, measures are being implemented to strengthen the leveraging effect of public funds on private R&D investments, to support the employment of researchers in the business sector, to encourage business R&D investments through generous R&D tax incentives, to support start-up and fast-growing innovative companies, and to use innovative public procurement to develop lead markets. Slovenia's policy for SMEs and entrepreneurship was set out in the Programme of Measures to Promote Entrepreneurship and Competitiveness (2007-13). R&D carried out by SMEs increased markedly (Panel 2).

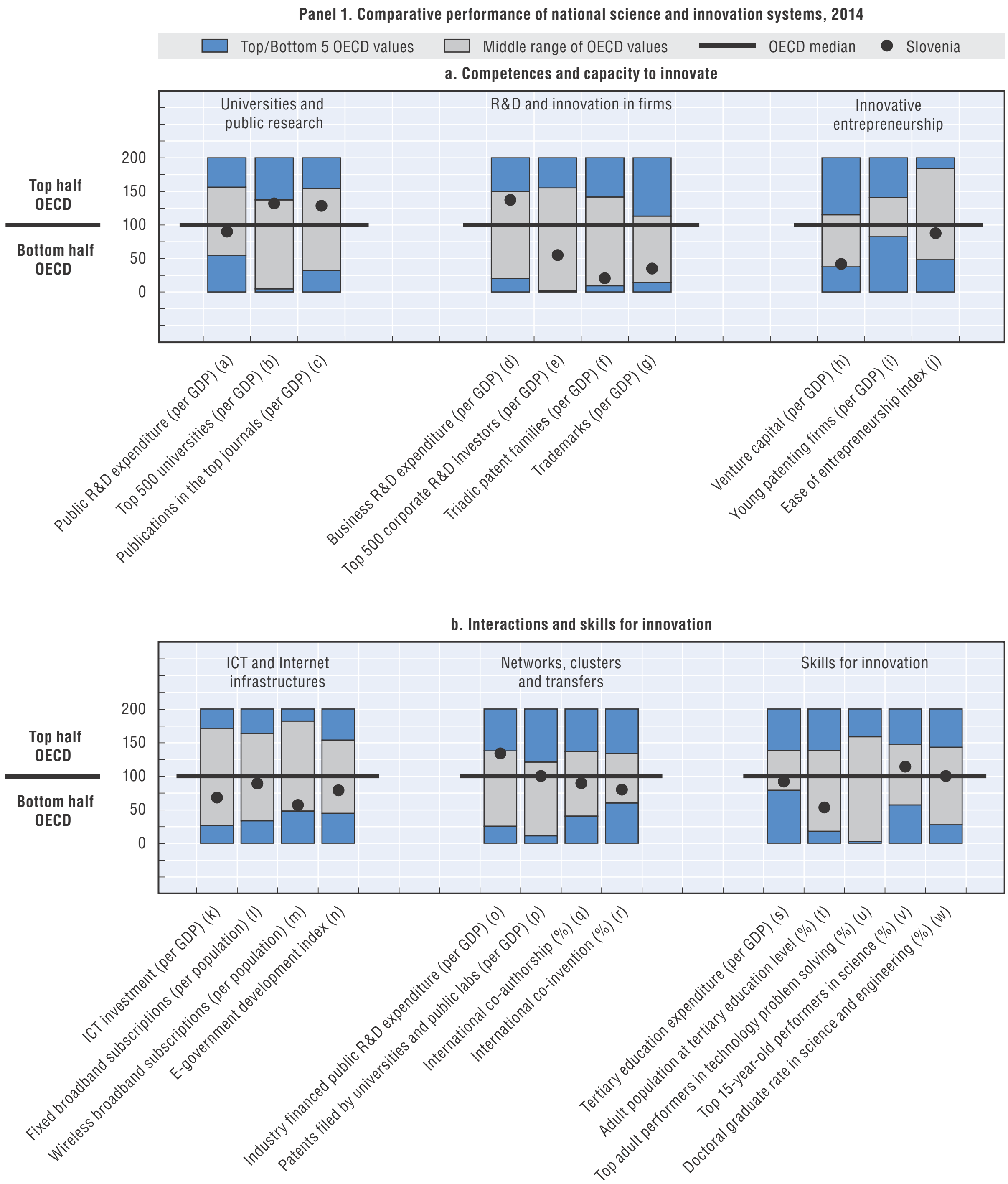
Hot issue 4: Targeting priority areas/sectors. Slovenia's Smart Specialisation Strategy (SSS) is still at the stage of public consultation and will be an important tool for the allocation of public funds. It is based on comparative advantages and takes into account previous investments in capacity and scientific excellence. Its goal is to support the further development of the public and business R&D potential in chosen areas and thus to enable Slovenia to become a technology leader in its priority fields. On the basis of comparative analyses of Slovenian competencies and potentials the following horizontal priority areas were identified: materials and technologies; electrical and electronic components and devices; tools, building blocks; and technologies for the management of process systems.

Six complementary vertical priorities were identified: smart cities; smart factories; smart homes; power and energy systems; bio-med; eco-Slovenia. Priority areas are currently the subject of broad public discussions and will result in the adoption of Smart Specialisation Strategy priority areas. Slovenia will concentrate domestic and international public funds on the priority areas in order to ensure competences and advantages in the relevant fields of science and business innovation. The allocation of the majority of EU Structural Funds and part of the national budget for R&D is, and will be, linked to the SSS.

Key figures, 2013

Economic and environmental performance	SVN	OECD	Gross domestic expenditure on R&D	SVN	OECD
Labour productivity			**GERD**		
GDP per hour worked, USD PPP, 2013	41.5	47.7	Million USD PPP, 2012	1 540	1 107 398
(annual growth rate, 2008-13)	(+1.2)	(+0.8)	As a % of total OECD, 2012	0.1	100
Green productivity			**GERD intensity and growth**		
GDP per unit of CO_2 emitted, USD, 2011	3.3	3.0	As a % of GDP, 2012	2.63	2.40
(annual growth rate, 2007-11)	(+1.3)	(+1.8)	(annual growth rate, 2007-12)	(+11.4)	(+2.0)
Green demand			**GERD publicly financed**		
NNI per unit of CO_2 emitted, USD, 2011	3.1	3.0	As a % of GDP, 2012	0.77	0.77
(annual growth rate, 2007-11)	(+1.4)	(+1.6)	(annual growth rate, 2007-12)	(+7.7)	(+2.8)

Figure 9.39. **Science and innovation in Slovenia**



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

Hot issue 5: Strengthening public R&D capacity and infrastructures. Slovenia has good universities (Panel 1[b]) and good performance in scientific publications in high-impact journals (Panel 1[c]). Unlike other transition economies, Slovenia has not only maintained but strengthened its PRIs. HERD was 0.29% of GDP and GOVERD around 0.34% of GDP in 2012. In the past five years, numbers of researchers and R&D personnel have increased steadily. However, the share of tertiary-educated population is below the OECD (Panel 1[t]) and EU averages. Recognising the importance of developing human resources, Slovenia devoted USD 56.7 million (EUR 34 million) from the national R&D budget and USD 23.3 million (EUR 14 million) from EU Structural Funds in 2012 to support young researchers and PhD students. The Research Infrastructure Roadmap (2012-20) sets out priorities for investments in research equipment, infrastructural programmes and new buildings. Slovenia allocated USD 75 million (EUR 45 million) from the national R&D budget and USD 23.3 million (EUR 14 million) from EU Structural Funds for research infrastructures in 2012.

Highlights of the Slovenian STI system

STI policy governance: In the past, a multidisciplinary approach in scientific research was hindered by the discipline-oriented allocation of R&D funding. The Slovenian Research Agency therefore established the Interdisciplinary Research Council to evaluate and allocate public funds for atypical or multidisciplinary or interdisciplinary research. The Agency has earmarked some 10% of public funds for such research projects.

New sources of growth: The Smart Specialisation Strategy will address relevant green innovations and technologies. Positive environmental impact and low carbon economy (efficient use of energy, renewable sources of energy, less use of environmentally harmful substances and emissions, recycling) are criteria in most public calls for support for research and innovation. SID Bank (*Slovenska izvozna in razvojna banka*) offers favourable credit lines for environmental projects and Ecofund funds initial investments in environmental technologies.

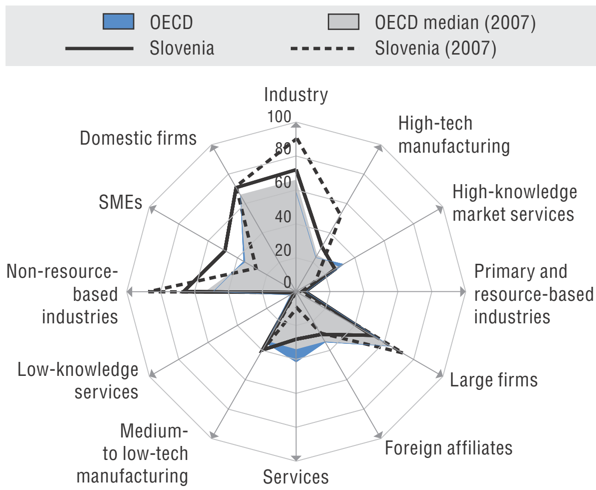
Skills for innovation: The supply of future science and innovation skills appears good, judging by the above-median scores of 15-year-olds on the science PISA test in 2012 and the share of doctoral graduates in science and engineering (Panel 1[v, w]). A measure to foster human resources in science and innovation, "Scientists at the beginning of a research career", was introduced in 2013. The main objective is to connect PRIs with the business sector by co-funding post-doctoral researchers. The National Higher Education Programme 2011-20 encourages everyone who is interested and capable to enter tertiary education and provides conditions for successful completion of their studies. According to NHEP, the state should cover the expenses of an individual's studies for the first study cycle irrespective of age, but only for four or five years full-time or for 240 or 300 ECTS (European Credit Transfer and Accumulation System) credits for the duration of a study programme. Also according to NHEP, the state will finance up to 60 or 120 ECTS, depending on the length of the study programme, for the second study cycle at any time in an individual's life if he or she has not yet obtained this level of education and if his or her study at his level has not yet been funded by the state.

Technology transfer and commercialisation: There are several new mechanisms to foster knowledge flows. The centres of excellence (CoE) involve partnerships between industrial partners and academia and seek to strengthen quality and co-operation, build critical mass and link up with top centres abroad. Competence centres (CCs) link science and industry and give a strong role to industrial partners, applied research and industrial networks. USD 188 million (EUR 112.8 million) has been allocated for these two types of centres for 2010-14. For its part, the Development Centres programme supports projects that include R&D and investments in related infrastructure to promote technological development through consortia.

Recent developments in STI expenditures: Slovenia's GERD reached 2.63% of GDP in 2012. Industry contributes 62.2% of GERD and government 28.7%, with 8.6% from abroad. National targets are 1.5% of GDP for public R&D and an ambitious 3.6% of GDP for GERD by 2020. However, the central government budget for R&D decreased over 2009-13. In 2013 GBAORD was approximately the same as in 2008. In contrast, EU Structural Fund and Social Funds for R&D increased in recent years.

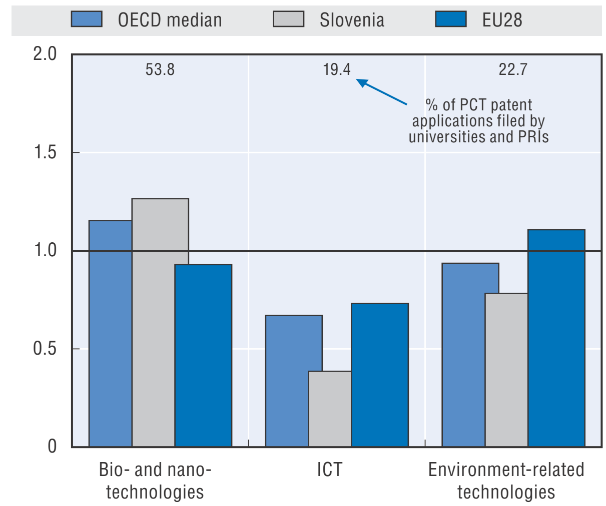
Panel 2. Structural composition of BERD, 2011

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

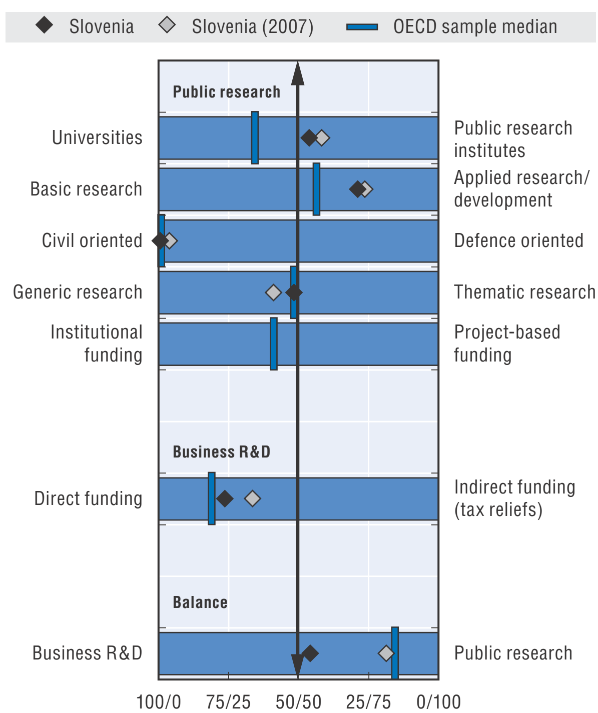


Panel 3. Revealed technology advantage in selected fields, 2009-11

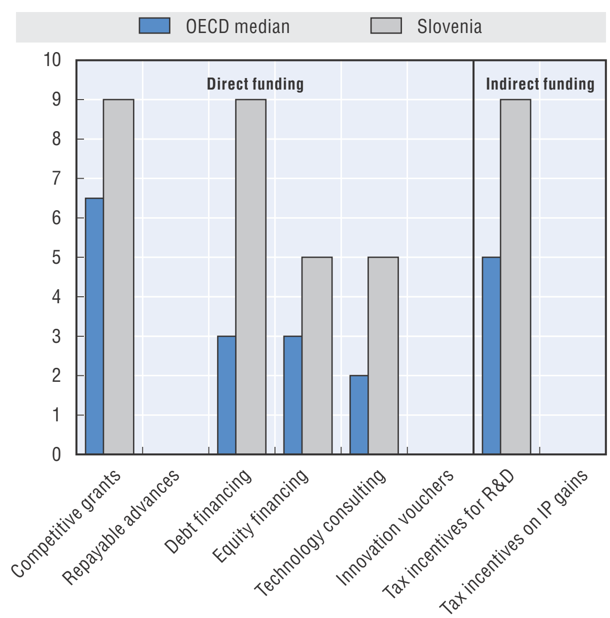
Index based on PCT patent applications



Panel 4. Allocation of public funds to R&D, by sector, type and mode of funding, 2012



Panel 5. Most relevant instruments of public funding of business R&D, 2014



Note: Policy information comes from country responses to the OECD STI Outlook policy questionnaires 2014 and 2012. Slovenia's responses are available in the *OECD STI Outlook Policy Database*, edition 2014 at *http://qdd.oecd.org/Table.aspx?Query=084816DF-8302-4E09-9BB8-3C6531F710FA*.

Source: See reader's guide and methodological annex.

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SOUTH AFRICA

An emerging economy, South Africa is at a critical stage of its Ten-Year Innovation Plan (TYIP) (2008-18) and is currently dovetailing these efforts with the National Industrial Policy Framework and other socio-economic policy imperatives.

Hot issue 1: Innovation to contribute to structural adjustment and the new approach to growth. To transform the industrial base and to increase competitiveness, South Africa is implementing a portfolio of R&D-led industry development programmes in the areas of additive manufacturing, advanced metals, aerospace, chemicals, energy, platinum, mining and ICT. These programmes are in addition to those identified in the more science-intensive TYIP. The TYIP underpins the country's transition to a knowledge economy and is built around five "grand challenges": biotechnology and bioeconomy (formerly pharmaceuticals), space, energy security, global change, and understanding of social dynamics. The National Development Plan (NDP): A vision for 2030 provides a roadmap for South Africa's transition towards a diversified economy by 2030, with innovation underpinning almost every aspect.

Hot issue 2: Innovation to contribute to addressing social challenges and inclusive development. While a focused programme on innovation for inclusive development has been launched, several initiatives are being introduced to address social challenges, with a strong emphasis on gender and black representation in science, technology and engineering. Examples include the Thuthuka programme and the 2013 Guidelines for Achieving Equity in the Distribution of Bursaries, Scholarships and Fellowships, which set targets of 80% for black and 60% for women in all human capital development projects.

Hot issue 3: Improving the governance of the innovation system and policy. The NDP stresses the need for the national system of innovation (NSI) to function in a coherent and co-ordinated manner, with broad objectives aligned with national priorities. It seeks to improve the governance of the innovation system, especially by ensuring the alignment of STI activities across government and by co-ordinating public funding. Accordingly, there has been growing emphasis on directing public funding to the key areas in the TYIP, the Industrial Policy Action Plan (IPAP) and the programme of action encapsulated in the New Growth Path. The required links between STI policies and the National Industrial Policy Framework also receive attention. The Technology Innovation Agency (TIA), created in 2010, is a critical platform for facilitating increased commercialisation of research findings. An external review of the TIA was conducted in 2012, and its recommendations are being considered for implementation.

Hot issue 4: Industry-STI linkages. Industry-financed public R&D expenditure is low (Panel 1[o]), an indication that industry-science links need to be improved. The government recognises the importance of strong links between the S&T and business communities for agenda setting and stimulating investment in STI. In 2013, the Minister of Science and Technology launched the STI Summit, a formal annual platform for discussions with South Africa's business leadership. The Department of Science and Technology (DST) and of Trade and Industry (the DTI) have embarked on a process of reviewing the basket of incentives and support instruments for increased R&D, innovation commercialisation and improving linkages with industry.

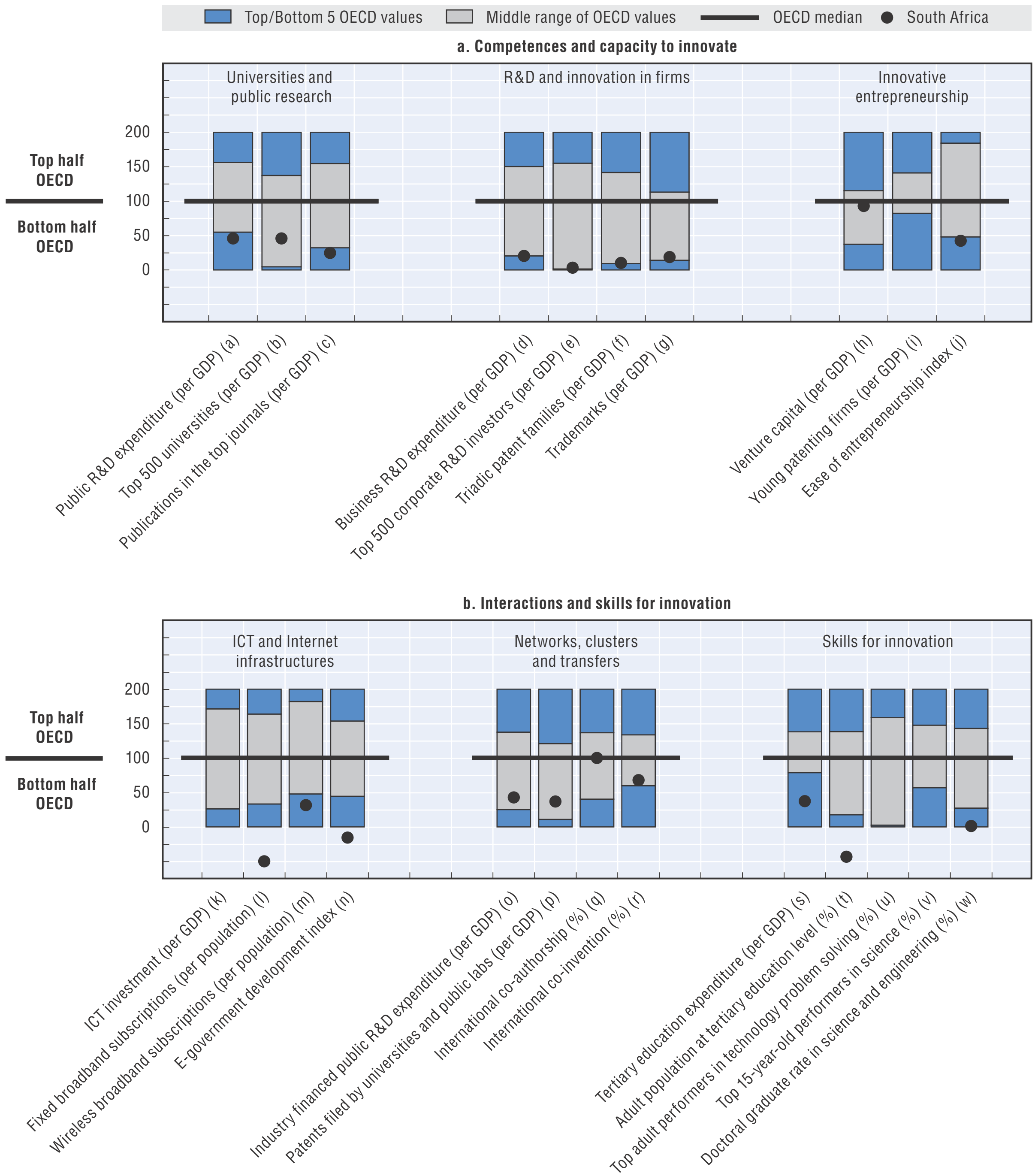
Hot issue 5: Human capital development. A major bottleneck for South Africa's socio-economic development in general, and for the advancement of STI in particular, is the lack of a broad skills foundation. The share of the adult population with tertiary-level education is extremely low by OECD standards (Panel 1[t]), and the ageing of the white male STI workforce further weakens the skills base. To increase the pool of human capital for STI, the government has a series of initiatives that focus on improving access to science and mathematics education for youth and supporting postgraduate students and researchers. Postgraduate students supported by the National Research Foundation doubled from 5 061 in 2008/09 to 11 400 in 2013/14, and the NDP aims to increase the number of doctoral graduates to 5 000 a year. To improve equity, the government issued in 2013 Guidelines for Achieving Equity in the Distribution of Bursaries, Scholarships and Fellowships.

Key figures, 2013

Economic and environmental performance	ZAF	OECD	Gross domestic expenditure on R&D	ZAF	OECD
Labour productivity			**GERD**		
GDP per hour worked, USD PPP, 2013	n.a.	47.7	Million USD PPP, 2011	4 652	1 107 398
(annual growth rate, 2008-13)	n.a.	(+0.8)	As a % of total OECD, 2011	0.4	100
Green productivity			**GERD intensity and growth**		
GDP per unit of CO_2 emitted, USD, 2011	1.3	3.0	As a % of GDP, 2011	0.76	2.40
(annual growth rate, 2007-11)	(+0.5)	(+1.8)	(annual growth rate, 2007-11)	(-2.8)	(+2.0)
Green demand			**GERD publicly financed**		
NNI per unit of CO_2 emitted, USD, 2011	1.4	3.0	As a % of GDP, 2010	0.34	0.77
(annual growth rate, 2007-11)	(+0.4)	(+1.6)	(annual growth rate, 2007-10)	(-5.5)	(+2.8)

Figure 9.40. **Science and innovation in South Africa**

Panel 1. Comparative performance of national science and innovation systems, 2014



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

Highlights of the South African STI system

New sources of growth: The government intends to support technology and capacity development in the areas mentioned under the initiative for R&D-led industry development. Initiatives include the development in 2014 of an Emerging Industries Action Plan (EIAP), which is aimed at providing a policy and funding framework for the technological maturation and commercialisation of large R&D projects with the potential to create substantial new industries. It will also seek to increase private-sector participation and stakeholder buy-in for these projects and to increase access to local and export markets. In addition, a sectoral innovation funding instrument has been launched to address technology and innovation issues within sectors, based on joint public-sectoral funding.

New challenges: Development of the renewable energy market is seen as essential to securing sufficient energy supply and to further the transition to a green economy. The Green Energy Efficiency Fund (GEEF), established in 2011 with USD 94 million (ZAR 500 million), assists South African companies that invest in energy efficiency and renewable energy projects through a loan with a payback period of 15 years. A Ten-year Waste R&D and Innovation Roadmap is currently being developed. The Department of Environmental Affairs has launched a Green Fund with USD 136 million (ZAR 800 million) committed and being disbursed to implementation and R&D projects that can inform policy through better evidence.

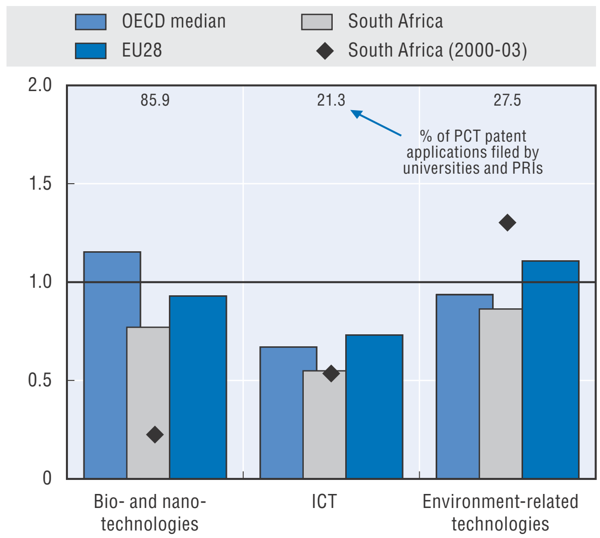
Universities and public research: South Africa has a national research system that is small in relative terms but has pockets of excellence (Panel 1[a, b, c, q]). Existing initiatives to enhance knowledge production, such as the Research Chairs and the Centres of Excellence, have helped increase the number and quality of scientific research outputs and increase the number of researchers. For example, international S&T publications by South African researchers increased by 3.2% a year over 2001-11. This remains a key focus for the government.

Innovation in firms: South Africa's business R&D input and innovation output are low by OECD standards (Panel 1[d, e, f, g]). BERD decreased in both absolute terms and as a share of GDP over 2008-11 (the latest year for which data are available). To address the longstanding problem of business R&D investment, the policy mix (or instruments) for promoting business-sector R&D and innovation continues to receive increased focus. The R&D tax incentives, which were significantly enhanced in 2006, now provide 150% in tax deductions on R&D expenditure incurred by firms of all sizes that undertake R&D in the country. The Industry Innovation Partnership (IIP) programme aims to foster government-business co-funding of R&D and innovation with a budget of USD 88 million (ZAR 500 million) for 2013-15. The Support Programme for Industrial Innovation (SPII) supports technology development through matching grants for the late developmental or early commercialisation phases. The Technology Localisation Programme is a supply-side scheme that provides a suite of tailor-made technology interventions to develop local technology and innovation capabilities and to improve the competitiveness of the manufacturing sector in areas linked to public procurement, with a budget of USD 84.7 million (ZAR 500 million) over 2014-17. The Competitive Supplier Development Programme (CSDP), driven by state-owned companies with support from DST, gives local enterprises technology support to strengthen their ability to supply competitively to large public procurement projects and foreign multinationals.

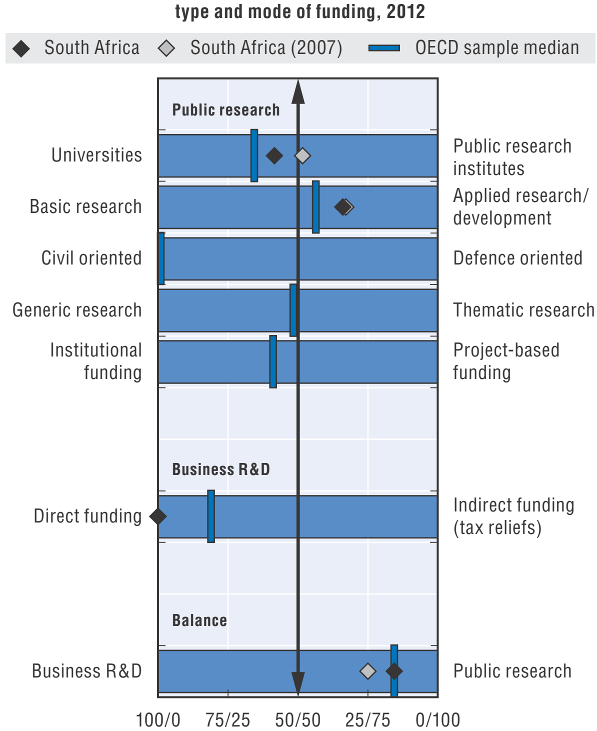
Technology transfer and commercialisation: The National Intellectual Property Management Office (NIPMO), was created in 2011 as an interim office and approved as a specialised service delivery unit (SSDU) within the DST in 2013 to implement the Intellectual Property Rights from Publicly Financed Research and Development Act, put into operation in 2010. The Act provides for more effective utilisation of intellectual property emanating from PRIs through NIPMO support to technology transfer offices to ensure technology transfer and commercialisation of research. As an incentive to PRIs for embarking on technology transfer activities rebates for statutory IP protection and maintenance costs are provided by NIPMO through the IP Fund.

Panel 2. Revealed technology advantage in selected fields, 2009-11

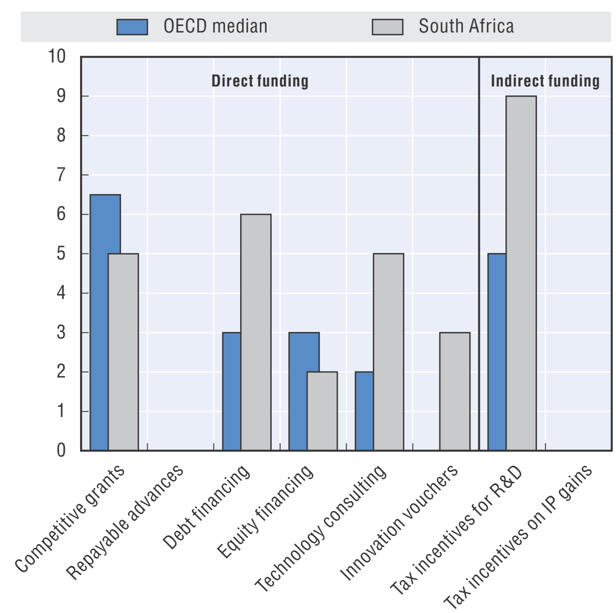
Index based on PCT patent applications



Panel 3. Allocation of public funds to R&D, by sector, type and mode of funding, 2012



Panel 4. Most relevant instruments of public funding of business R&D, 2014



Note: Policy information comes from country responses to the OECD STI Outlook policy questionnaires 2014 and 2012. South Africa's responses are available in the *OECD STI Outlook Policy Database*, edition 2014 at *http://qdd.oecd.org/Table.aspx?Query=759D6E4F-7086-446E-97D2-4AF828E7A13F*.

Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888933152401

SPAIN

Spain has been immersed in a prolonged recession, but growth is expected in 2014 and 2015. The government is currently deploying policies corresponding to two strategic documents, the Spanish Strategy for Science, Technology and Innovation (SSSTI) (2013-20) and the National/State Plan for Scientific and Technical Research and Innovation (2013-16), both approved by the Ministerial Council in February 2013.

Hot issue 1: Improving overall human resources, skills and capacity building. Spain's investment in tertiary education and the share of tertiary attainment in the adult population are near the OECD median (Panel 1[s, t]), and the government aims to raise STI skills training capacities to international standards. It also seeks to encourage job placement and opportunities for researchers in the public and private sectors. Both strategic documents establish several instruments to strengthen human resources for STI, including additional resources for doctoral and postdoctoral training grants and the introduction of mobility schemes. Among schemes to promote researcher careers, *Ramón y Cajal* facilitates the recruitment of national and foreign professors in Spain's science system, including an initial grant to begin their research projects in Spain and an additional USD 147 058 (EUR 100 000) for institutions that award them permanent contracts after five years. *Torres Quevedo* promotes permanent employment of PhDs in the private sector, technological centres and other business entities and especially in newly established high-technology enterprises. *Emplea* offers loans for hiring experts in the management of innovation, including the transfer and exploitation of knowledge, on the basis of three-year contracts, to perform these activities in enterprises, technological centres and technological platforms. The government allocated USD 515.7 million (EUR 350.7 million) for this activity in 2013.

Hot issue 2: Strengthening public R&D capacity and infrastructures. Spain's performance in scientific publication is at the OECD median, although the ratio of public R&D expenditures to GDP and the density of global 500 universities are slightly below (Panel 1[a, b, c]). The government aims to reinforce public research capabilities and to foster research excellence and infrastructures in order to increase the international impact of universities and research centres. To this end, it sponsors individual R&D projects on basic research and interdisciplinary applications of frontier knowledge. It also funds projects carried out in research centres, including investments to acquire equipment and develop scientific infrastructures. The 2013 budget allocated USD 482 million (EUR 328 million) for this purpose. The *Severo Ochoa* programme identifies, promotes and supports high-quality research centres; in the last three years and on the basis of international peer reviews, it has funded 18 centres, with a total of USD 107.5 million (EUR 72 million).

Hot issue 3: Encouraging innovation in firms and supporting entrepreneurship and SMEs. Business investment in R&D and innovation output are below the OECD median (Panel 1[d, e, f, g]), and both the business environment and the supply of venture capital require significant improvement (Panel 1[h, j]). As the country's economic structure is characterised by a predominance of SMEs and low R&D-intensive business sectors, policy will focus on the growth and internationalisation of innovative companies, increased business R&D spending in large companies, strengthening demand for HRST in companies and encouraging the generation and dissemination of emerging technologies. In particular, law to support entrepreneurs and their internationalisation, approved in 2013, provides fiscal incentives and easy access to finance and stipulates measures to boost entrepreneurial initiatives (particularly those that are export-oriented). Disbursements in public calls to support STI activities in firms reached USD 929 million (EUR 632 million) in 2013.

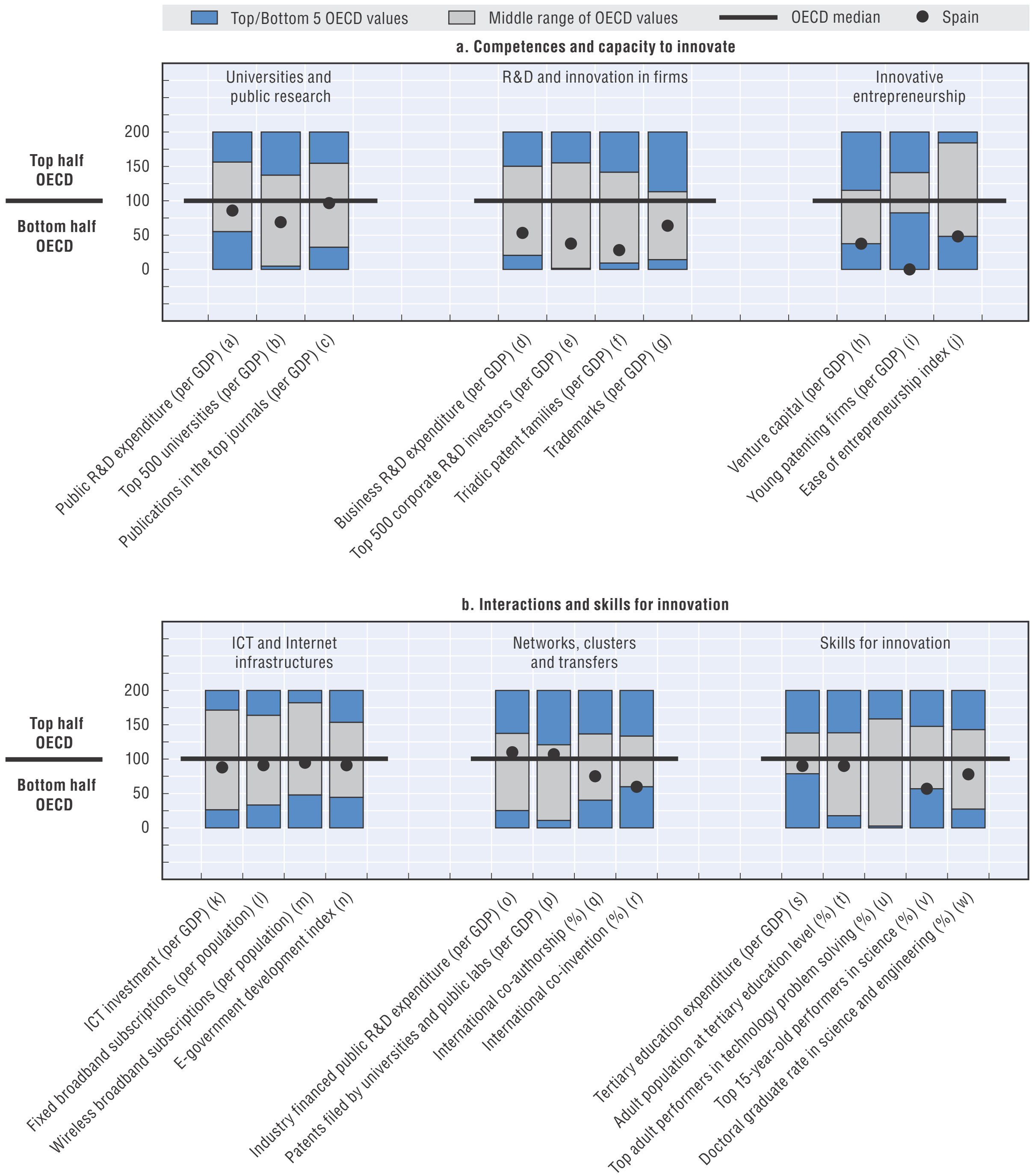
Hot issue 4: Innovation to contribute to addressing social challenges (including inclusiveness). *Retos Innovación* is a specific budget line for projects that address social challenges and key enabling technologies (photonics, microelectronics, nanoelectronics, advanced materials biotechnology and ICTs). In addition, the government sponsors co-operation on R&D projects addressing social challenges (*Retos Colaboración*) between universities, PRIs, private R&D centres and firms. It has also developed strategic actions for health and for the digital society and economy, with a 2013 budget of USD 3.21 billion (EUR 2.1 billion).

Key figures, 2013

Economic and environmental performance	ESP	OECD	Gross domestic expenditure on R&D	ESP	OECD
Labour productivity			**GERD**		
GDP per hour worked, USD PPP, 2013	52.4	47.7	Million USD PPP, 2012	19 556	1 107 398
(annual growth rate, 2008-13)	(+2.2)	(+0.8)	As a % of total OECD, 2012	1.8	100
Green productivity			**GERD intensity and growth**		
GDP per unit of CO_2 emitted, USD, 2011	4.5	3.0	As a % of GDP, 2012	1.30	2.40
(annual growth rate, 2007-11)	(+4.2)	(+1.8)	(annual growth rate, 2007-12)	(-0.4)	(+2.0)
Green demand			**GERD publicly financed**		
NNI per unit of CO_2 emitted, USD, 2011	4.4	3.0	As a % of GDP, 2011	0.66	0.77
(annual growth rate, 2007-11)	(+3.7)	(+1.6)	(annual growth rate, 2007-11)	(+1.7)	(+2.8)

Figure 9.41. **Science and innovation in Spain**

Panel 1. Comparative performance of national science and innovation systems, 2014



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

Hot issue 5: Addressing the challenges of STI globalisation and increasing international co-operation. By OECD standards Spain's science and innovation systems are not well integrated in international networks (Panel 1[q, r]). The government therefore seeks to expand Spain's participation in the European Commission's Joint Programming projects (e.g. ERA-NETs, JUs and JPIs). It will also foster international collaborative networks between research groups and centres. Spain participates in two future and emerging technologies (FET) initiatives: Graphene and the Human Brain Project. These EU-wide initiatives address science-driven, large-scale multidisciplinary research that offers substantial benefits for European competitiveness and society.

Highlights of the Spanish STI system

STI policy governance: The STI Act provides the legal framework for a new research funding and governance structure for the Spanish STI system through the creation of the State Research Agency (a funding body) and comprehensive reform of PRIs. The Act defines new governance mechanisms to ensure co-ordination of central and regional governments (Council for Science, Technology and Innovation Policy; Advisory Committee for Science, Technology and Innovation; and an STI information system to improve information sharing among central and regional administrations). In addition, the new Ministry for Economy and Competitiveness, created in 2012, took over the competences of the Ministry of Science and Innovation.

New sources of growth: Spain invests in enabling technologies, notably ICTs and biotechnology, which are important for health sciences and energy, but also space-related technologies. Spain has in recent years deepened its RTA in biotechnology and nanotechnologies, in environment-related technologies and in ICTs (Panel 3). Programmes and public-private partnerships (e.g. Strategic Action in Digital Society and Economy) target ICTs and research excellence projects and networks in biomedicine and health.

New challenges: Green innovation is a major focus, not least in renewable energy technologies. To support green growth, Spain has created an Environmental Technology Platform (PLANETA) to promote co-operation on environmental technologies by public and private research organisations.

Innovation in firms: BERD is below the OECD median (Panel 1[d]), and international comparisons of business innovation performance reveal weaknesses (Panel 1[e, f, g]), and SMEs outweigh large firms in terms of performing R&D (Panel 2). The economic crisis has also affected the number of companies carrying out R&D, which increased by 0.3% in 2012 from 2011, the first rise following a decline since 2008. A goal of the SSSTI is to increase BERD from 0.69% of GDP in 2012 to 1.20% in 2020. The government's structural reforms seek to improve the environment for business R&D and innovation by removing the limit on the amount of gross tax against which the tax credit for R&D can be taken and by substantially modifying the patent box tax relief. Finally, the Centre for Development of Industrial Technology (CDTI) offers information services to companies interested in developing R&D projects.

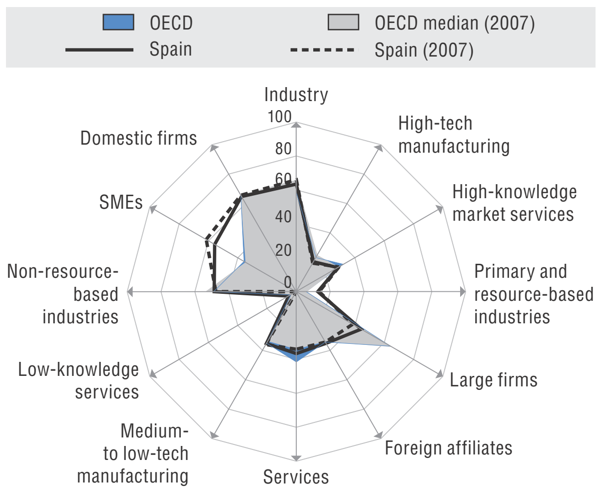
Innovative entrepreneurship: The rate of patenting by young Spanish firms is at the lower end of the middle range (Panel 1[i]). To address the lack of venture capital (Panel 1[h]) CDTI created in 2012 two venture capital firms (INNVIERTE programme) to promote venture capital in Spanish technological firms and support the creation and growth of new innovative firms. The CDTI remains responsible for funding industrial and innovative activities nearer to the market. It also supports the creation of business consortia in regions (e.g. Andalusia, Extremadura, Galicia) to develop strategic projects. The 2013 budget for these initiatives was USD 194 million (EUR 132 million).

ICT and Internet infrastructures: The Spanish government also attaches importance to of ICT infrastructure (the Digital Agenda for Spain 2013-20 replaces the Strategy for Avanza2). Support for ICT firms to innovate and conduct R&D (Strategic Action on Digital Society and Economy) amounted to USD 808 million (EUR 550 million). The Digital Agenda for Spain also includes ecommerce, eAdministration, health care, and telecommunication networks, with a budget of USD 1.5 billion (EUR 1 billion).

Technology transfer and commercialisation: Spanish PRIs and universities are quite active in patenting (Panel 1[p]). The challenge is to enhance the contribution of public research to the economy and society. Evaluations involving international assessment monitor and measure the impact and progress of *Campus de Excelencia Internacional*. The SSSTI (2013-20) has integrated technology and innovation activities with scientific research and aims to promote technology transfer through knowledge circulation and co-creation based on long-term public-private partnerships and commitments and reinforced researcher mobility between public and private research centres.

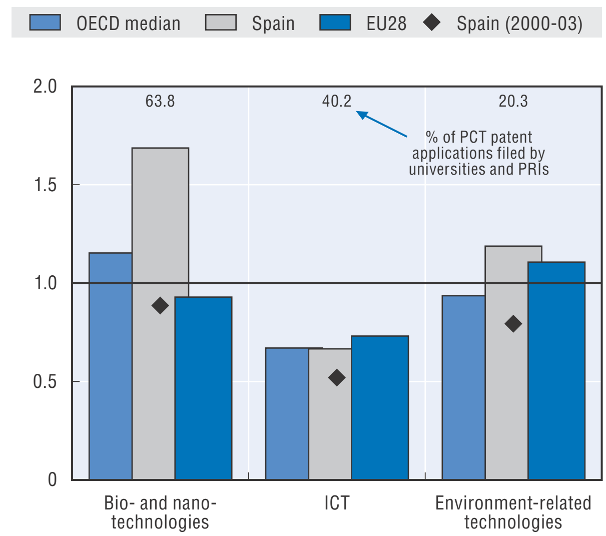
Panel 2. Structural composition of BERD, 2011

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

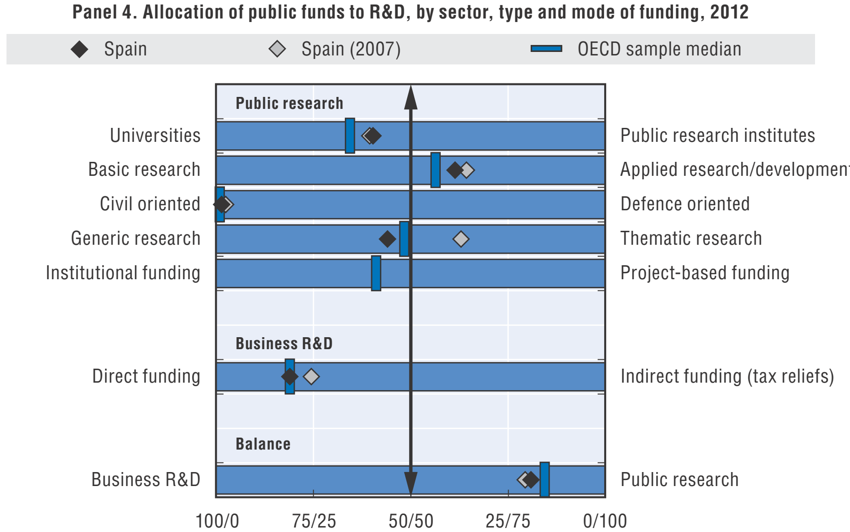


Panel 3. Revealed technology advantage in selected fields, 2009-11

Index based on PCT patent applications



Panel 4. Allocation of public funds to R&D, by sector, type and mode of funding, 2012



Note: Policy information comes from country responses to the OECD STI Outlook policy questionnaires 2014 and 2012. Spain's responses are available in the *OECD STI Outlook Policy Database*, edition 2014 at *http://qdd.oecd.org/Table.aspx?Query=AAB982AA-A642-472A-B5A0-8BE4A87288D0.*

Source: See reader's guide and methodological annex.

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SWEDEN

Following the 2008-09 crisis, Sweden's economy has grown significantly faster than that of the OECD area as a whole. Sustainable economic growth will depend on Sweden's future research and innovation performance. To secure Sweden's future as a leader in research and innovation, the government's Research and Innovation Bill 2013-16 establishes a more selective, quality-based funding approach, with a significantly increased government budget for R&D.

Hot issue 1: Innovation to contribute to addressing social challenges (including inclusiveness). Already in the 2008 research and innovation bill, the government presented 24 research areas of strategic importance for Swedish science, society and business, and invested USD 205 million (SEK 1.8 billion) a year. An additional USD 34.5 million (SEK 300 million) was invested in areas of strategic importance for society and business, following the research and innovation bill 2012. The Swedish Agency for Innovation Systems (VINNOVA), together with the Swedish Energy Agency and The Swedish Research Council Formas has launched a new initiative, Strategic Innovation Areas (SIA). VINNOVA has also launched a related programme, Challenge-Driven Innovation (CDI) to address specific social challenges and international competitiveness through "systems innovation". In both initiatives, the actors, primarily the main end users in industry and the public sector, are developing the agendas and defining the targets. Funding for SIA was around USD 16.8 million (SEK 145 million) in 2013, including around USD 2.3 million (SEK 20 million) from the private sector. It will increase to USD 145 million (SEK 1.25 billion) for 2016, with around 50% from the private sector.

Hot issue 2: Encouraging innovation in firms and supporting entrepreneurship and SMEs. BERD is relatively high, at 2.31% of GDP (Panel 1[d]), though substantially below the level of a decade ago. Industry R&D is concentrated in large firms, which dominate the Swedish economy. While venture capital investment as a share of GDP is at the top of the OECD middle range (Panel 1[h]), there are gaps in the supply of business angel and early-stage VC. In 2013, the public Innovation Bridge Foundation was merged into ALMI to develop a single public entity focused on early-stage funding, e.g. by offering risk-bearing loans, seed and expansion capital, as well as advisory services and incubator funding, to entrepreneurs and small businesses. VINNOVA's Research&Grow programme for innovative SMEs continues to be a key policy support measure worth USD 16.2 million (SEK 140 million) in 2013.

Hot issue 3: Reforming and improving the public research system (including university research). Public expenditure on R&D is high (Panel 1[a]). Much goes for research at Swedish universities, which are well placed in global rankings of world-class universities and publications (Panel 1[b, c]). HERD, at 0.92% of GDP in 2012, is the second highest in the OECD area. To raise the innovation-generating power of universities, the Swedish Research Council and VINNOVA are exploring ways to reform the incentive structures for university management and researchers created by the criteria and procedures for the distribution of basic funding (block grants) to universities.

Hot issue 4: Improving the framework conditions for innovation. Improving the framework conditions for innovation is a key theme of the recent National Innovation Strategy. A government-appointed committee was set up in 2011 to propose potential regulatory or tax reforms to improve conditions for business growth and R&D. Its recommendation to introduce R&D tax relief has been taken up by the government, which has proposed a 10% reduction in the employers' social security contributions for employees engaged in R&D. As the maximum total reduction per group will be USD 26 700 (SEK 230 000) a month, the tax relief will primarily benefit smaller firms.

Hot issue 5: Improving the governance of the innovation system and policy. The Ministry of Education and Research and the Ministry of Enterprise, Energy and Communications are largely responsible for research and innovation policy. A National Innovation Strategy was published in 2012 to improve co-ordination and to lay out the principles and direction of Swedish innovation policy with a 2020 perspective. Various agencies, led by VINNOVA, will monitor its implementation annually.

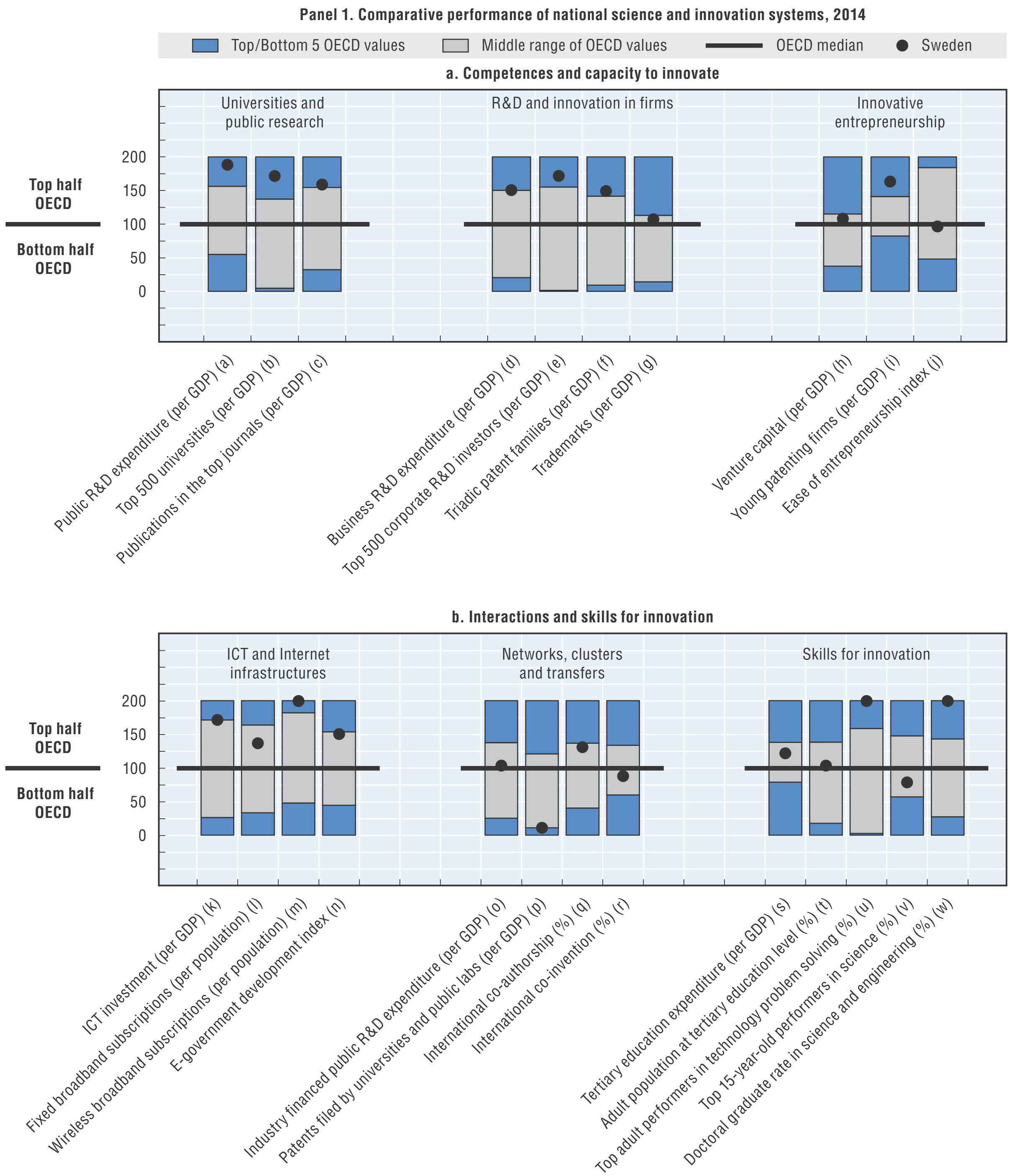
Highlights of the Swedish STI system

New sources of growth: Since 2012, the government has given USD 1 million (SEK 9 million) a year to VINNOVA to

Key figures, 2013

Economic and environmental performance	SWE	OECD	Gross domestic expenditure on R&D	SWE	OECD
Labour productivity			**GERD**		
GDP per hour worked, USD PPP, 2013	56.0	47.7	Million USD PPP, 2012	13 899	1 107 398
(annual growth rate, 2008-13)	(+1.0)	(+0.8)	As a % of total OECD, 2012	1.3	100
Green productivity			**GERD intensity and growth**		
GDP per unit of CO_2 emitted, USD, 2011	7.1	3.0	As a % of GDP, 2012	3.41	2.40
(annual growth rate, 2007-11)	(+2.7)	(+1.8)	(annual growth rate, 2007-12)	(+0.7)	(+2.0)
Green demand			**GERD publicly financed**		
NNI per unit of CO_2 emitted, USD, 2011	7.7	3.0	As a % of GDP, 2011	0.97	0.77
(annual growth rate, 2007-11)	(+2.7)	(+1.6)	(annual growth rate, 2007-11)	(+3.5)	(+2.8)

Figure 9.42. **Science and innovation in Sweden**



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

develop competence, support systems, networks, etc., for pre-commercial innovative procurement. From 2014, the Swedish Competition Authority (KKV) will have the main responsibility for practical support for public procurement, including innovative procurement. VINNOVA will, however, encourage agencies and municipalities to identify and specify their strategic development needs and targets, and this may eventually lead to innovative procurement.

Technology transfer and commercialisation: Closer collaboration between industry and academia is an integral part of the SIA and CDI programmes. Furthermore, other VINNOVA programmes, such as VINNVAXT and VINN Excellence Centres, as well as thematic programmes, aim to support mission-oriented, pre-competitive collaboration between R&D providers and industry. Several schemes continue to support centres of excellence at universities, which seek to create excellent academic research environments in which industry participates actively. The low number of patents filed by universities (Panel 1[p]) is due to the "professor's privilege" which entitles researchers (instead of institutions) to patent their inventions. The public research institutes, which were grouped into a single holding (known as RISE – the Research Institutes of Sweden Holding AB) in 2009, remain relatively small (Panel 4). Their purpose is to serve as a knowledge partner for businesses, as an intermediary between academia and industry, and as a nexus for participation in EU R&D projects.

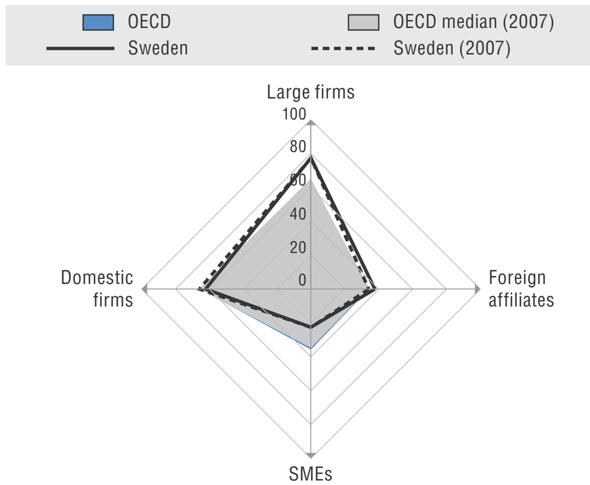
ICT and Internet infrastructures: ICT infrastructures are strong (Panel 1[k, l]). The programme ICT for Everyone – A Digital Agenda for Sweden was adopted in 2011. It sets an ICT policy goal for Sweden to become the world's leading economy in exploiting the opportunities of digitisation. Sweden's e-government development index is above the OECD median (Panel 1[n]). Preparations for the construction of the European Spallation Source (ESS) are now under way in Lund, as is the construction of Max the IV facility for a new-generation synchrotron radiation light source.

Skills for innovation: Sweden's share of doctorate graduates in science and engineering and adults' ability to solve technical problems top the OECD countries (Panel 1[w, u]). However, 15-year-olds' performance in science is below the OECD median (Panel 1[v]). Skill development is integral in most of VINNOVA's schemes. A specific on-going initiative in support of skill development is the Mobility for Growth scheme. In the new school curriculum, the teaching of entrepreneurship is mandatory. To attract overseas talent, the tax exemption rules for foreign experts and highly qualified personnel have been simplified, allowing those with remuneration above a ceiling value to be exempt from certain parts of income tax.

Recent developments in STI expenditures: Spending 3.41% of GDP on R&D (2012), Sweden has the world' fourth highest R&D intensity. The Research and Innovation Bill 2012 has increased the government budget for STI for 2013-16 by USD 464.6 million (SEK 4 billion) or by 15% compared to 2012.

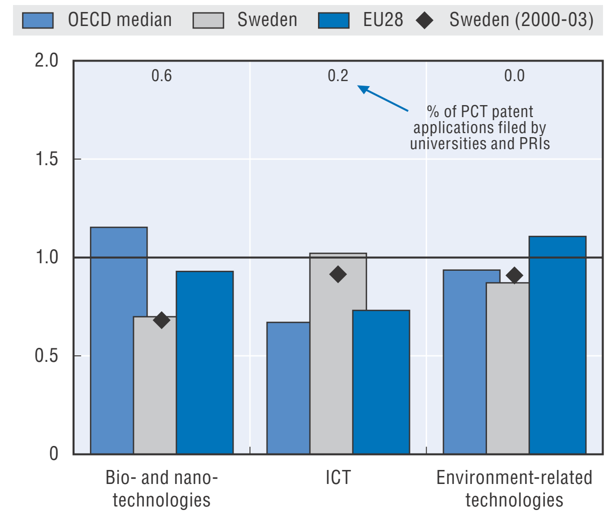
Panel 2. Structural composition of BERD, 2011

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

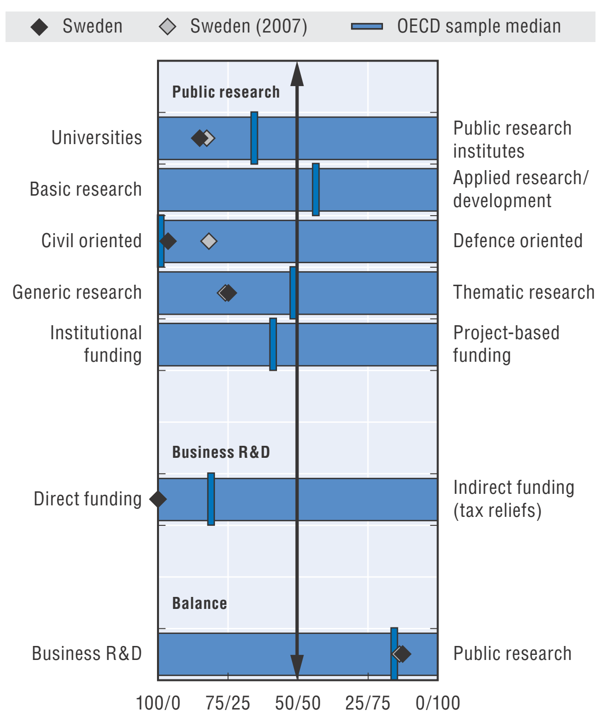


Panel 3. Revealed technology advantage in selected fields, 2009-11

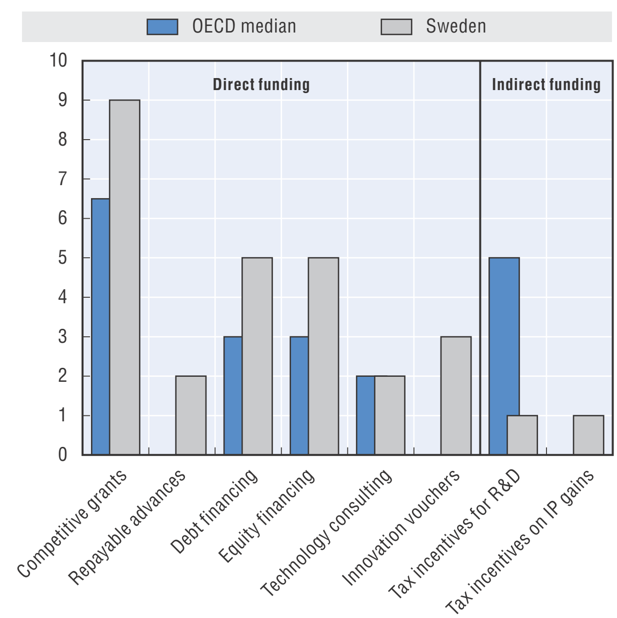
Index based on PCT patent applications



Panel 4. Allocation of public funds to R&D, by sector, type and mode of funding, 2012



Panel 5. Most relevant instruments of public funding of business R&D, 2014



Note: Policy information comes from country responses to the OECD STI Outlook policy questionnaires 2014 and 2012. Sweden's responses are available in the *OECD STI Outlook Policy Database*, edition 2014 at *http://qdd.oecd.org/Table.aspx?Query=4A329A44-560E-4875-AA34-14291D8061C6*.

Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888933152423

SWITZERLAND

Switzerland is a small open economy, with overall good performance and outstanding strengths in science, technology and innovation. Maintaining its leading position in global research and innovation is an overarching objective. The federal government's strategy document, Promotion of Education, Research and Innovation (ERI Dispatch) 2013-16, therefore aims to reinforce the high level of competition based public R&D investment, to increase the provision of well-qualified human resources and to ensure framework conditions that are conducive to innovation and help maintain Switzerland's position in international competition. The government's Financial Plan stipulates that the ERI budget should grow at an above-average rate of 3.7% a year during 2013-16, with a total planned federal expenditure of around USD 35.6 billion (CHF 26 billion). The Swiss Parliament approved 11 relevant budget lines totalling USD 32.9 billion (CHF 24 billion).

Hot issue 1: Improving public research. The Swiss science system is very productive: R&D expenditures of universities and public research institutes were 0.9% of GDP in 2012 (Panel 1[a]), and performance in scientific publications tops the OECD ranks (Panel 1[c]). Patenting by universities and PRIs is above the OECD median (Panel 1[p]).

The ERI Dispatch gives priority to strengthening Switzerland's international reputation as a competitive location for research and economic activities by increasing the amount of grant funding awarded on a competitive basis for research and innovation. The Swiss National Science Foundation (SNSF)'s Council initiated an evaluation of SNSF with a view to assessing and improving the SNSF's evaluation procedures in terms of their fairness and transparency and the extent to which they promote research excellence, increase the competitiveness of Swiss research and of researchers in Switzerland, and promote young researchers. The largely positive evaluation recommended a reform of the processes and procedures for external evaluations of funding applications, greater transparency through better documentation and information provision, and regular, systematic reviews and possible revisions of funding schemes.

Hot issue 2: Ensuring a supply of high-end HRST, including researchers. The country's tertiary-qualified adult population and the performance of 15-year-olds in science are slightly above the OECD median (Panel 1[t, v]). Doctoral graduates in S&E top the OECD ranks (Panel 1[w]). A lack of specialists is however perceived as an increasingly acute problem owing to demographic developments. It may be exacerbated by restrictions on immigration. In response, the September 2011 Specialists Initiative of the Federal Department of Economic Affairs (FDEA) was launched to meet the demand for specialists to a greater extent with Swiss human resources by 2020. The Law on Support and Co-ordination of Higher Education Institutes (LEHE) makes the federal and canton governments jointly responsible for the co-ordination and quality assurance of HEIs and constitutes a major reform of the Swiss higher education system. LEHE was adopted by the Federal Parliament in autumn 2011 but will not come into effect before 2015.

Hot issue 3: Improving framework conditions for innovation, including competitiveness. The Swiss government is committed to providing good framework conditions for innovation through a high-quality education system, a flexible legal framework, a reliable IPR system, the removal of regulatory constraints and good infrastructures. In 2013 the Commission for Technology and Innovation (CTI) introduced CTI KTT SUPPORT to foster knowledge and technology transfer (KTT) between research centres and firms. CTI also introduced national thematic networks (NTNs) aimed at boosting innovation capacity, especially through improved access for SMEs to scientific research findings. NTNs act as a bridge between industry and academia and provide industry with access to research-related facilities. Since 1 January 2013, eight have been accredited by CTI and are up and running. Innovation Mentors is a support measure to help create contacts and identify and implement ways of encouraging innovation. In 2013, nine innovation mentors were recruited to work at the CTI. The KTT Platforms bring together representatives from the world's business and science communities and provide a physical, interactive interface between innovation mentors and NTNs.

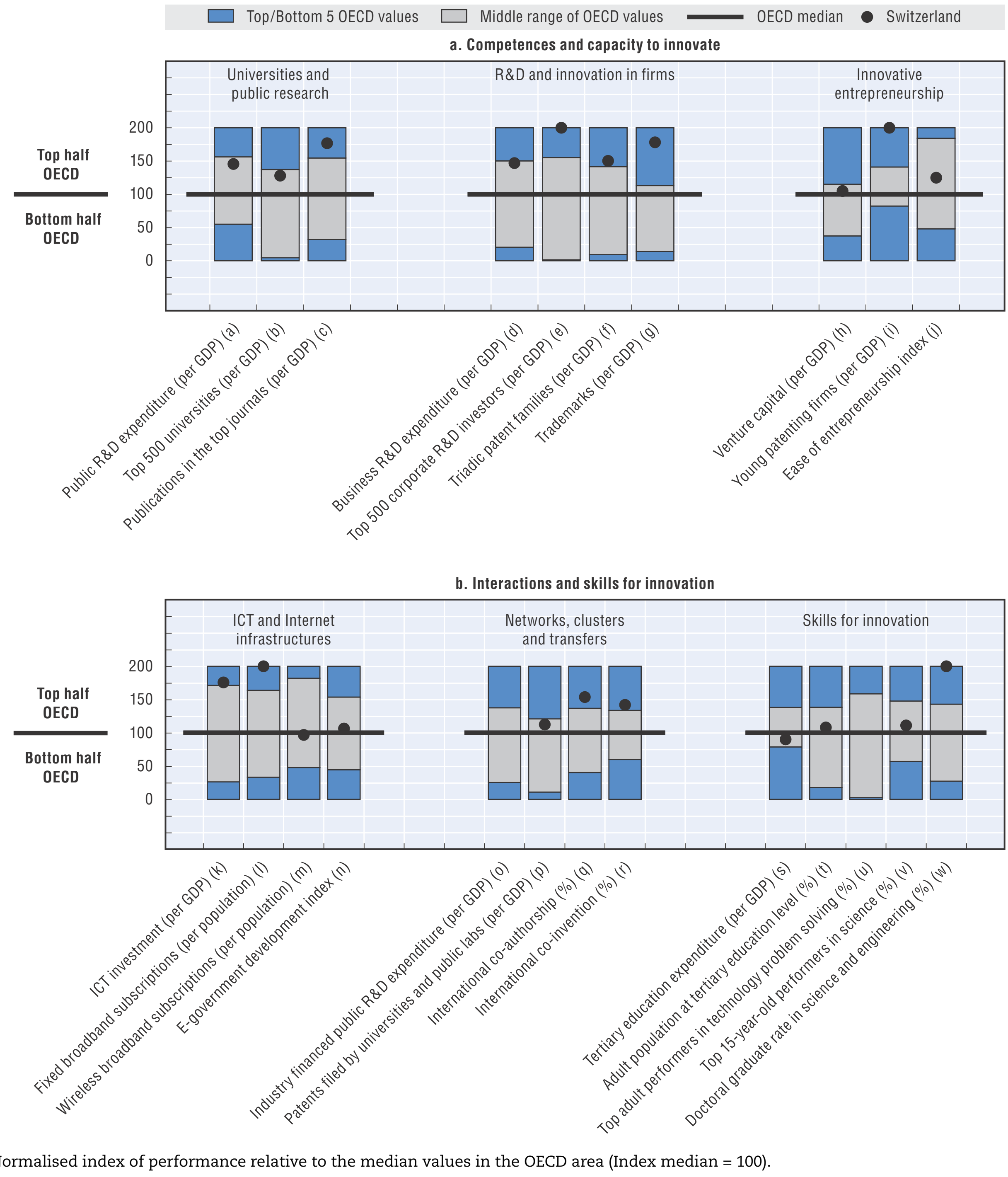
Key figures, 2013

Economic and environmental performance	CHE	OECD
Labour productivity		
GDP per hour worked, USD PPP, 2013	57.4	47.7
(annual growth rate, 2008-13)	(+0.4)	(+0.8)
Green productivity		
GDP per unit of CO_2 emitted, USD, 2011	7.7	3.0
(annual growth rate, 2007-11)	(+4.2)	(+1.8)
Green demand		
NNI per unit of CO_2 emitted, USD, 2011	8.2	3.0
(annual growth rate, 2007-11)	(+2.2)	(+1.6)

Gross domestic expenditure on R&D	CHE	OECD
GERD		
Million USD PPP, 2008	10 525	1 107 398
As a % of total OECD, 2008	1.1	100
GERD intensity and growth		
As a % of GDP, 2008	2.87	2.40
(annual growth rate, 2008-12)	n.a.	(+2.0)
GERD publicly financed		
As a % of GDP, 2008	0.72	0.77
(annual growth rate, 2008-12)	n.a.	(+2.8)

Figure 9.43. **Science and innovation in Switzerland**

Panel 1. Comparative performance of national science and innovation systems, 2014



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

Selected Highlights of the Swiss STI system

STI policy governance: Swiss governance features a reliance on bottom-up processes and federalism, with the Confederation and cantons sharing responsibility for research and higher education policy. Since 1 January 2013, the Federal Department of Economic Affairs (FDEA) has become the Federal Department of Economic Affairs, Education and Research (EAER), reflecting the integration of training, research and innovation as an economic policy issue. The State Secretariat for Education, Research and Innovation (SERI) at the EAER serves as the federal government's specialised agency for national and international matters concerning education, research and innovation policy.

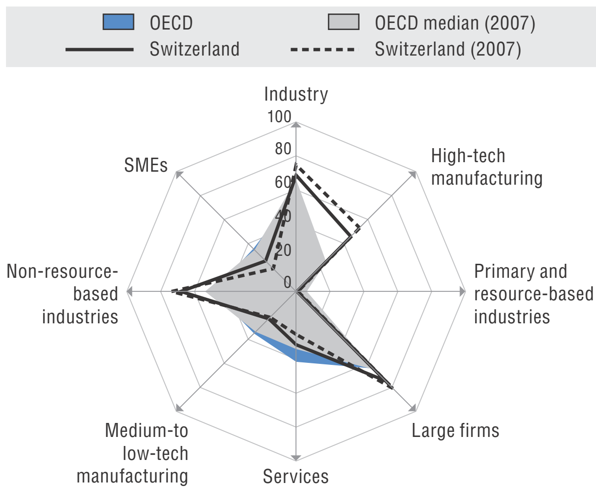
New challenges: The Federal Council has drawn up measures to secure the country's future energy supply. As part of its new Energy Strategy 2050, it emphasises increased energy savings (energy efficiency), the expansion of new renewable energies, and fossil fuel-based electricity production (cogeneration facilities, gas-fired combined-cycle power plants) and imports if necessary. Research on green energy is to play a strategic role in this context and will receive an additional USD 277 million (CHF 202 million) to support young scientists in energy-related research and to promote the "Energy" Programme and the inter-university Swiss Competence Centres for Energy Research.

Technology transfer and commercialisation: The CTI seeks to foster the development of innovative products and services by encouraging HEIs and companies to work together on joint R&D projects. A new initiative, CTI INNOVATION CHEQUE, gives firms an incentive to carry out R&D activities and facilitates their initial co-operation on innovation with public research facilities. Since the launch of the first batch of innovation cheques in September 2012, CTI has received a total of 272 applications, of which 38 were approved for funding in the Innovation Cheque budget for 2013.

Globalisation: Swiss research and innovation has strong international links (Panel 1[q, r]), and framework conditions for attracting FDI and human resources both in businesses and universities are generally favourable. A federal strategy for the internationalisation of education, research and innovation was adopted in 2010. On 13 September 2013, Parliament adopted the Federal decree on Swiss involvement in Horizon 2020 (2014-20) with USD 6 billion (CHF 4.4 billion) over a seven-year period. The federal government also earmarked some USD 31.9 million (CHF 23.3 million) for Swiss participation in the EU Co-operation in Science and Technology (COST) programme for 2013-16. For bilateral co-operation, the ERI Dispatch (2013-16) identified the BRICS countries, Japan and Korea as high priorities.

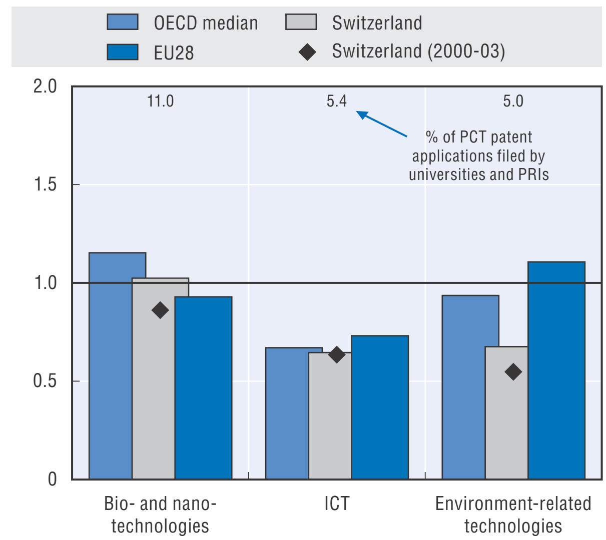
Panel 2. Structural composition of BERD, 2011

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

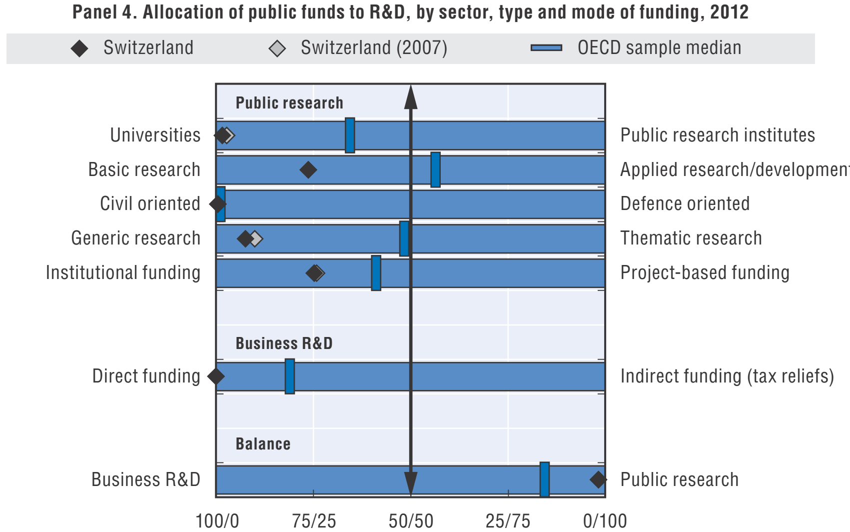


Panel 3. Revealed technology advantage in selected fields, 2009-11

Index based on PCT patent applications



Panel 4. Allocation of public funds to R&D, by sector, type and mode of funding, 2012



Note: Policy information comes from country responses to the OECD STI Outlook policy questionnaires 2014 and 2012. Switzerland's responses are available in the *OECD STI Outlook Policy Database*, edition 2014 at *http://qdd.oecd.org/Table.aspx?Query=C9BF6FC2-39A7-41DF-9EE9-D02491588642*.

Source: See reader's guide and methodological annex.

StatLink *http://dx.doi.org/10.1787/888933152434*

TURKEY

Turkey is a large, fast-growing, middle-income OECD economy. It has industrialised rapidly in recent years, although growth has slowed in the last two years. It has made significant strides in building up its STI capacities, and GERD grew by 8.2% annually over 2007-12. Currently, Turkey is in the process of deploying the National Science, Technology and Innovation Strategy (UBTYS) 2011-16, approved by the Supreme Council for Science and Technology (SCST).

Hot issue 1: Targeting priority areas/sectors. Turkey's National Science, Technology and Innovation Strategy (UBTYS) (2011-16) has a sectoral focus, with nine national priority sectors: automotive, machinery and manufacturing technologies, energy, ICT, water, food, defence, aerospace, and health. A high-level prioritisation meeting was established for each priority sector to determine technological needs through a consultative and consensus-building process. These were followed by studies to prepare technology roadmaps for sub-fields in these nine sectors. Since 2012, there were some 100 calls within the priority fields being launched through the call-based programme of the Scientific and Technological Research Council of Turkey (TÜBİTAK). Landmark projects, such as the domestic electric vehicles, are also part of Turkey's target-oriented support system. As cross-cutting technologies, biotechnology and nanotechnology, as well as ICT software R&D and innovation strategy and action plans are being prepared by the Ministry of Science, Industry and Technology (MoSIT), in support of the priority areas of UBTYS 2011-16.

Hot issue 2: Improving the design and implementation of STI policy. Turkey considers an ecosystem approach centred on the business sector and entrepreneurs crucial for a well-functioning innovation system. A policy-making approach based on the ecosystem concept has been in place since 2011. The high-level prioritisation groups, the Delphi surveys of experts in the sector concerned and the focus groups combine strategic and bottom-up initiatives and both qualitative and quantitative measures to set future sectoral priorities. Through this approach, there is broad and active participation by non-state actors. The Co-ordination Council for R&D, Innovation and Entrepreneurship aims to ensure the various public actors' integrity, coherence and target-oriented approach to the support mechanism. A special department has been set up in MoSIT for assessing the impact of Turkey's R&D and innovation support programme. TÜBİTAK has conducted an overall evaluation of the priority programmes from the supply-side perspective, using indicators to reveal strengths and weaknesses of different priority sectors. In 2014, MoSIT also published the Performance Index for Business Sector R&D Centres and Technoparks, which account for more than 60% of business R&D expenditure and employment.

Hot issue 3: Encouraging innovation in firms and supporting entrepreneurship and SMEs. Turkey's BERD was 0.42% of GDP in 2012, well below the OECD median (Panel 1[d]). BERD has increasingly concentrated on knowledge services at the expense of high-technology manufacturing (Panel 2). According to the World Bank's Ease of Doing Business Index, entrepreneurship conditions could be significantly improved. Support for entrepreneurship and SMEs is one of the priorities of the Supreme Council for Science and Technology, and several policy initiatives have been put in place. These include the development in 2012 of the Entrepreneurial and Innovative University Index to boost entrepreneurial and innovative activities in universities and to promote knowledge and technology transfer; the launch of several TÜBİTAK support programmes, such as the Venture Capital (Private Equity) Funding Programme (1514), the Individual Entrepreneurship (Phased) Support Programme (1512), the Individual Entrepreneurship Multi-Phased Co-Financing Programme (1512/B), and the Capacity Building for Innovation and Entrepreneurship Support Programme (1601), etc. MoSIT started the Technological Products Promotion and Marketing Programme in 2013 and the Technological Products Investment Support Programme in 2014. Both target firms that have previously received public/international R&D and innovation support.

Highlights of the Turkish STI system

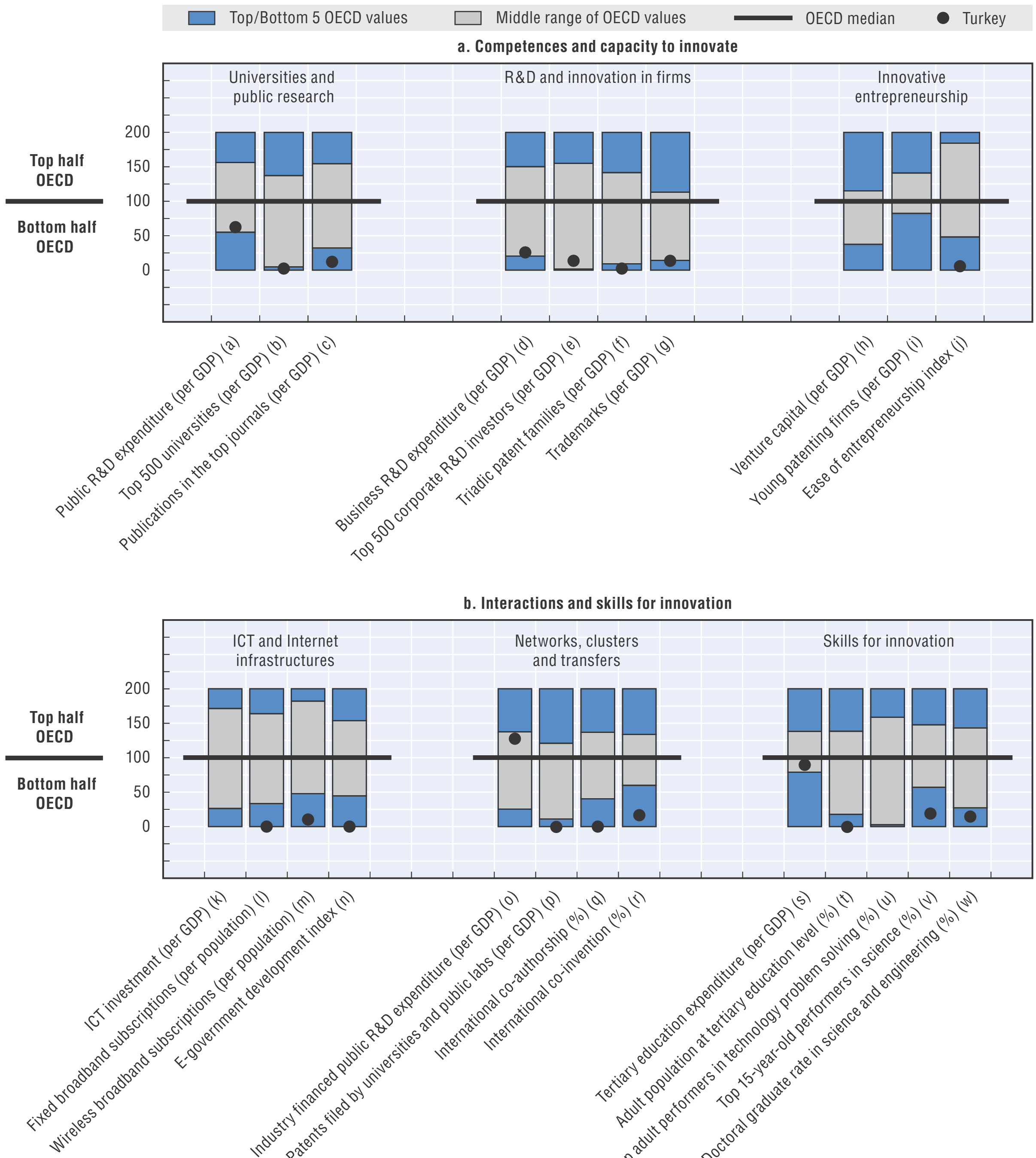
New challenges: The National Climate Change Action Plan (NCCAP) 2011-23 is Turkey's first green growth strategy. The goal of the Ministry of Energy is to reduce energy consumption by 20% per unit of GDP by 2023 (base 2011). The Technology Development Foundation of Turkey recently

Key figures, 2013

Economic and environmental performance	TUR	OECD	Gross domestic expenditure on R&D	TUR	OECD
Labour productivity			**GERD**		
GDP per hour worked, USD PPP, 2013	30.0	47.7	Million USD PPP, 2012	12 656	1 107 398
(annual growth rate, 2008-13)	(+0.5)	(+0.8)	As a % of total OECD, 2012	1.1	100
Green productivity			**GERD intensity and growth**		
GDP per unit of CO_2 emitted, USD, 2011	3.4	3.0	As a % of GDP, 2012	0.92	2.40
(annual growth rate, 2007-11)	(+0.0)	(+1.8)	(annual growth rate, 2007-12)	(+8.2)	(+2.0)
Green demand			**GERD publicly financed**		
NNI per unit of CO_2 emitted, USD, 2011	0.0	3.0	As a % of GDP, 2011	0.43	0.77
(annual growth rate, 2007-11)	n.a.	(+1.6)	(annual growth rate, 2007-11)	(+9.5)	(+2.8)

Figure 9.44. **Science and innovation in Turkey**

Panel 1. Comparative performance of national science and innovation systems, 2014



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

introduced a new Green Future Accelerator Fund with USD 10 million to step up the transfer of R&D results in green technology. Furthermore, under the coordination of TÜBİTAK, the Energy Efficiency Technology Roadmap was prepared, as one of the UBTYS's (2011-16) priority areas.

Universities and public research: Turkey's public research system is small (0.41% of GDP in 2012). It produces few international publications in top scholarly journals (Panel 1[c]) and has only one world-class university (Panel 1[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. Performance assessment has been reinforced in universities and PRIs, most notably based on a co-operation protocol signed between the Ministry of Development and TÜBİTAK to provide for the performance indicators, classification, and monitoring of current and future research centres. In 2013 TÜBİTAK introduced three new programmes to improve the efficiency of public research in universities. These include the Support Programme for Research, Technological Development and Innovation Projects in Priority Areas (1003), the Support Programme for Beginning Researchers (3001), and the Support Programme for National New Ideas and Products (1005). In addition, the Project Performance Award and the Incentive Programme for International Scientific Publications (UBYT) aim to reward successful projects and high-quality publications, respectively. In 2014, the SCST passed a new decree for a support programme that is open only to excellent research centres. MoSIT is preparing the University-Industry Cooperation Strategy and Action Plan, following 26 regional meetings of rectors, chambers of industry, researchers, SMEs and local stakeholders in 81 provinces during 2013.

Skills for innovation: Turkey has increased the number of full-time equivalent researchers three-fold since 2002 from a very low human resource base (Panel 1[s, t, v, w]). The National Science and Technology Human Resources Strategy and Action Plan (2011-16) aims to increase the contingent of R&D personnel, to foster a research culture, and to develop researchers' skills, mobility and employability. The Turkish Qualifications Framework, which seeks to improve the quality of education and training and to develop the qualifications required by the labour market, will be officially adopted in the second half of 2014. In addition, implemented by TÜBİTAK, the National Graduate Scholarship Programme supported 5 054 PhD students between 2000 and 2013, with 3 366 supported in 2013 alone, while the National Postdoctoral Research Fellowship Programme supported over 300 researchers over 2000-13. Ten international fellowships or grant programmes support the international mobility of Turkish and foreign students and researchers.

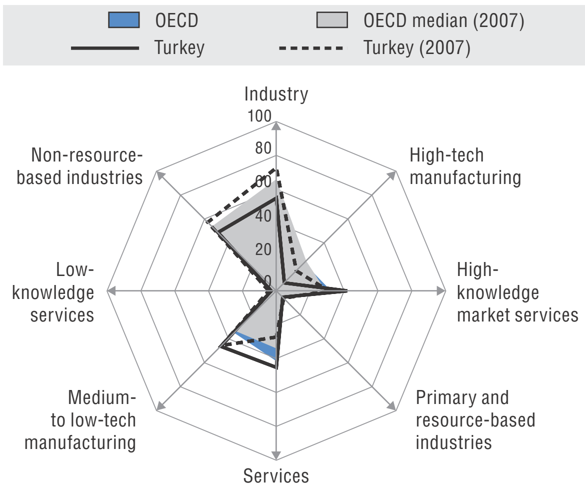
Clusters and smart specialisation: Smart specialisation and clustering have recently attracted policy attention. Provincial innovation platforms were set up in 2010 to stimulate co-operation and turn local knowledge into economic and social benefits. In 2011, TÜBİTAK launched a competitive funding programme to set up regional innovation platforms and local co-operation networks. The Law on Technology Development Zones fosters the creation of technology parks through support for infrastructure and tax incentives for companies and their R&D personnel in the parks. As of 2014, 55 zones have been established and 40 are in operation, whose performance is being monitored by MoSIT based on the Performance Index for Technoparks.

Technology transfer and commercialisation: By OECD standards universities and PRIs file few patents as a share of GDP (Panel 1[p]). In 2012, some existing programmes were revised, and new programmes, including TÜBİTAK's Technology Transfer Office Support Programme, were launched to facilitate the commercialisation of university R&D results and increase their impact on and benefit to society. The Patent Application Promotion and Support Programme, implemented by TÜBİTAK, was updated in 2013, in accordance with the needs of different stakeholders, to improve the quality and the quantity of patent applications.

Recent developments in STI expenditures: GERD grew significantly faster than the OECD average between 2007 and 2012. Business R&D spending recovered rapidly after the economic crisis. In 2012, GERD was 0.92% of GDP, and industry funded 46.8% of GERD (0.43% of GDP), up from 41% in 2009 (0.35% of GDP). The government is committed to sustained investment in STI and sets the targets for GERD and BERD at 3% and 2% of GDP, respectively, by 2023.

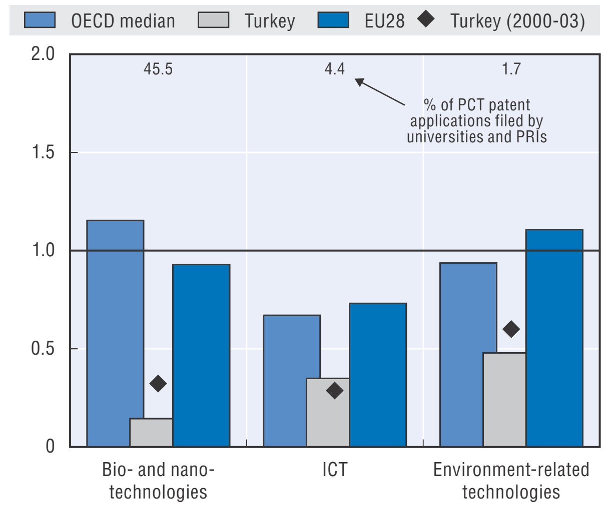
Panel 2. Structural composition of BERD, 2011

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

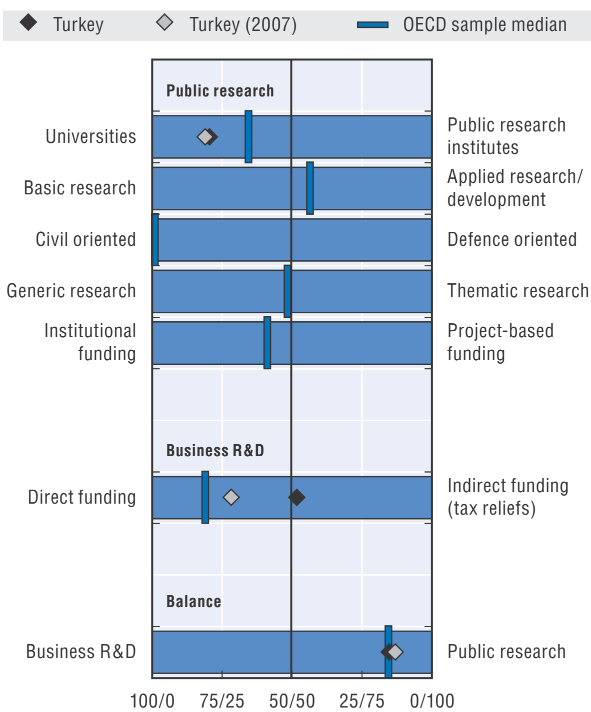


Panel 3. Revealed technology advantage in selected fields, 2009-11

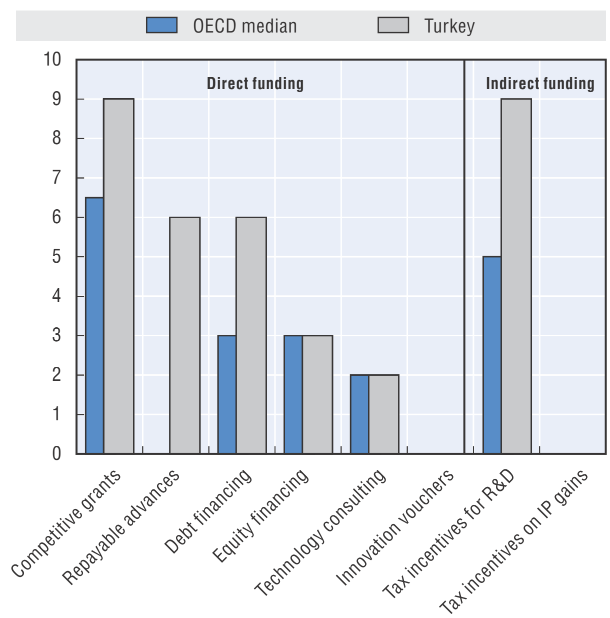
Index based on PCT patent applications



Panel 4. Allocation of public funds to R&D, by sector, type and mode of funding, 2012



Panel 5. Most relevant instruments of public funding of business R&D, 2014



Note: Policy information comes from country responses to the OECD STI Outlook policy questionnaires 2014 and 2012. Turkey's responses are available in the *OECD STI Outlook Policy Database*, edition 2014 at *http://qdd.oecd.org/Table.aspx?Query=1040551D-1182-4AB9-B2F2-BB4554354911*.

Source: See reader's guide and methodological annex.

StatLink *http://dx.doi.org/10.1787/888933152442*

UNITED KINGDOM

The United Kingdom is a very open economy, and its STI system enjoys a high level of funding and participation by foreign firms. In 2012, the government launched the Industrial Strategy, which focuses innovation policy on areas where government action can have a real and early impact.

Hot issue 1: Targeting priority areas/sectors – new industrial policy. The government's Industrial Strategy seeks to develop strategic partnerships with industry in 11 sectors. These are sectors in which the United Kingdom leads or has the potential to lead the world and which may be able to stimulate growth throughout the economy. The most significant of these are the co-funded Aerospace Technology Institute (USD 2.8 billion or GBP 2 billion), the Automotive Advanced Propulsion Centre (USD 1.5 billion or GBP 1 billion) and the Centres for Agricultural Innovation and an Agri-Tech Catalyst (USD 231 million or GBP 160 million).

The Industrial Strategy also sees the government investing in eight cross-platform emerging technologies for which the United Kingdom has the depth of research expertise and the business capability to make the most of them, with a budget of USD 879 million (GBP 600 million) in 2012. In addition, the government is developing a network of Catapult Centres, which give businesses access to specialist equipment and emerging technologies and connect them to other companies and to academic expertise.

Hot issue 2: Addressing challenges of STI globalisation and increasing international collaboration. UK researchers are well integrated in international networks (Panel 1[q, r]). Several initiatives promote strong links with emerging countries. For example, the Technology Strategy Board (TSB) has launched two jointly funded collaborative R&D programmes with China (on sustainable manufacturing technologies) and with India (on affordable health care and clean technology, particularly energy systems), worth a total of USD 15 million (GBP 10 million). The government is also investing USD 115 million (GBP 80 million) in the Global Collaborative Space Programme over five years to co-operate with emerging countries in developing space capabilities and technology. A further USD 108 million (GBP 75 million) will be invested annually to improve the research and innovation capacity of emerging countries and to build research partnerships with the United Kingdom.

Hot issue 3: Encouraging innovation in firms and supporting entrepreneurship and SMEs. The UK government has taken several measures to increase innovation in companies and support SMEs, especially through TSB programmes. In the 2013 Budget, the government announced an expansion of the Small Business Research Initiative (SBRI), which seeks to drive innovation through public procurement. This expansion will involve specific targets for key departments with the expectation that the value of procurement contracts via SBRI will increase from USD 57 million (GBP 40 million) in 2012-13 to over USD 290 million (GBP 200 million) in 2014-15. In 2012, the Innovation Vouchers programme was formally launched to enable start-up, micro, small and medium-sized UK businesses to access up to USD 7 000 (GBP 5 000) worth of advice and expertise from universities, research organisations or other private-sector knowledge providers. The Launchpads scheme supports the development and strengthening of clusters of high-technology companies in specific technologies and geographical locations. Launchpads provide base funding through approved R&D projects and acts as a catalyst to help the companies behind the projects to attract more investment. The United Kingdom is also currently setting up a new national development bank, the British Business Bank, to increase the supply and diversity of finance available for UK SMEs.

Highlights of the UK STI system

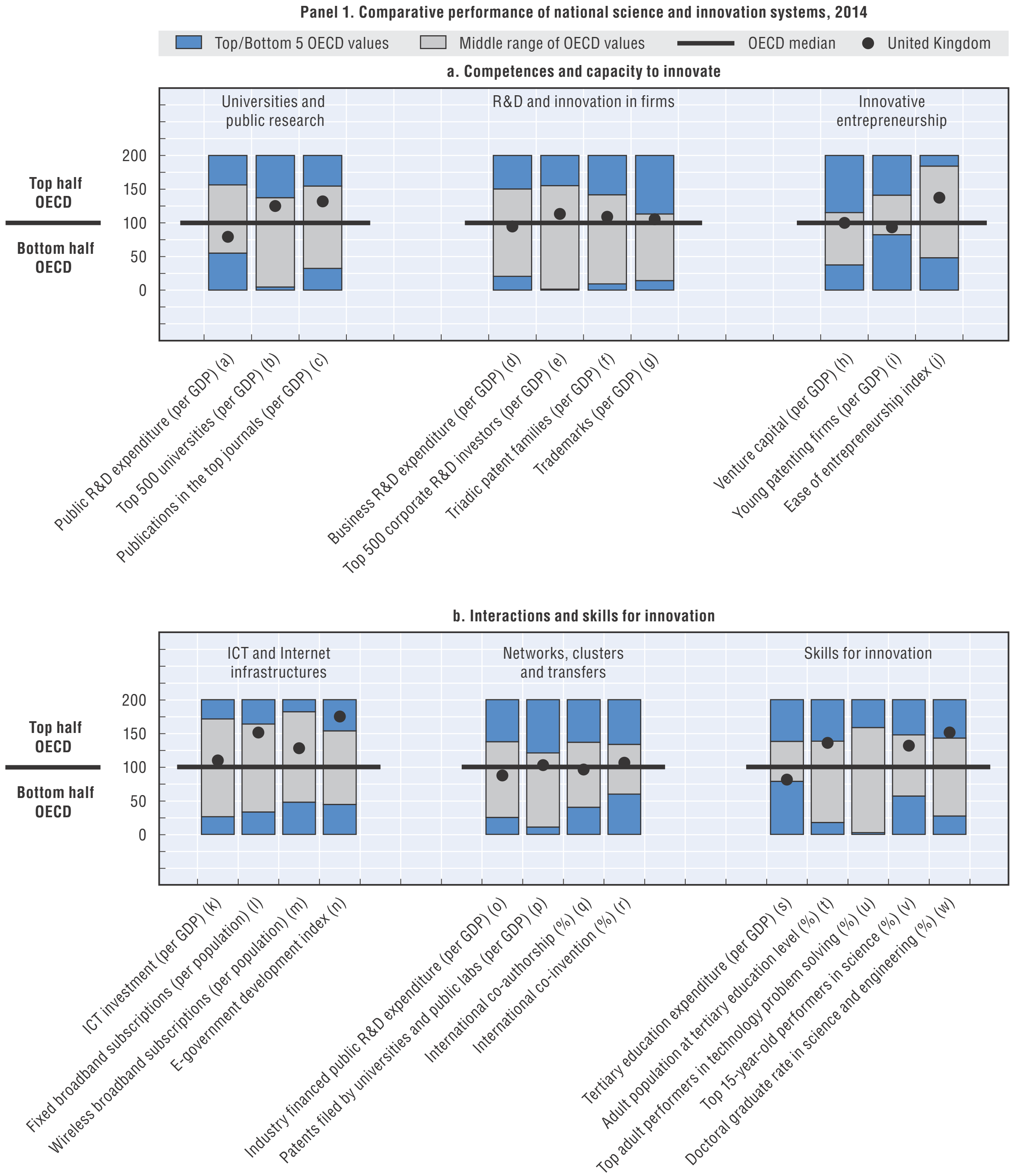
STI policy governance: The United Kingdom is increasingly investigating the feasibility and advantages of systems evaluations because it considers that evaluations of individual policy tools may not reveal the true extent of their impact in complex contexts. The TSB's review of the Low Carbon Vehicles Innovation Platform is an early example of the systems approach to evaluation.

Universities and public research: The United Kingdom is among the top performers in publication counts (Panel 1[c]) and boasts a large share of the world's leading universities

Key figures, 2013

Economic and environmental performance	GBR	OECD	Gross domestic expenditure on R&D	GBR	OECD
Labour productivity			**GERD**		
GDP per hour worked, USD PPP, 2013	46.6	47.7	Million USD PPP, 2012	39 110	1 107 398
(annual growth rate, 2008-13)	(-0.7)	(+0.8)	As a % of total OECD, 2012	3.5	100
Green productivity			**GERD intensity and growth**		
GDP per unit of CO_2 emitted, USD, 2011	4.8	3.0	As a % of GDP, 2012	1.73	2.40
(annual growth rate, 2007-11)	(+4.4)	(+1.8)	(annual growth rate, 2007-12)	(-0.8)	(+2.0)
Green demand			**GERD publicly financed**		
NNI per unit of CO_2 emitted, USD, 2011	4.4	3.0	As a % of GDP, 2012	0.52	0.77
(annual growth rate, 2007-11)	(+3.9)	(+1.6)	(annual growth rate, 2007-12)	(-2.3)	(+2.8)

Figure 9.45. **Science and innovation in the United Kingdom**



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

(Panel 1[b]), which are active in research and patent applications. Academic excellence plays a large part in university research funding, with block grant allocations dependent on the results of the Research Excellence Framework (REF) exercise for assessing research quality. In 2013, the government published additional guidelines for reviews of PRIs with principles that help reviewers identify and assess the specific role and impact of individual institutes.

Research Councils UK implemented an updated open access policy in 2013 and provided funding to over 100 universities to support its implementation. New measures in this respect include the Gateway to Research (*http://gtr.rcuk.ac.uk*), which enables text and data mining for research, and a freedom of information research exemption, and the Research Sector Transparency Board, which, established in 2012, advises government on how to increase access to research data.

Innovation in firms: The relative importance of R&D and innovation tax incentives in overall public support for business R&D and innovation has increased recently. The R&D tax credit rate for SMEs has risen to 225% and the minimum threshold of eligible expenditures was abolished as of 2012. An R&D expenditure credit (RDEC) scheme was introduced in 2013 and is slightly more generous than the large company R&D tax relief. It will replace the current tax credits from 2016. The R&D Allowance (RDA), formerly known as the scientific research allowance, gives relief for capital expenditures on R&D. The Patent Box scheme was introduced in 2013 to provide an additional incentive for companies to retain and commercialise existing patents.

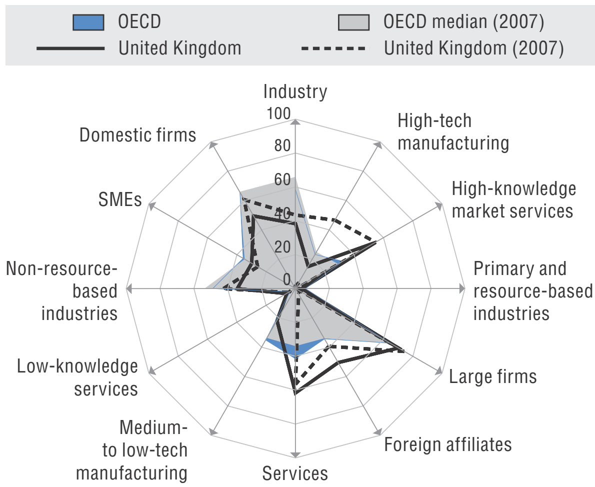
Innovative entrepreneurship: New legislation on copyright will be in force from 2014 to reflect the radical changes the digital revolution has brought to the creation and distribution of creative, scientific and academic material. The legislation extends the existing exceptions to copyright, but with suitable safeguards for rights holders. Other measures that can help IP holders improve the efficiency of IP application and protection include the Intellectual Property Office IP for Business toolkit and the Intellectual Property Enterprise Court.

Skills for innovation: The Department for Education (DfE) is spending up to USD 200 million (GBP 135 million) over four years (2011-15) on support for science, technology, engineering and mathematics in schools. Measures include STEMNET, which works with thousands of schools, colleges and STEM employers, to enable young people of all backgrounds and abilities to meet inspiring role models, understand real-world applications of STEM subjects, and experience hands-on STEM activities. The government is also providing more generous bursaries and scholarships to increase the number and quality of science and mathematics teachers in schools. The country continues to suffer shortfalls in engineering skills, as highlighted in the 2013 Perkins' Review of Engineering Skills, which calls on the government and the engineering community to focus their efforts on inspiring the engineers of the future and addressing skills shortages in the industry. The review makes 22 recommendations, focusing on inspiration, academic foundations, vocational education and higher education.

In tertiary education, government controls on total student numbers in publicly funded HEIs will be removed from 2015-16, allowing all institutions to compete freely for all suitably qualified students. The government anticipates that this will allow up to 60 000 additional, suitably qualified students to enter higher education. Moreover, through its funding of universities, the government will encourage universities to focus the additional places on STEM subjects, which are considered central to long-term economic growth.

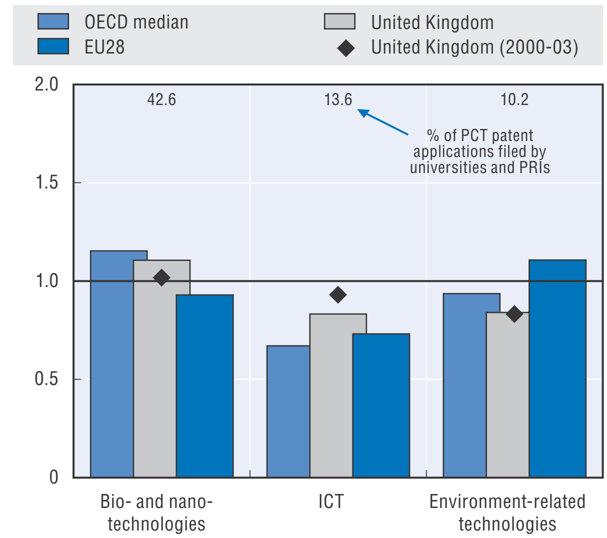
Panel 2. Structural composition of BERD, 2011

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

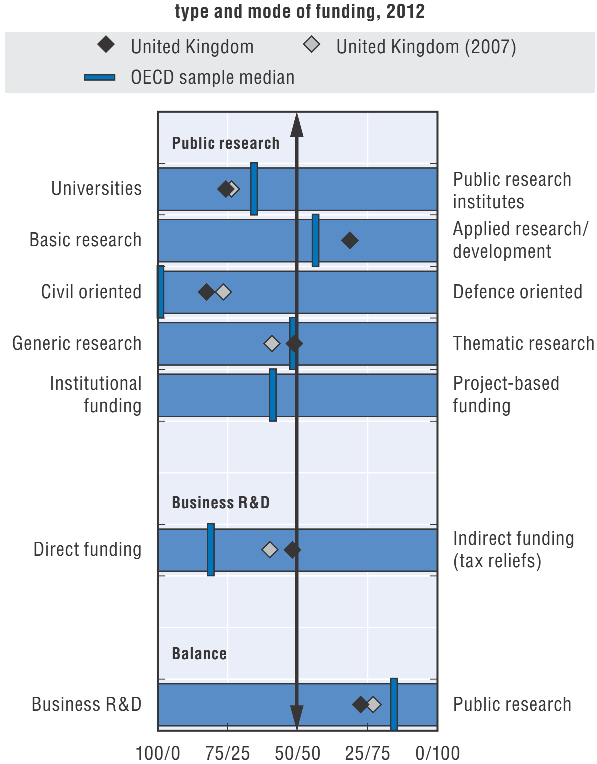


Panel 3. Revealed technology advantage in selected fields, 2009-11

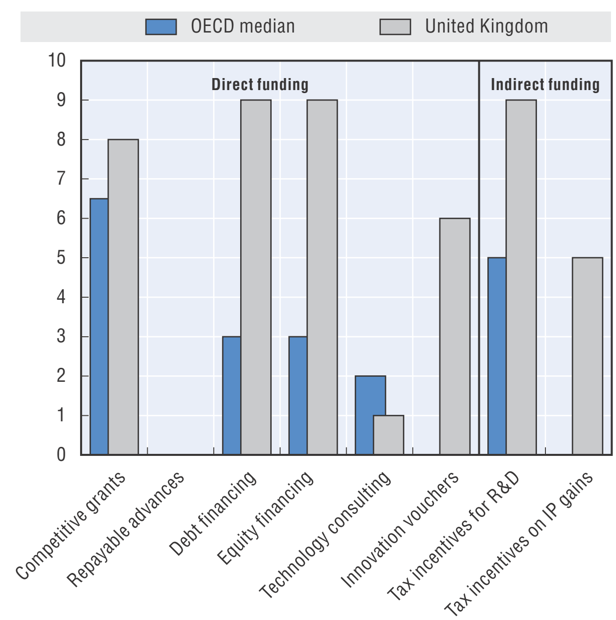
Index based on PCT patent applications



Panel 4. Allocation of public funds to R&D, by sector, type and mode of funding, 2012



Panel 5. Most relevant instruments of public funding of business R&D, 2014



Note: Policy information comes from country responses to the OECD STI Outlook policy questionnaires 2014 and 2012. The United Kingdom's responses are available in the *OECD STI Outlook Policy Database*, edition 2014 at *http://qdd.oecd.org/Table.aspx?Query=267C6F83-9320-4084-8AC4-732422AF9AA0*.

Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888933152452

UNITED STATES

The United States has long been, and still is, at the forefront of cutting-edge science, technology and innovation. However, indicators such as business innovation surveys and data on 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 and re-released in February 2011, provides the strategic directions for government policies to further an innovation-based economy.

Hot issue 1: Improving the framework conditions for innovation (including competitiveness). Overall, US STI policy is oriented to job creation, laying the foundations for future industries, and improving economic competitiveness. Several reforms to the patent system aim to bolster innovation. The America Invents Act of 2011 switched the US patent regime from the previous "first to invent" to a "first to file" system for patent applications filed on or after 16 March 2013. The Act also aims to improve patent quality and increase inventors' ability to protect intellectual property abroad. The US Patent and Trademark Office now offers a fast-track option for processing a patent within 12 months, reducing patent backlogs and limiting litigation.

Hot issue 2: Strengthening public R&D capacity and infrastructures. Overall, the United States has the world's largest and strongest science base, although this may not be very apparent in the aggregate performance indicators, which are around or below the OECD median (Panel 1[a, b, c]). For instance, the United States is home to 35 of the world's top 50 universities, and accounts for 26% of the world's articles in science and engineering. In addition to generating many publications, universities and PRIs are active in filing patents (Panel 1[p]), especially in bio- and nano- technologies (Panel 3). Under the President's Plan for Science and Innovation, the federal government prioritises investing in basic research capacity and in robust research infrastructure, including cyber infrastructure. Its support of basic and applied research increased from USD 59 billion in 2008 to a proposed USD 68.1 billion in 2014. In the 2014 budget, research accounts for 48% of total government R&D funding, up from 39% in 2008, with a concomitant decline in the share of development funding.

Hot issue 3: Improving overall human resources, skills and capacity building. With the second highest share of GDP spent on higher education in the OECD area, the United States has a good skills foundation and a high share of tertiary-qualified workforce (Panel 1[s, t]). However, there has been a relative decline in doctoral graduates in science and engineering and 15-year-olds perform below the OECD median in science (Panel 1[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. President Obama's call for a new effort to prepare 100 000 STEM teachers was renewed in 2013, and in June 2013 the Five-Year Strategic Plan for Federal STEM Education (2013-17) was released. The 2014 budget sets a goal of increasing by a third (or by one million) the number of well-prepared college graduates with STEM degrees over the next decade. The federal budget invests USD 3.1 billion overall in programmes on STEM education.

Hot issue 4: Innovation to contribute to sustainable/green growth. The federal government envisions a United States that leads the world in the research, development, demonstration and deployment of clean energy technology. The 2014 budget proposed USD 7.9 billion for clean energy technologies; USD 379 million for transformational energy R&D in advanced research projects of the Department of Energy (DOE), and USD 2.8 billion for DOE's Energy Efficiency and Renewable Energy Office, with a focus on improving clean vehicles and on developing advanced materials.

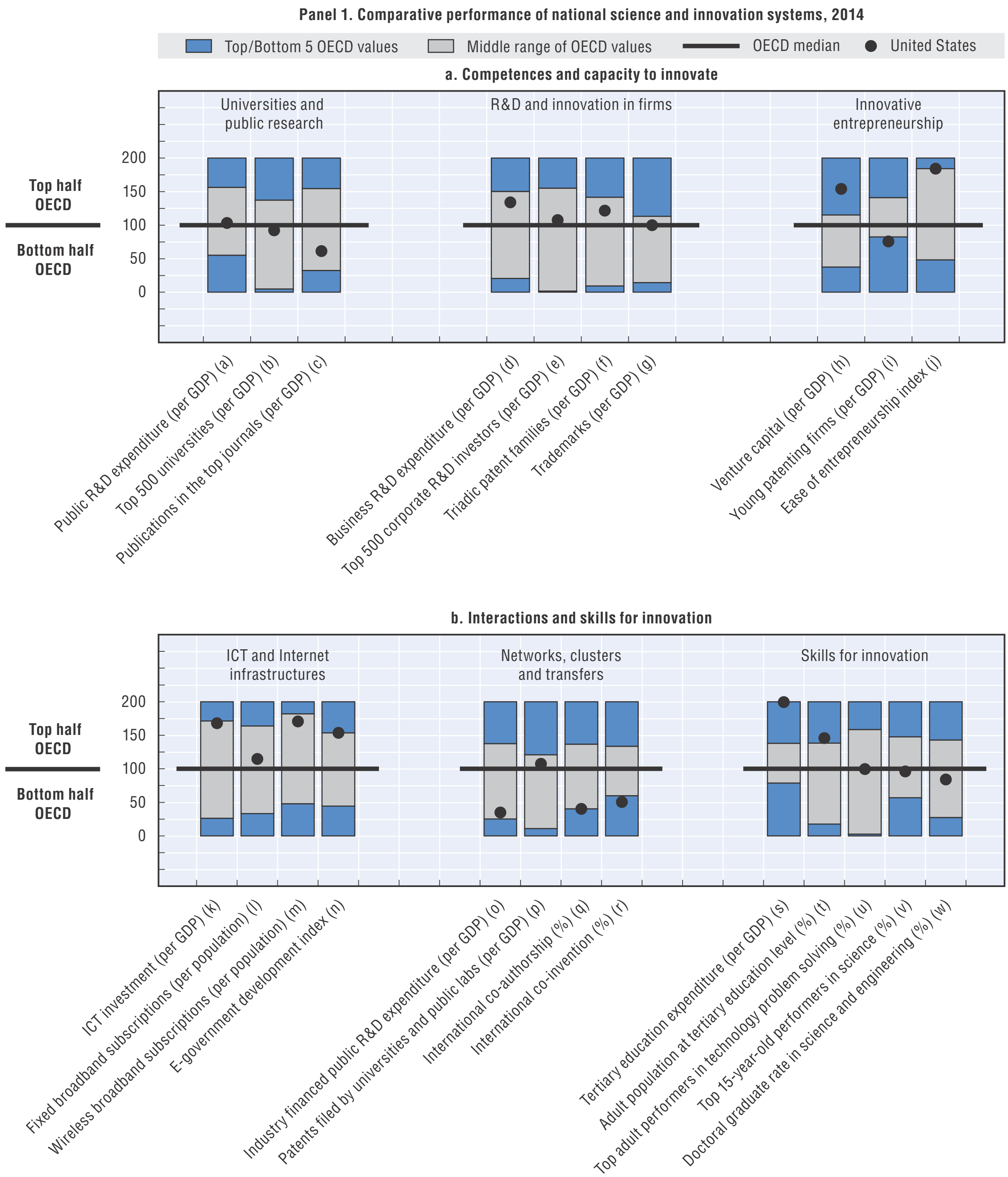
A Climate Action Plan was announced in June 2013 to address the impacts of global climate change. The 2014 budget proposes USD 2.7 billion for the US Global Change Research Programme (USGCRP) to better understand, predict, mitigate and adapt to global climate change.

Hot issue 5: Improving the returns and impact of science. 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 further implemented in 2014. Additionally, a second

Key figures, 2013

Economic and environmental performance	USA	OECD	Gross domestic expenditure on R&D	USA	OECD
Labour productivity			**GERD**		
GDP per hour worked, USD PPP, 2013	66.6	47.7	Million USD PPP, 2012	453 544	1 107 398
(annual growth rate, 2008-13)	(+1.5)	(+0.8)	As a % of total OECD, 2012	41.0	100
Green productivity			**GERD intensity and growth**		
GDP per unit of CO_2 emitted, USD, 2011	2.5	3.0	As a % of GDP, 2012	2.79	2.40
(annual growth rate, 2007-11)	(+1.9)	(+1.8)	(annual growth rate, 2007-12)	(+2.0)	(+2.0)
Green demand			**GERD publicly financed**		
NNI per unit of CO_2 emitted, USD, 2011	2.5	3.0	As a % of GDP, 2012	0.94	0.77
(annual growth rate, 2007-11)	(+1.9)	(+1.6)	(annual growth rate, 2007-12)	(+3.1)	(+2.8)

Figure 9.46. **Science and innovation in the United States**



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

Open Government National Plan was released, which revised the Plan of 2012. In 2013, *data.gov*, which provides information and tools to leverage federal datasets, was expanded to improve public access.

Highlights of the US STI system

STI policy governance: Because of fiscal austerity, federal R&D investments are expected to decrease from USD 147 billion in 2010 to USD 142.7 billion in 2014, but then to rebound. Efforts have been made to strengthen STI policy and evaluation. In 2013, new guidance was published to strengthen the federal grant-making process by streamlining eight federal regulations to be fully implemented in 2014. Federal agencies jointly identified a Roadmap for Science of Science Policy (SOSP) in 2008 and have been working since to improve evaluation and impact assessment of science. In addition, the National Science Foundation is carrying out a research programme on the Science of Science and Innovation Policy to build an analytical and knowledge base for SOSP and an academic SOSP community.

New sources of growth: The 2014 federal budget invests USD 2.9 billion in order to create high-quality manufacturing jobs and make America a magnet for manufacturing. The aim is to expand R&D on innovative manufacturing processes, advanced industrial materials and robotics, to encourage entrepreneurship, and to improve the transition from discovery to the marketplace.

New challenges: Improving the health of Americans, while maintaining American leadership in biomedical research and building the bioeconomy of the future, is an emerging policy issue. The Administration is committed to funding health research with a focus on neuroscience and on increasing the impact of these investments on health outcomes. Launched with USD 100 million in 2014, the BRAIN initiative searches for new ways to treat, cure and prevent brain disorders, such as Alzheimer's disease, epilepsy and traumatic brain injury.

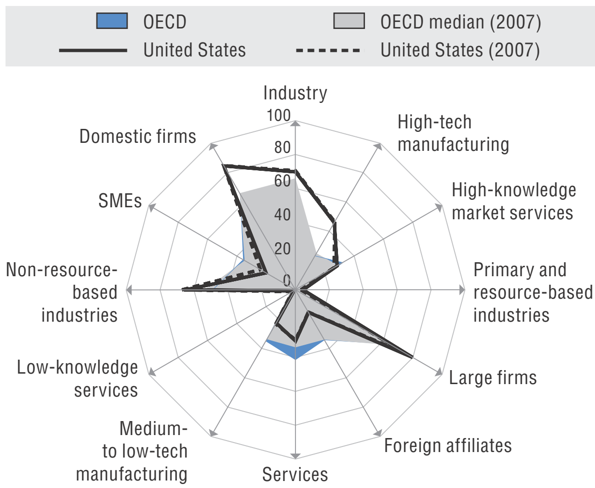
Innovation in firms: While public funding of business R&D has declined since 2008, primarily because of declines in defence budgets, more emphasis has recently been placed on direct support for business R&D and innovation. The Research and Experimentation Tax Credit expired in 2013, however, negotiations continue on a retroactive extension. Over the next several years, a greater share of US R&D investments for competitive R&D 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 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.

Technology transfer and commercialisation: US federal agencies continue to make progress on reshaping their priorities and programmes to meet the goals laid out in the President's October 2011 Memorandum on Accelerating Technology Transfer and Commercialization of Federal Research in Support of High Growth Businesses. The environment for innovative entrepreneurship is very good (Panel 1[h, j]). In late 2011, the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programmes were re-authorised through 2017 and expanded. The SBIR funds R&D and innovation activities in SMEs and young firms, and the STTR supports collaboration on R&D by SMEs and universities.

Clusters and smart specialisation: The federal government works with agencies such as the Small Business Administration and the Economic Development Administration to develop regional clusters on advanced technologies (e.g. robotics, energy, cybersecurity), food systems, broadband and recreation. The Office of Innovation and Entrepreneurship promotes entrepreneurship at the regional level through the i6 Challenge, a multiagency competitive grant programme.

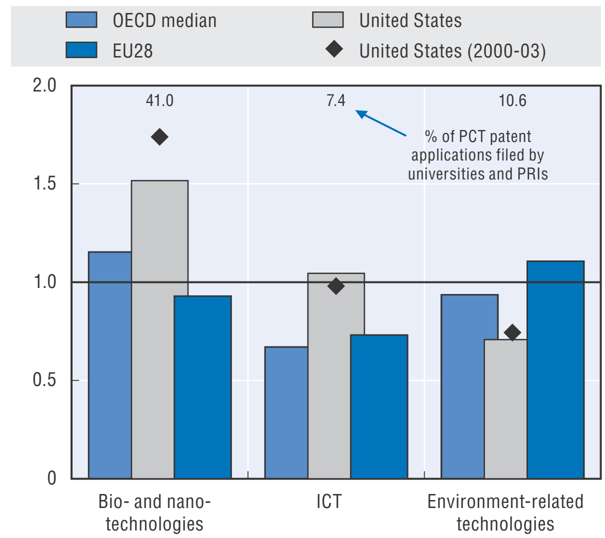
Panel 2. Structural composition of BERD, 2011

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

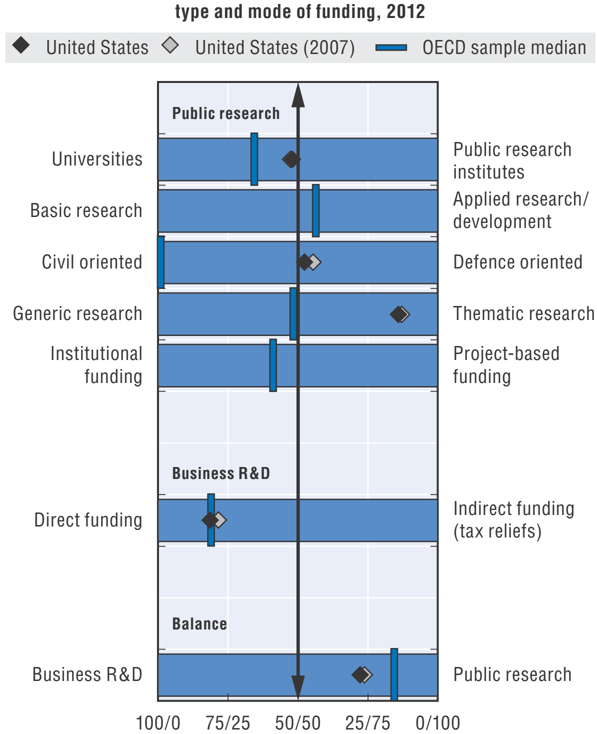


Panel 3. Revealed technology advantage in selected fields, 2009-11

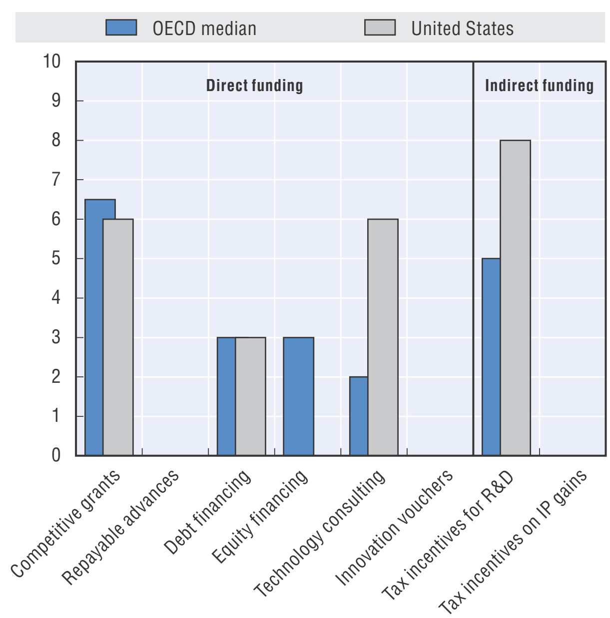
Index based on PCT patent applications



Panel 4. Allocation of public funds to R&D, by sector, type and mode of funding, 2012



Panel 5. Most relevant instruments of public funding of business R&D, 2014



Note: Policy information comes from country responses to the OECD STI Outlook policy questionnaires 2014 and 2012 and the OECD Economic Survey of the United States, 2012. The United States' responses are available in the *OECD STI Outlook Policy Database*, edition 2014 at *http://qdd.oecd.org/Table.aspx?Query=BFE08001-3733-4D05-A8F3-537B47DCF18E*.

Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888933152463

EUROPEAN UNION

The European Union's 28 member states account for 25% of world GDP and 15% of world trade (excluding intra-EU trade) as well as nearly 31% of OECD-area GERD. EU members are at different stages of economic development and their STI capabilities also differ, as do their industrial and trade structures. The EU's Horizon 2020, adopted at the beginning of 2014, sets the strategic direction for EU research and innovation policy and investment until 2020.

Hot issue 1: Improving the design and implementation of STI policy. Assessing national research and innovation policy and reform programmes is a key function of the European Commission's Directorate General for Research and Innovation. As part of the Europe 2020 Strategy, the Commission introduced the European semester mechanism to undertake detailed analyses of members' economic and structural policy and reform efforts, including research and innovation (R&I) policy, and to provide recommendations for the following 12-18 months. It also monitors the performance of R&I in member states with a focus on the impact of R&I investments and reforms on economic growth and prosperity and progress towards the Europe 2020 R&I goals.

Hot issue 2: Addressing societal challenges (including inclusiveness). Horizon 2020, the new EU Framework Programme for Research and Innovation, focuses on major societal challenges (health and ageing, energy efficiency, sustainable transport, etc.). It facilitates the transfer of innovative ideas to the marketplace by financing relevant research and innovation projects.

Hot issue 3: Improving the framework conditions for innovation. The Innovation Union flagship, launched in 2010, tackles weaknesses in framework conditions for innovation. The initiative focuses on reducing the barriers to and improving the conditions for: strengthening the knowledge base and reducing fragmentation; getting good ideas to market; maximising social and territorial cohesion; pooling forces, e.g. through European Innovation Partnerships, to achieve breakthroughs; leveraging policies externally; and monitoring implementation of Innovation Union commitments.

Hot issue 4: Reforming the public research system (including university research). The European Research Area (ERA) aims to strengthen members' S&T research, competitiveness and capacity to address grand challenges collectively by enabling researchers, PRIs and businesses to collaborate freely across borders. A 2012 EC communication, *A Reinforced European Research Area Partnership for Excellence and Growth,* aims to improve Europe's research performance. It recommended measures that are currently being implemented to complete the ERA by 2014, as called for by the European Council. The ERA will also address members' public research issues, including competitive funding, transnational research funding and trans-border use of research infrastructures. Last year, the ERA Progress Report started to cover ERA reforms and implementation. The report is an essential element of the ERA policy monitoring system and relates to the European Semester policy cycle mentioned above.

Highlights of the EU STI system

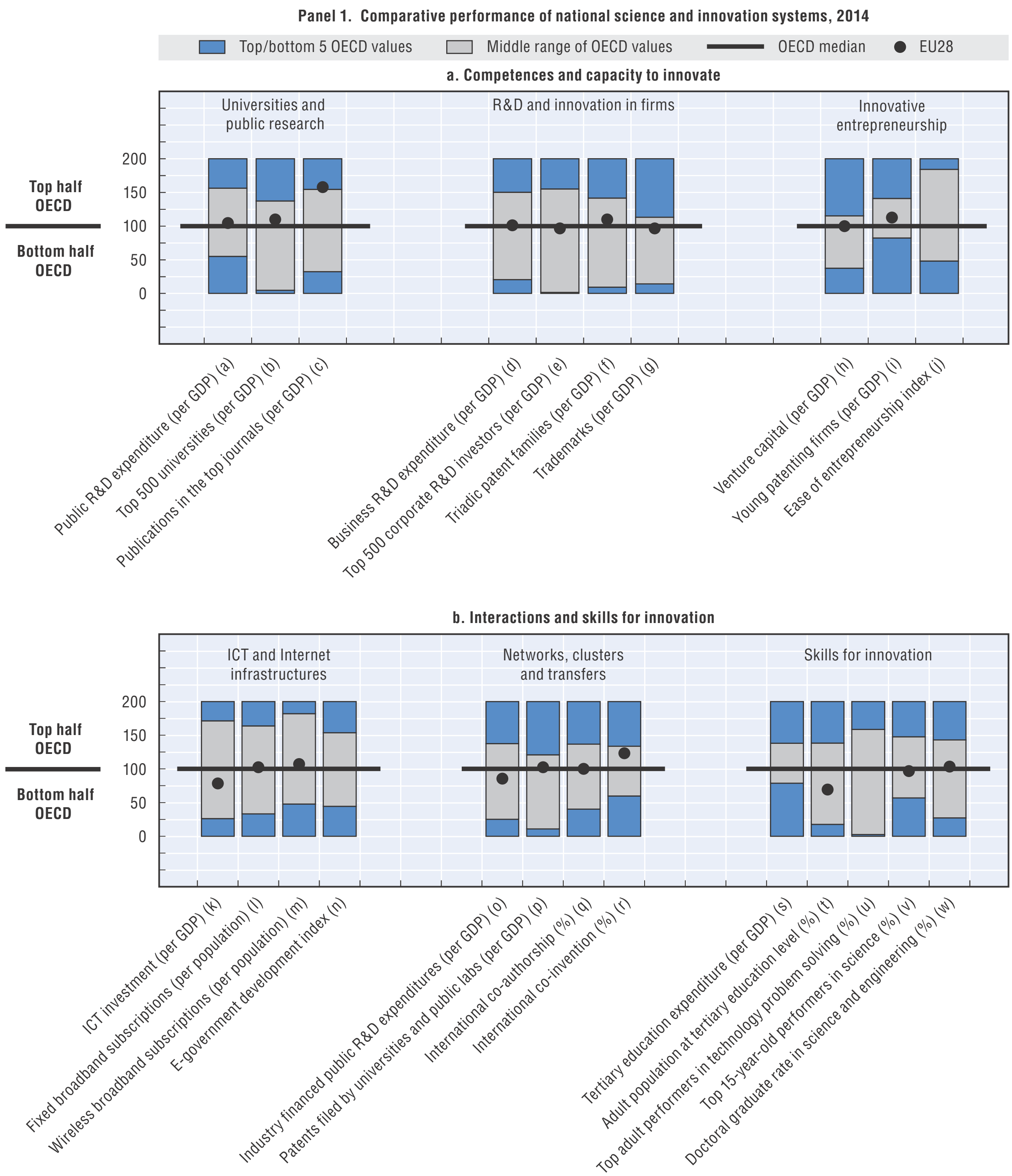
STI policy governance: The governance of Horizon 2020 is an open and simple structure that reduces red tape so that participants can focus on what is really important. The approach aims to get new projects off the ground quickly. DG Research and Innovation has recently strengthened the use of foresight for priority setting by creating a unit responsible for Science Policy, Foresight and Data. The Horizon 2020 evaluation system includes cross-cutting impact indicators for assessing the wider long-term impacts, including socio-economic, of research and innovation funding.

New challenges: The EU considers research essential for addressing major societal challenges. Although Europe's national research programmes are among the most advanced in the world, it is recognised that they are insufficient to tackle the major societal challenges Europe faces today. EU joint programming aims to pool national research efforts to make more efficient use of Europe's public R&D resources and to tackle common challenges more effectively. To address societal challenges, Horizon 2020 has a budget of USD 35.4 billion (EUR 29.7 billion) that will support the development by innovative enterprises of viable products with real market potential. This market-driven

Key figures, 2013

Economic and environmental performance	EU28	OECD	Gross domestic expenditure on R&D	EU28	OECD
Labour productivity			**GERD**		
GDP per hour worked, USD PPP, 2013	47.6	47.7	Million USD PPP, 2012	341 485	1 107 398
(annual growth rate, 2008-13)	n.a.	(+0.8)	As a % of total OECD, 2012	30.8	100
Green productivity			**GERD intensity and growth**		
GDP per unit of CO_2 emitted, USD, 2011	n.a.	3.0	As a % of GDP, 2012	2.07	2.40
(annual growth rate, 2007-11)	n.a.	(+1.8)	(annual growth rate, 2007-12)	(+2.3)	(+2.0)
Green demand			**GERD publicly financed**		
NNI per unit of CO_2 emitted, USD, 2011	4.0	3.0	As a % of GDP, 2011	0.70	0.77
(annual growth rate, 2007-11)	(+3.1)	(+1.6)	(annual growth rate, 2007-11)	(+2.8)	(+2.8)

Figure 9.47. **Science and innovation in the European Union**



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

approach will include creating partnerships between the private sector and member states to bring together the needed resources.

Universities and public research: Created in 2007, the European Research Council (ERC) is the first pan-European funding agency for cutting-edge research. It has funded 4 500 projects and generated 20 000 articles over 2007-13. It is now part of Horizon 2020, with a budget of USD 15.8 billion (EUR 13.1 billion) for 2014-20. It accounts for 17% of the overall Horizon 2020 budget and represents an increase of 60% in real terms from the 7th Framework Programme (2007-13).

Innovation in firms: One of the features of Horizon 2020 is full integration of innovation in the programme, with a significant increase in resources to support business R&D and innovation. Under Horizon 2020, the industrial leadership and competitive frameworks, with a budget of USD 20.2 billion (EUR 17 billion) and a wide range of actions, will support business research and innovation, with business expected to play a major role.

Innovative entrepreneurship: Horizon 2020 will facilitate the participation of SMEs in the programme. A new instrument, with funds of at least USD 3.6 billion (EUR 3 billion), will support innovative small companies. SMEs can also engage in collaborative projects as part of a consortium. A minimum of 20%, or about USD 10.3 billion (EUR 8.65 billion) of the total combined budgets for Leadership in Enabling and Industrial Technologies and Societal Challenges, is devoted to support for SMEs. Horizon 2020 also aims to remove barriers to innovation and facilitate co-operation between the public and private sectors.

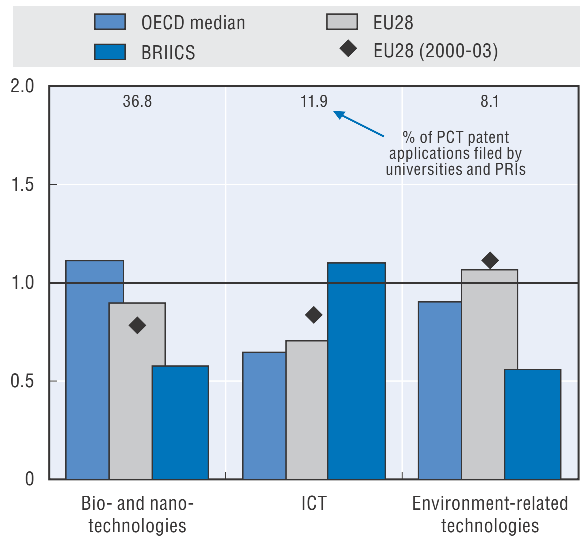
Clusters and smart specialisation: The Regions of Knowledge programme, under the 7th Framework Programme, promoted cross-border co-operation by research-driven clusters with a budget of USD 150 million (EUR 126 million) over 2007-13. Within the EU's new Cohesion Policy, one *ex ante* condition makes smart specialisation a condition for any future investment in Research and Innovation and the Digital Agenda. It aims to boost regional innovation by enabling regions to focus on their strengths. This initiative is supported through the future European Structural and Investment Funds (ESIF) with USD 96.4-130 billion (EUR 80-100 billion). DG Research and Innovation works closely with DG for Regional and Urban Policy to ensure that smart specialisation strategies are duly incorporated in the operational programmes and partnership agreements, and that they underpin the investment in R&I proposed by member states and regions in the context of the European Structural and Investment Funds.

Skills for innovation: The EU considers human resources a key to Europe's future competitiveness. The EURAXESS initiative addresses the mobility of researchers and seeks to make research careers attractive, while the European Partnership for Researchers aims at improving career prospects for researchers in Europe, stimulating young people to embark on research careers and helping retain European talent and attract researchers from other world regions. New EU measures are being prepared under the Innovative Doctoral Training Principles.

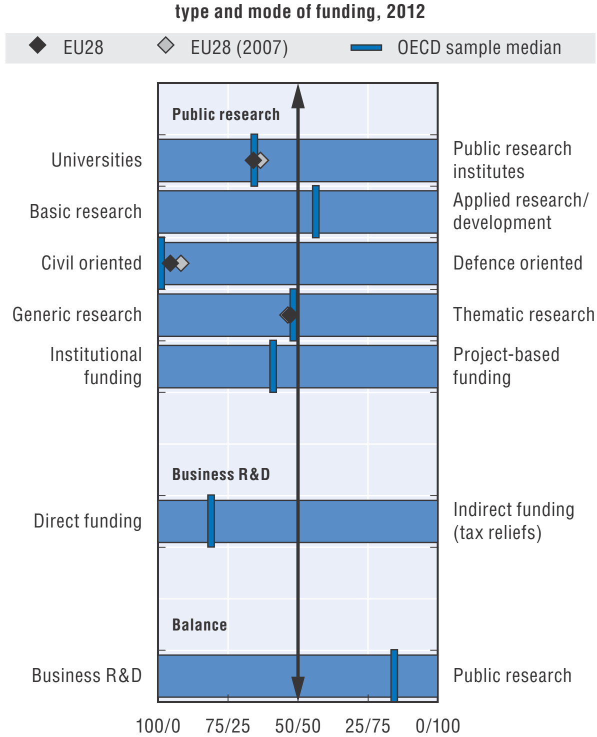
Recent developments in STI expenditures: With nearly USD 98.6 billion (EUR 78.6 billion) for 2014-20, Horizon 2020 is one of the few areas of the EU budget with a major increase. Thanks to Horizon 2020, the EU R&D budget for 2014-20 has increased by nearly 30% in real terms from the last programming period (2007-13).

Panel 2. Revealed technology advantage in selected fields, 2009-11

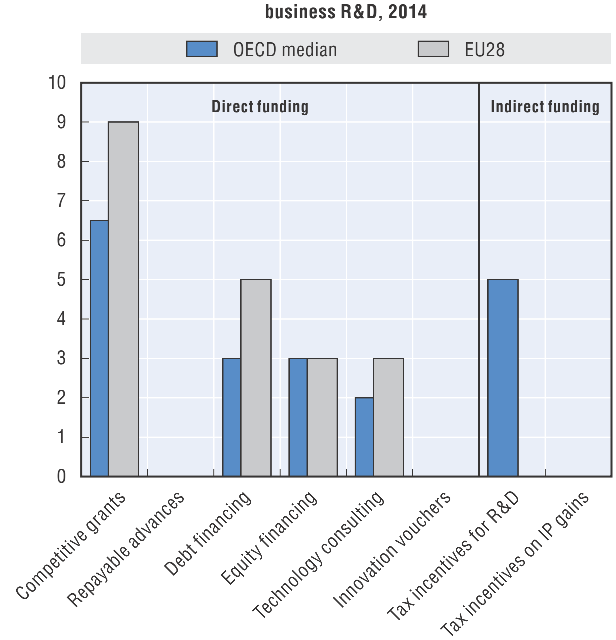
Index based on PCT patent applications



Panel 3. Allocation of public funds to R&D, by sector, type and mode of funding, 2012



Panel 4. Most relevant instruments of public funding of business R&D, 2014



Note: Policy information comes from country responses to the OECD STI Outlook policy questionnaires 2014 and 2012. European Union's responses are available in the *OECD STI Outlook Policy Database*, edition 2014 at *http://qdd.oecd.org/Table.aspx?Query=4684D449-1AE3-4C16-B10E-97D433EF213B*.

Source: See reader's guide and methodological annex.

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ANNEX 9.A

Methodological annex to the 2014 OECD STI Outlook country profiles

Introduction

The country profiles (Chapter 9) present the main features, strengths and weaknesses of national STI systems and major recent changes in national STI policy. This annex describes the conceptual background, sources and methodology used to design these profiles.

Following the expansion of the statistical framework in the 2012 edition, which included some 20 indicators, the country profiles 2014 include over 300 indicators in selected STI areas. The policy dimension has been also reinforced through a more systematic and comprehensive use of national science, technology and innovation (STI) policy information.

The country profiles are at the interface of two main streams of work carried out under the auspices of the Committee for Scientific and Technological Policy (CSTP):

- The policy research conducted by the Working Party on Technology and Innovation Policy (TIP), on the links between innovation and sustainable growth and the evaluation of national STI public support schemes, and the work of the former Working Party on Research Institutions and Human Resources (RIHR), on the main institutional, regulatory and management conditions needed to strengthen the knowledge base for innovation and the research capabilities of public research institutions (PRIs). The policy dimension of the country profiles has also benefited from experience gained through the OECD Country Reviews of Innovation Policy and previous OECD work on national innovation systems (NIS). The main and most recent source of country-specific STI policy information is provided by countries' responses to the STIO policy questionnaire 2014 which was circulated to CSTP delegates between November 2013 and January 2014. Official documents and external sources, such as the EU Erawatch/TrendChart reports were also used when appropriate.
- The statistical work and empirical analysis conducted by the Working Party of National Experts on Science and Technology Indicators (NESTI) on the measurement of innovation and the development of internationally comparable S&T indicators for policy analysis. The statistical dimension of the country profiles has also drawn on data collections and empirical work of the Committee on Industry, Innovation and Entrepreneurship (CIIE) and the Committee for Information, Computer and Communications Policy (ICCP), in their areas of work. Finally, the reviews of STI

indicators and STI trends carried out for the *OECD Science, Technology and Industry Scoreboard* are a key reference (OECD, 2009, 2011a, 2013a).

This methodological annex first introduces the conceptual framework used in this edition to assess national innovation systems (NIS). It then looks at the key indicators chosen to gauge the performance of innovation systems. It reviews the reasons for the choices made, the sources used, some limitations on interpretation of the data and certain technical aspects (calculations, normalisation criteria, etc.).

What should be measured: A conceptual framework

A particular effort has been made to improve evidence on how innovation systems function and perform by mapping and measuring input, output and outcomes (OECD, 2010a).

The following framework provides the standard structure used to describe the NIS and to map the innovation policy mix (OECD, 2010b). It is used throughout the *OECD STI Outlook 2014*, in particular to relate the policy profiles (thematic approach) to the country profiles (country approach). It served a role in the design of the policy questionnaire used to collect information and official data on major STI policy programmes and on recent changes in national STI policy.

Public intervention may seek to: *i)* improve STI policy governance; *ii)* improve the competences and capacity of STI actors to innovate in universities and public research institutes (PRIs), on the one hand, and firms, on the other; *iii)* improve interactions among STI actors to accelerate technology transfer and increase their capacity to connect to international knowledge networks; and *iv)* improve skills for innovation.

STI policy governance

As the portfolio of innovation policy instruments has broadened, STI policy has become increasingly sophisticated. The accumulation of STI policy initiatives over time has raised the risk of government failures and the dispersal of state power to supra- and sub-national, quasi-state and non-state actors; it has also favoured the emergence of new forms of multi-level and multi-actor governance (Flanagan et al., 2010) that make the possible side effects of public intervention increasingly difficult to detect and anticipate. Moreover, in the aftermath of the 2008 financial crisis, governments are under strong pressure to find new sources of growth, to meet social and global challenges and to consolidate their fiscal accounts (OECD, 2010c). Good governance requires identifying strategic priorities, combining the right instruments and making the most of stable, or even shrinking, resources.

More detailed information about the rationale for and major aspects of STI policy intervention, as well as recent STI policy trends, can be found in "Part II: STI policy profiles" of this volume.

STI actors' competences and capacity to innovate

Universities and public research

Public-sector research is considerably smaller than business research and development (R&D) in the majority of OECD countries; higher education and government expenditure on R&D account for 30% of total OECD expenditures on R&D (OECD, 2014a). However, PRIs and research universities play an extremely important role in innovation systems by providing new knowledge, especially in areas in which economic benefits are uncertain or less immediate. Public research also meets specific needs of national interest, such as defence, and of the population at large, e.g. health care (see the policy profile on "Public research missions and orientation"). In addition public research tends to be counter-cyclical and to serve as a buffer by complementing funding gaps arising from declines in private R&D investment during economic downturns (see Chapter 1). Gross domestic expenditures on R&D (GERD) declined by 1.3% in 2009 in the OECD area, driven by a sharp contraction of business R&D spending (-4.2%), while expenditure by higher education (+4.9%) and government (+4.0%) kept growing (OECD, 2014a). The same occurred in 2002 after the explosion of the IT bubble, although to a lesser extent.

Innovation in firms

Firms are major actors in national innovation systems (see Chapter 5 on "Innovation in firms"). They turn ideas into economic value, account for the largest share of domestic R&D in many countries and also carry out non-technological innovation. In addition, start-ups can exploit knowledge that is not used or is underused by existing companies and draw on existing knowledge to enter new or established markets (Acs et al., 2009). This is especially true in knowledge-intensive sectors.

Public sector innovation

Increasingly sophisticated public demand and new challenges due to fiscal pressures require innovative public-sector approaches. Public-sector innovation involves significant improvements in public services delivery in terms both of the content of these services and of the instruments used to deliver them. Many OECD countries intend to create services that are more user-focused, better defined and better target user demand. However, there is limited knowledge and awareness of the full range of tools available to policy makers for accelerating innovation in this area and the STI Outlook focuses on the other types of STI actors.

STI actors' interactions

Science is the basis of most innovation, especially in frontier fields (such as biotechnology). Innovation is increasingly achieved through the convergence of scientific fields and technologies (OECD, 2010c). The rapidly increasing amount of knowledge required for innovation has encouraged STI actors to co-operate and connect to global knowledge flows.

ICT and scientific infrastructure

Empirical studies point to a positive link between increased adoption and use of information and communication technologies (ICTs) and economic performance at the firm and macroeconomic level (OECD, 2012). Governments see ICTs and the Internet as a major platform for research and innovation (see the policy profile on "Innovation and the digital economy").

To conduct scientific research and to attract and retain world-class researchers requires a critical mass of large-scale scientific infrastructures, costly equipment and modern facilities and thus large amounts of public and private investments.

Clusters

Clusters are geographic concentrations of firms, universities, PRIs, and other public and private entities that facilitate collaboration on complementary economic activities.

Clusters facilitate knowledge spillovers and a collective pool of knowledge that result in higher productivity, more innovation and more competitive firms. Governments promote clusters through investments in ICT, scientific infrastructure and knowledge, networking activities and training (see the policy profile on "Cluster policy and smart specialisation").

Knowledge flows and the commercialisation of public research results

Various mechanisms facilitate knowledge valuation, circulation and commercialisation. Intellectual property rights (IPRs), such as patents or trademarks, facilitate the transfer of knowledge and technologies by ensuring that the knowledge generated will not be misappropriated and that much of the benefits can be internalised (see the policy profile on "Patent policies"). Technology transfer from academia is encouraged to increase the economic impact of investments in public research. The commercialisation of public research results via the cession of intellectual property (IP), the establishment of new ventures (e.g. academic spin-offs), contracting to universities and PRIs by industrial actors or the setting up of collaborative R&D projects may also create additional financial resources for universities and PRIs (see the policy profile on "Commercialisation of public research"). IPRs are therefore increasingly traded in markets and the number of intermediaries that broker commercialisation activities, notably IP services, has risen (see the policy profile on "IP markets"). Open science also increases the channels for transferring and diffusing research results (e.g. ICT tools and platforms, alternative copyright tools) and open innovation in firms creates a division of labour in the sourcing of ideas and their exploitation (see the policy profile on "Open science").

Globalisation of STI systems

Trade, investment and research systems are increasingly globalised (OECD, 2009). Countries and firms engage in international co-operation in STI with a view to tapping into global pools of knowledge, HR and major research facilities, to sharing costs, to obtaining more rapid results, and to managing the large-scale efforts needed to address challenges of a regional or global nature effectively (see Chapter 3 on "Globalisation of innovation policies").

Human resources for innovation

Education

Formal education remains the main vehicle for improving the supply of the diverse and complex skills required for innovation. Because it raises attainment levels and the general level of education, formal education can inspire talented young people to enter innovation-related occupations and equip people with the highest skills. In addition to scientific, technological, engineering and mathematics skills, innovation requires soft skills (entrepreneurship, creativity, leadership etc.) (see the policy profile on "Strengthening education and skills for innovation").

Employment and lifelong learning

The supply of the highly skilled can be further enlarged by improving the attractiveness of research and entrepreneurial careers, by facilitating the sectoral and international mobility that eases the cross-fertilisation of ideas and learning, or by facilitating the transition from higher education and training to employment and *vice versa*. The acceleration of technological change has made lifelong learning a key means of preserving and upgrading the pool of human resources for science and technology (HRST). Demand for the highly skilled can also be boosted through support for job openings in academia or in the business sector, especially in small and medium-sized enterprises (SMEs). Mismatches between demand and supply can be addressed by promoting mobility and training and by building knowledge about current and future skills needs (see the policy profile on "Labour market policies for the highly skilled").

Innovation culture

It is increasingly recognised that innovation is influenced by the social and cultural values, norms, attitudes and behaviours that inform an innovation culture. Building an innovation culture implies raising public awareness of and interest in S&T, especially among youth, valuing the contribution of S&T to well-being and social welfare, fostering an entrepreneurial spirit through a positive attitude towards risk taking, nurturing a research culture while raising awareness of IPRs in the research community, etc. (see the policy profile on "Building a science and innovation culture").

Key figures

The table of key figures provides an overview of a country's economic and environmental performance, the size of its national research system and the relative importance of the government's commitment to R&D through public funding. It also shows how these indicators have changed from 2007 to 2012. When data are not available for these years, the nearest years are used. Growth rates are compound annual growth rates* expressed in percentage.

Economic and environmental performance

Innovation is widely acknowledged as a major driver of productivity and economic performance and is seen as a key way to create new business values while also benefiting people and the planet and addressing global challenges.

Labour productivity, levels and annual growth. Welfare is traditionally gauged through the GDP per capita indicator. Changes in GDP per capita are explained by changes in labour productivity (GDP per hour worked) and labour utilisation (hours worked per person employed). Labour productivity is defined as the volume of output divided by the volume of labour input, namely GDP per hour worked, in current US dollars at purchasing power parity (PPP). Labour productivity is however a partial productivity measure and reflects the joint influence of a host of factors. It is easily misinterpreted as technical change or as the productivity of the individuals in the labour force. Data are drawn from the OECD Productivity Database which provides estimates of productivity growth and levels and allows for comparison of standards of living and underlying factors across countries (*www.oecd.org/std/productivity-stats/*).

* Compound annual growth rates are calculated based on indicator values in constant prices, according to the following formula in which CAGR is the compound annual growth rate, I is the value considered over the period of time between t_0 and t_1:

$$\text{CAGR}\ {}^{I}_{t_1,t_0} = \left[\ \left(I_{t_1}|I_{t_0}\right)^{\left(1|(t_1-t_0)\right)}\ \right] - 1$$

A central element of green growth is the efficiency with which environmental and natural resources are used in production and consumption. A declining asset base and climate change constitute risks for growth and sustainable development. Environmental outcomes are also important determinants of health and wellbeing. The main concerns relate to the effects of increasing atmospheric greenhouse gas (GHG) concentrations on global temperatures and the Earth's climate, and the consequences for ecosystems, human settlements, agriculture and other socio-economic activities that can affect global economic output (OECD, 2011b). Carbon dioxide (CO_2) accounts for the largest share of GHG emissions. Fuel combustion in economic activities and by households is a main source of climate change and GHG emissions.

Green productivity, levels and annual growth. Green productivity, or environmental and resource productivity, is production-based CO_2 productivity, i.e. GDP generated per unit of CO_2 emitted through fuel consumption. Estimates are computed by the International Energy Agency (IEA) on the basis of the IEA energy balances and the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (IEA, 2013).

Green demand, levels and annual growth. Green demand is demand-based CO_2 productivity, i.e. real net national income (NNI) generated per unit of CO_2 emitted or gross national income (GNI) per unit of CO_2 emitted for Brazil, the People's Republic of China, India, Indonesia, the Russian Federation and South Africa. Demand-based emissions reflect the CO_2 emissions embodied in final domestic demand from energy used during the various stages of production of the goods and services consumed, irrespective of where the stages of production occurred. Trends in demand-based emissions serve as a diagnostic complement to the more traditional production-based measures. The estimates of CO_2 emissions are calculated using a combination of input-output tables, bilateral trade data and production-based CO_2 emissions. Data are drawn from the OECD Green Growth Indicators Database.

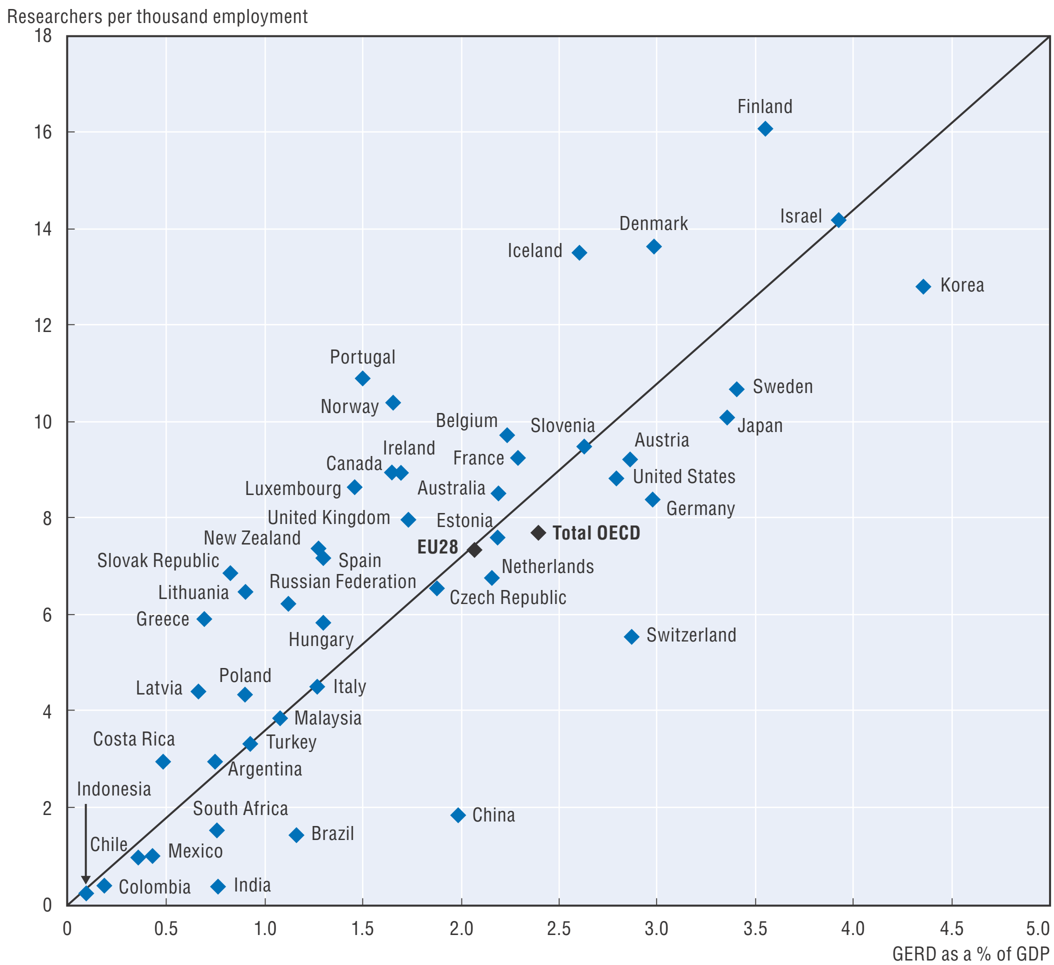
Gross domestic expenditure on R&D

Gross domestic expenditure on R&D (GERD) is total intramural expenditure on R&D performed on the national territory during a given period, i.e. it includes R&D performed within a country and funded from abroad but excludes payments for R&D performed abroad (OECD, 2002). GERD is one of the most widely used measures of innovation inputs. It reflects a country's R&D efforts and investments and its potential for generating new knowledge. GERD is expressed in current US dollars PPP. R&D expenditures are derived from harmonised national R&D surveys based on joint OECD/Eurostat efforts to collect internationally comparable data on resources for R&D. GERD data –including for the following indicators if not otherwise specified- are drawn from the OECD Main Science and Technology Indicators (MSTI) Database which seeks to reflect the level and structure of efforts in the field of science and technology (*www.oecd.org/sti/msti*). Additional data for Latvia and Lithuania are drawn from Eurostat Science, Technology and Innovation (STI) Databases and from the UNESCO Institute for Statistics (UIS) for Colombia, Costa Rica, India, Indonesia and Malaysia.

GERD, intensity and annual growth. Many OECD and non-OECD countries "target" a certain level of GERD intensity to help focus policy decisions and public funding (see the policy profile on "National strategies for STI"). The volume of GERD to be achieved is often expressed as a percentage of gross domestic product (GDP). Compound annual growth rates are calculated based on R&D expenditures at constant prices.

In many economies most R&D expenditures cover personnel costs, which include researcher salaries and compensation. GERD intensity as a percentage of GDP and researchers per thousand employment are therefore closely related (OECD, 2011a). To avoid redundancy, data on researcher density are not presented in the country profiles. The researcher population in Figure 9.A.1 is estimated in full-time equivalent (FTE).

Figure 9.A.1. **GERD as a percentage of GDP and researchers per thousand employment, 2013 or latest available year**



Note: For GERD: data for Austria refer to 2013; data for Colombia, Costa Rica, Iceland, Malaysia, Mexico, New Zealand and South Africa refer to 2011; data for Australia and Brazil refer to 2010; and data for Switzerland refer to 2008. For other countries, data refer to 2012.
For researchers: data for Canada, Costa Rica, France, Iceland, Israel, Latvia, Lithuania, Malaysia, Mexico, New Zealand, South Africa and the United States refer to 2011; data for Brazil and Colombia refer to 2010; data for Indonesia refer to 2009; data for Australia and Switzerland refer to 2008; and data for India refer to 2005. Otherwise data refer to 2012.
Source: OECD, based on *OECD Main Science and Technology Indicators (MSTI) Database*, June 2014, *www.oecd.org/sti/msti*; Eurostat, *Science, Technology and Innovation Databases*, June 2014, *http://epp.eurostat.ec.europa.eu/portal/page/portal/science_technology_innovation/data/database*; UNESCO Institute for Statistics (UIS), *Science, Technology and Innovation Database*, June 2014, *http://data.uis.unesco.org/Index.aspx?DataSetCode=SCN_DS*. Data retrieved from IPP.Stat on 08 July 2014, *http://stats.oecd.org//Index.aspx?QueryId=57863*.

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Publicly financed GERD, intensity and annual growth. GERD is financed by various sources: business enterprises (industry), government, higher education, private non-profit institutions (PNPs) and foreign funds (abroad). In the country profiles, public funding of GERD encompasses financing by the government and higher education sectors. It reflects public commitment to R&D relative to the size of the country. It is expressed as a percentage of GDP. Data are based on harmonised national R&D surveys and drawn from the OECD Research and Development Statistics (RDS) Database which provides detailed information on a range of R&D statistics (*www.oecd.org/sti/rds*), except for Latvia and Lithuania for which data come from Eurostat STI Databases and for Colombia, Costa Rica, India, Indonesia and Malaysia for which data come from the UIS.

Benchmarking national innovation performance (Panel 1 of the country profiles)

The performance of a country's national innovation systems as compared to all OECD countries is represented in Panel 1 of the country profiles. Panel 1 (double graph) reflects the country's strengths and weaknesses in several areas (see the conceptual framework discussed above). A standard set of indicators is used to: *i)* describe the competences and capacity of the science base and the business sector to innovate, as well as the framework conditions for entrepreneurship; *ii)* provide some insights on interactions between STI actors via the deployment and use of the Internet and their participation in domestic and international co-operation networks; and *iii)* depict the status of the human resources (HR) pool and prospects for increasing human capital further through inflows of new S&T talent.

Indicators are normalised (by GDP or population) to take account of the size of the country. Data for GDP are drawn from the OECD MSTI Database and are based on national accounts. Data for GDP for Latvia and Lithuania are drawn from Eurostat Annual National Accounts (ANA) Databases and for Brazil, Colombia, Costa Rica, India, Indonesia and Malaysia from the World Economic Outlook (WEO) Databases of the International Monetary Fund (IMF).

The country's values are compared to the median value observed in the OECD area, i.e. the middle position among OECD countries for which data are available. Non-OECD countries are also compared and may appear out of range (e.g. lower than the lowest OECD country). The use of the median avoids a statistical bias towards large players that skew the average, while still reflecting international rankings. The median has also the advantage over a simple ranking that it preserves the deviation between country values. The distance of the country's value from the median value will appear on the chart at a proportional distance from the median. This applies equally to all countries. In a simple ranking, the difference between two successive country values is 1 and the distance to the median is the rank. All indicators are presented in indices and reported on a common scale from 0 to 200 (0 being the lowest OECD value, 100 the median value and 200 the highest) to make them comparable. The benchmark charts also highlight the position and dispersion of the top five and bottom five OECD values. When data are not available, the country's relative position does not figure on the graph (no dot).

Given X_t^c the indicator for country *c* at time *t*, and X_t^{Max}, X_t^{Med} and X_t^{Min} the respective OECD maximum, median and minimum values for this indicator, the country index I_t^c shown in Panel 1 is calculated as followed:

If $X_t^c > X_t^{Med}$ then $I_t^c = 100 + \left(X_t^c - X_t^{Med}\right) / \left(X_t^{Max} - X_t^{Med}\right) * 100$

If $X_t^c < X_t^{Med}$ then $I_t^c = 100 - \left(X_t^c - X_t^{Med}\right) / \left(X_t^{Min} - X_t^{Med}\right) * 100$

The standard set of indicators includes the following:

Universities and public research

(a) Public expenditure on R&D (per GDP). Higher education and government research institutions play a key role in the national STI system. Public expenditure on R&D (per GDP) measures the public sector's relative R&D performance. Public expenditure on R&D is the sum of higher education expenditure on R&D (HERD) and government expenditure on R&D (GOVERD) and is expressed as a percentage of GDP. Data are drawn from OECD MSTI Database and based on harmonised national R&D surveys and national accounts. Data for Latvia and Lithuania are drawn from Eurostat STI Databases and data for Colombia, Costa Rica, India, Indonesia and Malaysia from the UIS.

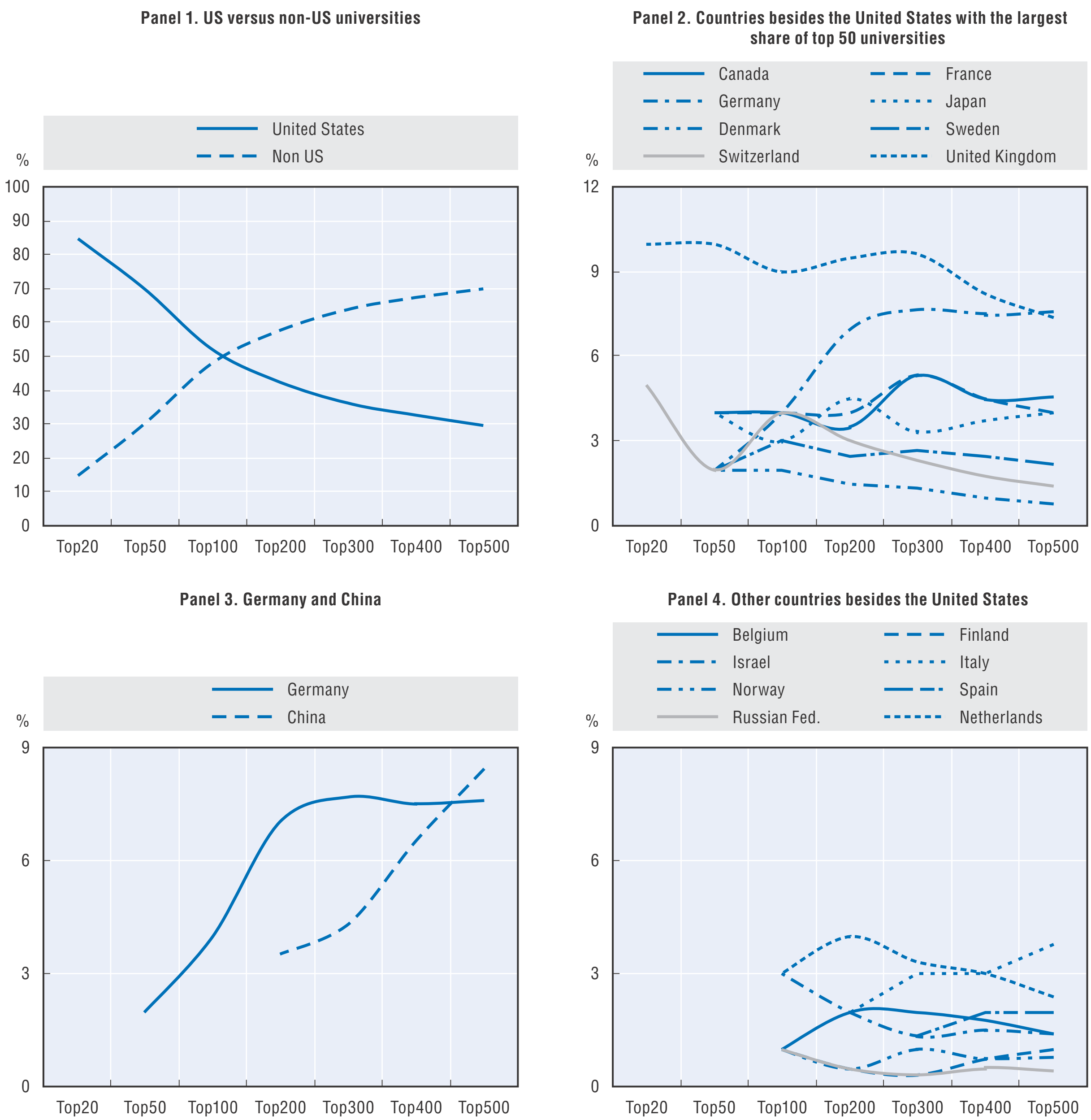
(b) Top 500 universities (per GDP). Excellent research is often concentrated in a few higher education institutions with strong international impact. The Academic Ranking of World Universities (ARWU), also known as the Shanghai ranking, ranks the world's top universities and medium-high performing institutions according to a composite indicator based on number of alumni; staff winning Nobel Prizes and Fields Medals; number of highly cited researchers selected by Thomson Scientific; number of articles published in *Nature* and *Science*; number of articles indexed in the Science Citation Index Expanded and Social Sciences Citation Index; and per capita performance with respect to the size of the institution (Table 9.A.2). More than 1 000 universities have been ranked by the ARWU every year since 2003 and the list of the leading 500 are published on the web (*www.shanghairanking.com*). This indicator has certain limits however. The bibliometrics-based indicators skew the ARWU ranking towards English-speaking institutions and emphasise the natural sciences over the social sciences or humanities, as well as research excellence over the quality of teaching. However, this last is less an issue for benchmarking the performance of the science base, as this publication seeks to do. In addition, the ranking tends to focus on larger institutions and does not reflect research performance in PRIs; this may disadvantage countries in which the science base relies heavily on public labs. The top 500 universities are expressed per million US dollars of GDP PPP to take into account countries' size and relative wealth.

According to the ARWU data, most countries have a relatively constant share of world-class universities as measured at different performance thresholds (Panels 2 and 4). This may reflect a homogeneous science base of institutions of different classes and of different visibility. The United States, Germany and China deserve further attention however (Panels 1 and 3). The United States has the world's best universities with 17 of the top 20 and 35 of the top 50, but its share drops rapidly when the performance threshold is lowered to include institutions below the top 50, i.e. high- and medium-high-performing institutions. The situation is different for Germany and China, which lack universities in the top 20 and top 50 but whose share in the world's top universities increases markedly from the top 50 to the top 200 for the former and from the top 300 to the top 500 for the latter. The selected benchmark threshold will therefore have an impact on these three countries' performance compared to other countries. With a higher benchmark threshold, the United States will perform better and Germany and China will perform less well. With a lower benchmark threshold, the reverse will be true.

For the top 50, US universities lead eight other countries in 2013: the United Kingdom (5), Canada (2), France (2), Japan (2) and Denmark, Germany, Sweden and Switzerland (all at 1). A similar exercise was conducted for the *OECD STI Scoreboard* on the basis of bibliometric data (OECD, 2013a). University hotspots were identified as the higher

Figure 9.A.2. **Impact of ranking thresholds on country's performance in ARWU ranking, 2013**

Country share in ARWU ranking of universities



Source: Based on Academic Ranking of World Universities (ARWU) (2013), "Shanghai ranking" 2003-13, *www.shanghairanking.com.*

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education institutions with the highest impact as measured by the average number of citations received by an article compared to the world average of citations in the same time period, document type and subject area. The normalised impact of an institution (main author affiliated to the institution) was calculated for 2007-11. These results are presented in Table 9.A.1 beside the top 50 ranking based on ARWU data. The ARWU ranking has little effect on US performance or tends to increase slightly the number of US institutions in the top 50 as well as the impact of countries with larger institutions (see comments on the limitations of this indicator above).

Table 9.A.1. **The world's top 50 universities, according to the OECD STI Scoreboard 2013 and ARWU ranking 2013, 2007-11**

	STI Scoreboard 2013	ARWU ranking 2013				
	2007-11	2007	2008	2009	2010	2011
United States	34	37	36	37	35	34
United Kingdom	8	5	5	5	5	5
Netherlands	2	1	1	..	1	1
Canada	..	2	2	2	2	2
Switzerland	2	1	1	1	1	1
Denmark	1	1	1	1	1	1
Sweden	..	..	..	1	1	1
Japan	..	2	2	2	2	2
Chinese Taipei	2	..	..	..	..	..
Israel	1	..	..	..	..	..
France	..	1	2	2	2	2
Total number of countries	**7**	**8**	**8**	**8**	**9**	**9**

Source: OECD (2013), *OECD Science, Technology and Industry Scoreboard 2013: Innovation for Growth*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/sti_scoreboard-2013-en* and Academic Ranking of World Universities (ARWU) (2013), "Shanghai ranking" 2003-13, *www.shanghairanking.com*.

StatLink http://dx.doi.org/10.1787/888933152508

The STI Outlook presents one indicator to compare the performance of universities across countries. A more detailed approach would require considering a wider range of indicators to reflect other dimensions of performance (e.g. teaching quality, technology transfer, innovative and entrepreneurial activities etc.).

(c) Publications in top-quartile journals (per GDP). Publication is the main means of validating and disseminating research results. Publications in top journals provide a measure of "quality-adjusted" research output and serve as an indicator of the expected impact of institutions' scientific production. Publications in the top-quartile journals are defined as documents published in the most influential 25% of the world's scholarly journals (in their category, in the reference period, by authors' institutional affiliation, in a given country). This ranking is based on the Scientific Journal Ranking (SJR) an impact-factor normalised index that takes the prestige of the journals as a measure of quality. Scientific production is based on whole counts of documents by authors' institutional affiliation in the country. Bibliometric data are drawn from the Elsevier Research Intelligence database. However, although publications are commonly used as proxies for academic research output, it is worth mentioning that publishing institutions are not necessarily all public sector research institutions. Publications counts are expressed in per million US dollars of GDP at PPP to take into account the size and the relative wealth of the country.

Table 9.A.2. **Indicators and weights used for the ARWU ranking of universities**

Criteria	Indicator	Definition	Weight
Quality of education	Alumni of an institution winning Nobel Prizes and Fields Medals	Defined as those who obtain bachelor's, master's or doctoral degrees from the institution. Different weights are given according to the period of obtaining a degree. The weight is 100% for alumni obtaining degrees after 1991, 90% for alumni obtaining degrees in 1981-90, 80% in 1971-80, and so on, and finally 10% in 1901-10. If a person obtains more than one degree from an institution, the institution is only considered once.	10%
Quality of faculty	Staff of an institution winning Nobel Prizes and Fields Medals in Physics, Chemistry, Medicine and Economics and Fields Medal in Mathematics.	Defined as those who work at an institution at the time of winning the prize. Different weights are given according to the period of winning the prize. The weight is 100% for winners after 2001, 90% for winners in 1991-2000, 80% in 1981-90, 70% in 1971-80, and so on, and finally 10% in 1911-20. If a winner is affiliated with more than one institution, each institution is assigned the reciprocal of the number of institutions. For Nobel prizes, if a prize is shared by more than one person, weights are set for winners according to their share of the prize.	20%
	Highly cited researchers in 21 broad subject categories	These individuals are the most highly cited within each category. The definition of categories and detailed procedures can be found at the website of Thomson ISI (see source).	20%
Research output	Papers published in *Nature* and in *Science* in the four years preceding the publication of the ARWU ranking	To distinguish the order of author affiliation, a weight of 100% is assigned for corresponding author affiliation, 50% for first author affiliation (second author affiliation if the first author affiliation is the same as corresponding author affiliation), 25% for the next author affiliation, and 10% for other author affiliations. Only publications of "articles" and "proceedings papers" are considered. Institutions specialised in humanities and social sciences are not taken into account and weighting in the ARWU composite index is reallocated proportionally to other criteria.	20%
	Papers indexed in Science Citation Index-expanded and Social Science Citation Index in the year preceding the publication of the ARWU ranking	Only publications of "articles" and "proceedings papers" are considered. When calculating the total number of papers of an institution, a special weight of two was introduced for papers indexed in Social Science Citation Index.	20%
Per capita academic performance	Weighted scores of the above five indicators divided by the number of full-time equivalent (FTE) academic staff.	If the number of academic staff of a country's institutions cannot be obtained, a weighted score of the above five indicators is used. The data are obtained from national agencies such as the Ministry of Education, the Bureau of Statistics, the Association of Universities and Colleges, the Rector's Conference.	10%
Total			100%

Source: Academic Ranking of World Universities (ARWU) (2013), "Shanghai ranking" 2003-13, *www.shanghairanking.com* (accessed on 5 June 2014); based on the official website of the Nobel Prize, *www.nobelprize.org*; International Mathematical Union, List of fields medallists web page, *www.mathunion.org/index.php?id=prizewinners*; Thomson Reuters, Highly Cited Researchers website, *www.highlycited.com*; Thomson Reuters, Web of Science website, *www.webofknowledge.com* (papers published in *Nature* and *Science* and articles indexed in Science Citation Index-Expanded and Social Science Citation Index); national sources (number of FTE academic staff).

Business R&D and innovation

(d) Business R&D expenditure (per GDP). Business enterprise expenditure on R&D (BERD) accounts for the bulk of R&D activity in most OECD countries. It is frequently used to compare countries' private-sector efforts on innovation since industrial R&D is more closely linked to the creation of new products and production techniques and mirrors market-oriented innovation efforts. Data are drawn from the OECD MSTI Database and are based on harmonised national R&D surveys and national accounts, except for Latvia and Lithuania for which data come from Eurostat STI Databases and for Colombia, Costa Rica, India, Indonesia and Malaysia for which data come from the UIS.

(e) Top 500 corporate R&D investors (per GDP). Big companies make an important contribution to R&D and innovation. Large firms tend to introduce innovations of larger scale and bigger impact than SMEs which more frequently tend to be "adopters" and "pioneers" (OECD, 2009). In addition, large firms often drive collaboration, as they play a

structuring role in innovation clusters that also include SMEs. Large firms also play the role of "innovation assemblers": by integrating innovations from SMEs in their own products, they bring SMEs' innovations to markets. The 2013 *EU Industrial R&D Investment Scoreboard* (*http://iri.jrc.ec.europa.eu/scoreboard13.html*) presents economic and financial information about the world's 2 000 largest companies ranked according to the level of their own-funded R&D investments. The top 500 accounted in 2012 for 82% of the 2 000 firms' total R&D investments. Data are based on companies' publicly available audited accounts. The EU Scoreboard is intended to raise awareness of the importance of R&D for businesses and to encourage firms to disclose information about their R&D investments and other intangible assets. It gathers information about a sample of 527 European and 1 473 non-European firms that invested more than EUR 22.6 million in R&D in 2012. For different reasons (changes in exchange rates, mergers and acquisitions, etc.), the composition of the sample may vary from year to year and data are not fully comparable from one edition of the EU Scoreboard to the next. It is worth noting that companies' accounts do not include information on where R&D is actually performed and that companies' total R&D investment is attributed to the country in which it is registered. The EU Scoreboard's approach to BERD is, therefore, different from that of statistical offices or the OECD which attribute data to a specific territory. The EU Scoreboard data are primarily of interest to those concerned with benchmarking company commitments and performance (e.g. companies, investors and policy makers), while BERD data are primarily used by economists, governments and international organisations interested in the R&D performance of territorial units defined by political boundaries (EC, 2013). The two approaches are complementary. The number of top 500 corporate R&D investors is expressed per million US dollars of GDP at PPP to take account of the size of the country.

(f) Triadic patents (per GDP). Patents provide a uniquely detailed source of information on the inventive activity of countries. Triadic patents are typically of relatively high value and eliminate biases arising from home advantage and the influence of geographical location. Triadic patent families are defined as patents applied for at the European Patent Office (EPO), the Japan Patent Office (JPO) and the US Patent and Trademark Office (USPTO) to protect a same invention. Counts are presented according to the priority date and the residence of the inventors. The number of triadic patent families applied for over the 2009-11 period is expressed per billion US dollars of GDP at PPP. Data for patents are drawn from the OECD Patent Database (*www.oecd.org/sti/ipr-statistics*).

(g) Trademarks (per GDP). A trademark is a sign that distinguishes the goods and services of one undertaking from those of other undertakings. Firms use trademarks to launch new products on the market in order to signal novelty, promote their brand and appropriate the benefits of their innovations. Trademarks convey information not only on product innovations, but also on marketing innovations and innovations in the services sector. The number of trademark applications is highly correlated with other innovation indicators (OECD, 2011a). Because the data relating to trademark applications are publicly available immediately after filing, trademark-based indicators can provide timely information on the level of innovative activity (OECD, 2011a). Trademark-based indicators are therefore a good predictor of economic downturns (OECD, 2010c). However, trademarks counts are subject to home bias as firms tend to file trademarks in their home country first. Trademarks abroad correspond to the number of applications filed at the USPTO (Graham, 2013), the Office for Harmonization in the Internal Market (OHIM), and the JPO, by application date and country of residence of the applicant. For the United States, EU

members and Japan, counts exclude applications in their domestic market (USPTO, OHIM and JPO, respectively). Counts are rescaled by taking into account the relative average propensity of other countries to file in these three offices (OECD, 2013a). The number of trademarks applied for over the 2010-12 period is expressed per billion US dollars of GDP at PPP. Data for trademarks are drawn from OECD calculations based on USPTO Bulk Downloads: Trademark Application Text hosted by Reed Technology Information Services; OHIM Community Trademark Database CTM Download; JPO Annual Reports 2001-13.

Entrepreneurship

(h) Venture capital (per GDP). A financial and policy environment that fosters the start-up and growth of new firms is essential for innovation to flourish. Access to finance for new and innovative small firms is vital but banks may be reluctant to lend to risky ventures. For entrepreneurial firms, especially if they are young, technology-based and have high growth potential, venture capital is an important source of funding during the seed, start-up and growth phases. Venture capital (VC) is private equity provided by specialised firms acting as intermediaries between primary sources of finance (insurance, pension funds, banks, etc.) and private companies whose shares are not freely traded on any stock market. Data for VC investments are drawn from the OECD Entrepreneurship Financing Database (OECD, 2014b).

(i) Patenting firms less than 5 years old (per GDP). The presence of young firms among patent applicants underlines the inventive dynamics of firms early in their development. Young firms are defined as firms less than five years old with an incorporation date in business registers (ORBIS©) between 2004 and 2011. Patenting firms are those filing patent applications at the European Patent Office (EPO), at the US Patent and Trademark Office (USPTO) or through the Patent Cooperation Treaty (PCT) between 2008 and 2011. It should be stressed that this experimental indicator is obtained by matching patent (EPO/USPTO/PCT patent filings) and business (listed in the ORBIS database) data: the names of applicants as they appear in the patent were linked with those of firms listed in business registers. Counts are limited to a set of patent applicants which have been successfully matched with business register data. In addition, only countries with average matching rates over 70% over the period are included. Counts of young patenting firms are expressed per billion USD GDP using PPPs. Data for young patenting firms are based on the OECD Patent Database and the ORBIS Database (Bureau Van Dijk Electronic Publishing).

(j) Ease of entrepreneurship index. For businesses to enter the market and grow they need a suitable regulatory framework. Most OECD countries have lowered barriers to entrepreneurship during the last decade (OECD, 2010c). The "barriers to entrepreneurship" indicator is one of the OECD Indicators of Product Market Regulation (PMR) and measures regulations affecting entrepreneurship. The index uses a scale of zero to six to evaluate: i) complexity of regulatory procedures (e.g. licences and permits system, communication and simplification of rules and procedures); ii) administrative burdens on start-ups (e.g. administrative burdens for corporations and sole proprietor firms, barriers in services sector) and iii) regulatory protection of incumbents (e.g. legal barriers to entry, antitrust exemptions, barriers in network sectors). As lower values suggest lower barriers, the barriers to entrepreneurship index is reversed so as to be read in the same way as other indicators used in this international benchmark. The ease of entrepreneurship index is calculated as 6 minus the barriers to entrepreneurship index. Calculations are made with 2013 data drawn from the OECD, Product Market Regulation Database (*www.oecd.org/economy/pmr*).

Internet for innovation

The Internet has become a critical infrastructure for businesses, consumers/users and the public sector (OECD, 2011a). In terms of data transmission, traffic levels have increased exponentially and are expected to continue to do so. New network applications and the expected migration of mobile users to more advanced 3G networks place larger demands on existing infrastructures by generating more traffic flow.

(k) ICT investment (per GDP). ICT investment is defined according to the 1993 System of National Accounts (SNA). It has three components: *i)* information technology equipment (computers and related hardware); *ii)* communications equipment; and *iii)* software. Software includes acquisition of pre-packaged software, customised software and software developed in house. Measuring investment in software is often problematic, as its capitalisation in national accounts is recent, methodologies vary and there are difficulties linked to its acquisition (e.g. rental and licence, embedded in hardware, or developed on own account). ICT investment is expressed as a percentage of GDP. Data for ICT investment are taken from *Measuring the Digital Economy: A New Perspective* (OECD, 2014c), except for Latvia and Lithuania for which data come from Eurostat ANA Databases.

(l) Fixed broadband subscriptions (per population). Broadband provides high-speed Internet access and enables the broader participation of customers, suppliers, competitors, government laboratories and universities in the innovation process. It makes outsourcing and off-shoring more efficient and has changed personal and business practices dramatically (OECD, 2010c). OECD work also indicates a strong correlation between the penetration of broadband and the use of e-government services by citizens (OECD, 2009). While mobile broadband is developing rapidly and has become the dominant broadband access channel in OECD countries, fixed wired broadband connections are still the foundation of high-speed data transport (OECD, 2012). Fixed broadband includes all subscriptions to DSL lines offering Internet connectivity (the DSL line is excluded if it is not used for Internet connectivity, e.g. leased lines), cable modem, fibre-to-the-premises (e.g. house, apartment) and fibre-to-the-building (e.g. apartment LAN) and other broadband over power lines capable of download speeds of at least 256 kbit/s. It does not include 3G mobile technologies and Wi-Fi. The number of fixed broadband subscriptions includes business and residential connections and is expressed per 100 inhabitants. Data for fixed broadband subscriptions are drawn from the OECD Broadband Statistics portal (*www.oecd.org/sti/ict/broadband*) which are compiled from information collected directly from telecommunications firms and national regulators twice a year. For non-OECD countries, data come from the ITU World Telecommunication/ICT Indicators 2013 Database and population data come from Eurostat and the UIS.

(m) Wireless broadband subscriptions (per population). Wireless broadband includes subscriptions with advertised download speeds of at least 256 kbit/s through satellites, terrestrial fixed wireless, terrestrial mobile wireless (including standard mobile subscriptions and dedicated data subscriptions). It does not include Wi-Fi. The number of wireless broadband subscriptions includes business and residential connections, to the exclusion of satellite subscriptions that tend to be null,and is expressed per 100 inhabitants. Data for fixed broadband subscriptions are drawn from the OECD Broadband Statistics which are compiled from information collected directly from telecommunications firms and national regulators twice a year. For non-OECD countries,

data come from the ITU World Telecommunication/ICT Indicators 2013. Database and population data come from Eurostat and the UIS.

(n) E-government readiness index. Governments increasingly use the Internet to improve their interaction with citizens by making it easier for them to obtain information, fill out necessary forms and file taxes (OECD, 2012). ICTs support changes in public services delivery by allowing more personalised, better-quality services, changes in work organisation and management through greater back-office coherence and efficiency; this improves the transparency of government activities as well as citizen engagement. OECD countries are transforming government through the use of ICT and ICT-enabled governance structures, new collaboration models (i.e. sharing data, processes and portals), and networked or joined-up administrations. ICTs increasingly drive public-sector innovation. The e-government readiness index is a composite index which shows how prepared a country is to use ICT-enabled public administrations for greater efficiency and measures its capacity to develop and implement e-government services. The index ranges from 0 (low level of readiness) to 1 (high level). Data are drawn from the UN e-government survey 2013.

Knowledge flows and commercialisation

Public research is the source of significant scientific and technological breakthroughs. To optimise the economic and social benefits from public research and the return on public R&D investments, effective linkages are needed between academia and industry. Knowledge flows between public research institutions and industry are channelled through spin-offs, joint research projects, training, consultancy and contract work, the commercialisation of public research output, staff mobility between workplaces and informal co-operation by researchers.

(o) Industry-financed public R&D expenditures (per GDP). Direct funding of public research by industry takes the form of grants, donations and contracts and influences the scope and orientation of public research, generally steering it towards more applied and commercial activities. The share of public R&D expenditure financed by industry is the domestic business enterprise sector's contribution to the intramural R&D expenditures of the higher education (HERD) and government (GOVERD) sectors. Data are drawn from the OECD MSTI Database and are based on harmonised national R&D surveys and national accounts, except for Latvia and Lithuania for which data come from Eurostat STI databases and for Colombia, Costa Rica, India, Indonesia and Malaysia for which data come from the UIS.

(p) Patents filed by universities and public labs (per GDP): The pool of available public research output can be diffused and commercialised via patenting and licensing. Patents applications by universities and public research institutions cover the government sector, higher education and hospitals. They include patent applications filed under the PCT between 2007 and 2011, by priority date and applicant's country of residence. Patent applicant names are allocated to institutional sectors using a dataset developed by Eurostat and Katholieke Universiteit Leuven (KUL). Because there are important variations in the names recorded in patent documents, misallocations to sectors may occur and thus introduce biases in the resulting indicator. Patent data are drawn from the Worldwide Patent Statistical Database (PATSTAT), EPO, Spring 2014 and ECOOM-EUROSTAT-EPO PATSTAT Person Augmented Table (EEE-PPAT), October 2013. Only countries having filed at least 250 patents over the period are included. Patent counts by universities and PRIs are expressed per billion USD GDP PPP.

(q) International co-authorship in total scientific articles (%). The growing specialisation of scientific disciplines and the increasing complexity of research encourage scientists to engage in collaborative research. Production of scientific knowledge is shifting from individuals to groups, from single to multiple institutions, and from a national to an international focus. Researchers increasingly network across national and organisational borders (OECD, 2009). International co-authorship of research publications provides a direct measure of international collaboration in science. International co-authorship is measured as the share of scientific articles produced in collaboration by two or more authors from different countries between 2011 and 2013. Data are drawn from the Elsevier Research Intelligence database.

(r) International co-invention in PCT patent applications (%). International co-invention of patents is a measure of the internationalisation of research and illustrates formal R&D co-operation and knowledge exchange among inventors in different countries. International collaboration by researchers can take place either within a multinational corporation (with research facilities in several countries) or through a research joint venture among several firms or institutions (e.g. universities or public research institutions). International co-operation is less widespread for patented inventions than for scientific publications (OECD, 2011a). International co-invention is measured as the share in total patents invented domestically of patent applications filed under the PCT between 2009 and 2011 with at least one co-inventor located abroad. Data are drawn from the OECD Patent Database.

Human resources for innovation

Education systems play a broad role in supporting innovation because knowledge-based societies rely on a highly qualified and flexible labour force. While basic competences are generally considered important for absorbing new technologies, high-level competences are essential for the creation of new knowledge and technologies.

(s) Tertiary education expenditure (per GDP). Education expenditure represent the total cost of services provided by all types of educational institutions (e.g. public institutions, government-dependent private institutions, and independent private institutions), without regard to sources of funds (whether they are public or private). Tertiary-level programmes include those delivering university degree, vocational qualifications, or advanced research degrees of doctorate standard, at a minimum at Level 5 of the International Standard Classification of Education (ISCED) 1997. Education expenditure data are drawn from the OECD Education and Training Database, based on the UNESCO-OECD-Eurostat (UOE) data collection on education statistics, compiled from national administrative sources, reported by ministries of education or national statistical offices.

(t) Adult population at tertiary education level (%). The adult population with tertiary educational attainment is a measure of a country's pool of workers with advanced, specialised knowledge and skills. It indicates its potential to absorb, develop and diffuse knowledge and shows its capacity to upgrade continuously its high-end skills supply. Educational attainment affects all aspects of adult learning. Adults with higher levels of educational attainment are more likely to participate in formal and non-formal education during their working lives than adults with lower levels of attainment. Tertiary graduates are those with a university degree, vocational qualifications, or advanced research degrees of doctorate standard, at a minimum at ISCED Level 5. The adult population is defined as

those aged 25 to 64 years old. Data on population and educational attainment are compiled from national labour force surveys (LFS). Data come from *OECD Education at a Glance 2014* (*www.oecd.org/edu/eag.htm*) (OECD, 2014d). For Latvia and Lithuania data are drawn from Eurostat Education and Training databases. For Argentina, China, Colombia, Costa Rica, Indonesia and South Africa, data are from the UIS Education Database.

(u) Top adult performers in technology problem solving (%). The Survey of Adult Skills defines problem solving in technology-rich environments as "using digital technology, communication tools and networks to acquire and evaluate information, communicate with others and perform practical tasks". It focuses on "the abilities to solve problems for personal, work and civic purposes by setting up appropriate goals and plans, and accessing and making use of information through computers and computer networks" (OECD, 2013b). Problem solving in technology-rich environments represents the intersection of what are sometimes described as "computer literacy" skills (i.e. the capacity to use ICT tools and applications) and the cognitive skills required to solve problems. Data are drawn from the OECD Skill Outlook 2013 based on countries' results in the Programme for the International Assessment of Adult Competencies (PIACC) (OECD, 2013b).

(v) 15-year-old top performers in science (%). Demand for skills increasingly emphasises capabilities for adapting and combining multidisciplinary knowledge and solving complex problems. The acquisition of such skills starts at a very early age. The top performers in science are the students who reach the two highest levels of proficiency (levels 5 and 6) in the OECD Programme for International Student Assessment (PISA) 2013 science assessment (i.e. they have obtained scores of more than 633.33 points). The number of top performers is expressed as a percentage of 15-year-olds. Data are drawn from the OECD PISA 2013 Database (*www.pisa.oecd.org*).

(w) Graduation rate in science and engineering at doctoral level. Doctoral graduates are those with the highest educational level and are key players in research and innovation. They have been specifically trained to conduct research and are considered best qualified to create and diffuse knowledge (OECD, 2010c). They have attained the second stage of university education and obtain a degree at ISCED Level 6. They have successfully completed an advanced research programme and gained an advanced research qualification (e.g. Ph.D.). Graduation rates represent the estimated percentage of an age cohort that will complete the corresponding level of education during its lifetime (the number of graduates, regardless of their age, is divided by the population at the typical age of graduation). However, in some countries, graduation rates at the doctoral level are inflated by a high proportion of international students (e.g. Germany, Sweden and Switzerland). Science degrees include: life sciences; physical sciences; mathematics and statistics; and computing. Engineering degrees comprise: engineering and engineering trades; manufacturing and processing; and architecture and building. The rates presented combine graduation rates at doctoral level and the share of doctorate graduates by field of study. They constitute a good proxy of graduation rates in science and engineering at doctoral level. Data are drawn from *OECD Education at a Glance 2014* (OECD, 2014d) and the OECD Education Database (*www.oecd.org/edu/database*). For Latvia and Lithuania data are drawn from Eurostat Education and Training databases. For Argentina, China, Colombia, Costa Rica, Indonesia and South Africa, data are from UIS.

Structural composition of BERD (Panel 2 of the country profiles)

A country's industrial structure determines the composition of its BERD and affects the growth prospects of its business research system.

Industrial structure

Industries and services are defined on the basis of the International Standard Industrial Classification (ISIC) Rev.4. The sectors are classified according to their R&D intensity (R&D expenditures relative to output). Data are drawn from the OECD ANBERD Database (*www.oecd.org/sti/anberd*). ANBERD has recently moved to the new sectoral classification, ISIC Rev.4, in line with the OECD STAN family of sectoral databases. Sectoral groupings may refer to years anterior to those for which industrial breakdown is available for countries in which recent data are available according to the new classification. For Latvia and Lithuania data are drawn from Eurostat STI databases.

The sectoral groupings are defined as:

Industry includes Mining (Section B), Manufacturing (Section C) utilities, i.e. Electricity, gas, steam and air conditioning supply (Section D) and Water supply, sewerage, waste management and remediation activities (Section E) and Construction (Section F). *Services* includes market-sector services (Sections G-N Divisions 45-82) and non-market-sector services (Sections O-T). Public-sector services encompass government (84), education (85), health (86-88), other community, social and personal services (90-96), and services to private households (97-98). However the distinction between market and public services on an industry-based definition is only approximate, as some services can be provided by public or private entities, or by a mix of the two (OECD, 2013a).

High-technology manufacturing includes manufacture of basic pharmaceutical products and pharmaceutical preparations (Section C Division 21), manufacture of computer, electronic and optical products (26), manufacture of air and spacecraft and related machinery (30.3). *Medium-high to low-technology industries* includes all other manufacturing industries. High- and medium-high-technology manufacturing is usually defined on the basis of industry R&D intensity, i.e. R&D expenditures relative to output. As countries are adopting the new ISIC revision and ISIC Rev.4 data are becoming available, technology aggregates are currently being redefined. In the meantime, an approximate correspondence from the ISIC Rev.3 definition has been adopted.

High-knowledge market services refer to ISIC Rev.4 Section J: Information and communication (Divisions 58-63); K: Finance and insurance (64-66); and M: Professional, scientific and technical activities (69-75), including scientific research and development (72). *Low-knowledge services* include all other market services.

Primary-resource-based industries are those that involve the harvesting, extraction and processing of natural resources. This aggregate includes: Agriculture, forestry and fishing (Section A), Mining and quarrying (Section B), Food products, beverages and tobacco (Section C Divisions 10-12), Wood and products of wood and cork (16), Pulp, paper and paper products (17), Coke, refined petroleum products and nuclear fuel (19), Other non-metallic mineral products (23), Basic metals (24) and Electricity, gas and water supply (Sections D-E). Owing to their small contribution to total BERD and issues of data availability, Wearing apparel, dressing and dying of fur (14) and Leather, leather products and footwear (15) are not included. This sectoral grouping is not represented in the charts of countries in which these industries contribute marginally to business R&D expenditures.

Firm population

SMEs play a key role in the R&D and innovation system. They are defined as firms with fewer than 250 employees; large firms have 250 employees and more. BERD data by firm size come from the OECD RDS Database.

Role of multinationals

Foreign affiliates contribute in many ways to a host country's international competitiveness by providing domestic firms with access to new markets, introducing new technologies and generating knowledge spillovers. In particular, foreign affiliates invest a higher share of their revenue in R&D than domestic firms (OECD, 2009). In addition, in the search for new technological competences, larger local market opportunities and lower R&D costs, companies are moving their research activities abroad. The geographical origin of a foreign affiliate is the country of residence of the ultimate controller. An investor (company or individual) is considered to be the investor of ultimate control if it is at the head of a chain of companies and controls directly or indirectly all the enterprises in the chain without itself being controlled by any other company or individual. The notion of control implies the ability to appoint a majority of administrators empowered to direct an enterprise, to guide its activities and determine its strategy. In most cases, this ability can be exercised by a single investor holding more than 50% of the shares with voting rights. Data come from the OECD AMNE Database.

Revealed technology advantage in selected technological areas (Panel 3 of the country profiles)

The revealed technology advantage (RTA) index provides an indication of the relative specialisation of a given country in selected technological domains and is based on patent applications filed under the Patent Cooperation Treaty. It is defined as a country's share of patents in a particular technology field divided by the country's share in all patent fields. The index is equal to zero when the country holds no patents in a given sector; is equal to 1 when the country's share in the sector equals its share in all fields (no specialisation); and above 1 when a positive specialisation is observed. Only economies with more than 250 patents over the period reviewed are included. Data are drawn from the OECD Patent Database.

Allocation of public funds to R&D, by sector, type and mode of funding (Panel 4 of the country profiles)

This figure shows several features of national research systems that are areas of direct or indirect public intervention.

Public research

Universities versus public research institutes (by sector of performance). Public research is traditionally performed by universities and PRIs (see the policy profile on "Public research missions and orientation"). Although there is a general trend in the OECD area towards reinforcing the role of universities, PRIs still make a major contribution in several countries (e.g. China, Luxembourg, the Russian Federation). The figure shows the balance between R&D performed by universities and R&D performed by PRIs, as a percentage of total public expenditures on R&D. Public expenditure on R&D is the sum of HERD and GOVERD. Data are drawn from the OECD MSTI Database and are based on harmonised national R&D

surveys. Data for Latvia and Lithuania are drawn from Eurostat STI Databases and data for Colombia, Costa Rica, India, Indonesia and Malaysia from the UIS.

Basic research versus applied research/development (by mission/orientation). Most basic research is performed by universities and PRIs (see the policy profile on "Public research missions and orientation"). Basic research is essential for developing new scientific and technological knowledge and builds the long-term foundations of knowledge societies. It is experimental or theoretical work undertaken primarily to acquire new knowledge, without any particular application or use in view. The figure shows the balance between public expenditure on R&D for basic research and public expenditure on R&D for the purpose of applied research and experimental development. Total public expenditure on R&D is the sum of HERD and GOVERD. Data are drawn from the OECD RDS Database and are based on harmonised national R&D surveys. Data for Latvia and Lithuania are drawn from Eurostat STI databases and data for Colombia, Costa Rica, India, Indonesia and Malaysia from the UIS.

Civil-oriented versus defence-oriented (by socio-economic objective). Government budget appropriations or outlays for R&D (GBAORD) by socio-economic objective indicate the relative importance of various socio-economic objectives, such as defence, health and the environment, in public R&D spending. These are the funds committed by the federal/central government for R&D (GBAORD generally covers only the federal or central government). Programmes are allocated according to socio-economic objectives on the basis of intentions when the funds are committed and may not reflect the actual content of the projects implemented. They reflect policies at a given moment in time. The classification used is the European Commission's Nomenclature for the Analysis and Comparison of Scientific Programmes and Budgets – NABS (see the *OECD Frascati Manual,* OECD, 2002). The GBAORD data are based on funders' reports; they are less accurate than "performer-reported" data, but they are more timely and can be linked back to policy issues by means of a classification by "objectives" or "goals".

Civil GBAORD equals to total GBAORD less defence. Defence R&D financed by government, including military nuclear and space but excluding civilian R&D financed by ministries of defence (e.g. meteorology). Data are drawn from the OECD RDS Database and based on budget data assembled by national authorities using statistics collected for budgets. Data for Latvia and Lithuania are drawn from Eurostat.

Generic research versus thematic research (by socio-economic objective). Generic public research includes: general university funds (GUF), a block grant which includes an estimated R&D content, granted by government to the higher education sector; and non-oriented GBAORD, which covers research programmes financed with a view to the advancement of knowledge. Thematic public research includes all other GBAORD. Data are drawn from the OECD RDS Database and based on budget data assembled by national authorities using statistics collected for budgets. Data for Latvia and Lithuania are drawn from Eurostat.

Institutional versus project-based funding (by funding mechanism). Governments support public research by means of institutional and project-based funding (see the policy profile on "Financing public research"). Institutional "block" grants provide stable long-run funding of research, while project-based funding can promote competition within the research system and target strategic areas. Project funding is defined as funding attributed on the basis of a project submission by a group or individuals for an R&D activity that is limited in scope, budget and time. Institutional funding is defined as the general funding of institutions with no direct selection of R&D projects or programmes (OECD, 2010c). The figure shows the balance between institutional funding and project funding for selected

OECD countries. However it does not reflect the share of block funding allocated on performance criteria and the spread of new performance-based funding mechanisms, e.g. the research excellence initiatives. Data are based on an exploratory project carried out by NESTI on public R&D funding and comparability may be limited (Van Steen, 2012; OECD, 2013). Complementary data are drawn from Eurostat STI Databases.

Business R&D

Private investment in R&D and innovation may be below a socially optimal level, mainly because returns are uncertain or the innovator cannot appropriate all of the benefits. Governments therefore play an important role in fostering investment in R&D and innovation (see the policy profile on "Government financing business R&D and innovation"). They can choose among various tools to leverage private-sector R&D. They can offer firms direct support via grants, loans or procurement or they can use fiscal incentives, such as R&D tax incentives (R&D tax credits, R&D allowances, reductions in R&D workers' wage taxes and social security contributions, and accelerated depreciation of R&D capital (see the policy profile on "Tax incentives for R&D and innovation").

Direct versus indirect funding (by funding mechanism). Direct R&D grants or subsidies target specific projects with high potential social returns. Tax credits reduce the marginal cost of R&D activities and allow private firms to choose which projects to fund. The optimal balance of direct and indirect R&D support varies from country to country, as each tool addresses different market failures and stimulates different types of R&D. For instance, tax credits mostly encourage short-term applied research, while direct subsidies foster more long-term research. Direct government funding of R&D is the amount of business R&D funded by the government as reported by firms. It is the sum of different components (contracts, loans, grants/subsidies) with different impacts on the cost of performing R&D. R&D grants and loans decrease the cost of performing R&D, but contracts (usually awarded through competitive bidding) do not directly affect the cost of performing R&D. Foregone revenues on R&D and innovation tax incentives are an estimated cost of the R&D tax concession. As the cost of tax incentives is estimated and reported in different ways across counties, these indicators are experimental. Eligible R&D expenditures can differ, and companies may use R&D tax incentives in some circumstances to fund intramural or extramural R&D, some of which may take place in other sectors. Tax incentives are excluded from the definition of government-funded BERD to minimise the risk of double counting. Data are drawn from the OECD RDS Database and from the NESTI data collection on R&D tax incentives (*www.oecd.org/sti/rd-tax-stats.htm*).

Balance

Business R&D versus public research. Governments support both public-sector research and business R&D and innovation but in different proportions. Most public money spent on R&D goes to universities and PRIs. However, public support to business R&D seems to have gained ground in many countries over the past five years. The figure shows the relative balance between government funding to universities and PRIs and government funding to business R&D. The former is defined as the sum of HERD and GOVERD funded by both government and higher education. The latter is defined as the sum of government-funded BERD and the estimated cost of R&D tax incentives, if any. The balance is expressed as a percentage of the sum of the two. Data are drawn from the OECD RDS Database and the NESTI data collection on R&D tax incentives.

Most relevant instruments of public funding of business R&D (Panel 5 of the country profiles)

Governments finance business R&D and innovation through a mix of complementary direct and indirect instruments (see Chapter 1 and the policy profile on "Government financing business R&D and innovation"). Direct funding allows governments to target specific R&D activities and depends on discretionary decisions by governments and arm-length organisations (e.g. national funding agencies). Tax incentives reduce the marginal cost of R&D and innovation spending and are usually more neutral in terms of industry, region and firm characteristics. While direct subsidies tend to target long-term research, R&D tax schemes are more likely to encourage short-term applied research and boost incremental innovation rather than radical breakthroughs.

Direct funding. Governments may offer financial support to firms through a variety of competitive grants, repayable advances (e.g. subordinated to profit making by firms), debt financing mechanisms (e.g. loans at preferential rate, credit guarantee schemes that reimburse a pre-defined share of the outstanding loan to the lender in the event of a loan default, risk-sharing mechanisms such as guarantee funds and mutual guarantee associations that provide lenders with insurance against firms' risk of default, etc.). Many countries have schemes and funds to access early-stage finance, particularly for equity, and to support the venture capital industry, e.g. through public venture capital funds, co-investment funds with private investments and "funds of funds" (see the policy profile on "Financing innovative entrepreneurship"). Technology consulting and extension programmes, albeit not a funding instrument per se, help firms access expertise, knowledge and technology at low or no cost. Innovation vouchers whose face value varies across countries are granted to firms for the purchase of knowledge services from universities and public research and education providers. Direct funding through public procurement is not included in the figure.

Indirect funding. Tax incentives applicable to different tax arrangements, including corporate and personal income taxes, are also widely used to encourage private investments in R&D and the exploitation of IP assets, to attract business angels and leverage early-stage finance, and to attract foreign talent or foreign multinationals (see the policy profiles on "Tax incentives for R&D and innovation" and "Financing innovative entrepreneurship"). In the figure, a distinction is made between tax breaks that are granted on the basis of expenditures incurred for R&D and innovation activities (expenditure-based) and tax breaks that are granted on gains from innovative activities (income-based).

Data are drawn from country responses to the STI Outlook policy questionnaire 2014. Responses were provided by self-assessment by Delegates to the OECD Committee for Scientific and Technological Policy to the question: "C.3) Which of the following are the principal instruments of public funding of business R&D and innovation in your country? How has the relative balance between these instruments changed recently, if at all? Please rate the relative relevance of the following financial instruments in your country's policy mix (high; medium; low; and not used) and indicate whether their share in the total has increased/decreased or is remained unchanged." Responses have been aggregated as followed: 0 = not used; 1 = low and decreasing relevance; 2 = low and stable relevance; 3 = low and increasing relevance; 4 = medium and decreasing relevance; 5 = medium and stable relevance; 6 = medium and increasing relevance; 7 = high and decreasing relevance; 8 = high and stable relevance; 9= high and increasing relevance.

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