OECD Science, Technology and Industry Outlook 2012

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BETTER POLICIES FOR BETTER LIVES

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Foreword

The OECD Science, Technology and Industry Outlook 2012 *is the ninth in a biennial series designed to review key trends in science, technology and innovation (STI) in OECD countries and a number of major non-member economies: Argentina, Brazil, China, Colombia, Egypt, India, Indonesia, the Russian Federation and South Africa. It aims at informing 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 the current and possible future implications for national STI policies both at global and national level.*

The 2012 STI Outlook *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 draws 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 towards the development of more experimental STI indicators.*

The 2012 edition covers issues that are high on the STI policy agenda in light of the current financial and economic crisis, fiscal budgetary constraints and major global and societal challenges (green growth, ageing societies, economic and inclusive development), and considers the outlook for STI policy. It provides, in a series of new thematic STI policy profiles, a cross-country comparison of STI policy orientations, instruments and governance in the OECD area and beyond. The presentation of main trends in national STI policies has been re-designed to improve readability and to facilitate joint use of cross-country comparisons and country-specific analysis. The focus is on national STI priorities, policies and programmes introduced between 2010 and 2012. The STI country profiles have also been re-designed to better link issues of policy interest at national level (country profiles) with the cross-country material provided in the STI policy profiles. The 2012 edition offers insights into national innovation systems: their structural characteristics, their STI performance benchmarked against selected harmonised indicators and recent important national STI policy developments. Moreover, with over 300 STI-related indicators, the Outlook's statistical framework has been radically expanded.

Finally, the 2012 STI Outlook *has been revamped with a view to the future OECD Innovation Policy Platform (IPP), a web-based interactive space that will provide access to open data, learning resources and opportunities for collective learning on innovation policy. The IPP is also designed to help users analyse innovation systems and identify and prioritise good practice solutions. The 2012* STI Outlook *will serve as one of the first pillars of the IPP.*

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The *2012 STI Outlook* is a collective effort, the first ever on this scale, 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.

Chapter 1, "Innovation in the crisis and beyond", was prepared by Caroline Paunov and received input from Fernando Galindo-Rueda, Valentine Millot and Andrew Wyckoff. Winfrid Blaschke, Sebastien Martin and Gert Wehinger of the OECD Directorate for Financial and Enterprise Affairs (DAF) provided statistical material and comments. Participants at the OECD Thematic Workshop on Financing R&D and Innovation in the Current Macroeconomic Context, held in December 2011 at the OECD headquarters, also contributed greatly to this chapter.

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Table of contents

Part III
MAIN TRENDS IN SCIENCE, TECHNOLOGY AND INNOVATION (STI) POLICY

Acronyms

BERD	Business enterprises expenditure on R&D
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
GOVERD	Government intramural expenditure on R&D
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 Occupation
ISIC	International Standard Industrial Classification
IT	Information technology
JPO	Japan Patent Office
MNE	Multinational enterprise
OHIM	Office for Harmonization in the Internal Market
PCT	Patent Cooperation Treaty
PPP	Purchasing power parity
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
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

Abbreviations

ARG	Argentina	EST	Estonia	MEX	Mexico
AUS	Australia	FIN	Finland	NLD	Netherlands
AUT	Austria	FRA	France	NOR	Norway
BEL	Belgium	GBR	United Kingdom	NZL	New Zealand
BRA	Brazil	GRC	Greece	POL	Poland
CAN	Canada	HUN	Hungary	PRT	Portugal
CHE	Switzerland	IDN	Indonesia	RUS	Russian Federation
CHL	Chile	IND	India	SVK	Slovak Republic
CHN	People's Republic of China	IRL	Ireland	SVN	Slovenia
COL	Colombia	ISL	Iceland	SWE	Sweden
CZE	Czech Republic	ISR	Israel	TUR	Turkey
DEU	Germany	ITA	Italy	USA	United States
DNK	Danemark	JPN	Japan	ZAF	South Africa
EGY	Egypt	KOR	Korea		
ESP	Spain	LUX	Luxembourg		

Country groupings

BRIICS	Brazil, Russian Federation, India, Indonesia, People's Republic of China, South Africa
EU27	European Union (Austria, Belgium, Bulgaria, 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

1. The information in this document with reference to "Cyprus" relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Turkey shall preserve its position concerning the "Cyprus issue".
2. The Republic of Cyprus is recognised by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.

Executive summary

Short-term shocks – linked to the economic crisis – and long-term shocks – environmental, demographic and societal – have put OECD economies before unprecedented challenges. Under extremely stringent budgetary constraints, governments are mobilising all policy domains to design appropriate responses for reaching strong and sustainable growth. They must seize the opportunities offered by the Internet and global markets, as well as mobilise the main assets of their countries – human capital, knowledge capital, and creativity. In this agenda, innovation policies are given a pivotal role, which they can fulfill only if they adapt to this new context: they need relevance, coherence and inclusiveness in order to achieve efficiency and effectiveness.

Innovation in times of crisis

The economic crisis which started in 2008 has had a significant impact on science, technology, innovation (STI) domains and policies. It has accelerated a number of trends and magnified certain challenges, most of which had already appeared prior to 2008. A re-examination of STI policies has therefore become more urgent. In this new environment some countries have adapted or have begun to adapt, while others have found it difficult to evolve. As a result, the gap between countries that grow and innovate and those that do not has been widening.

The global economic crisis immediately had a strong negative impact on innovation worldwide. Total OECD-area business expenditure on research and development (R&D) declined by a record 4.5% in 2009; it declined across all major OECD R&D spenders except Korea and France. In 2010 the recovery that occurred in some countries did not always imply a return to pre-2009 R&D levels. This pattern, a dip followed by partial recovery, is confirmed by indicators such as patents and trademarks. Among the countries most active in innovation, there is a striking contrast between Sweden and Finland, which have experienced a drop in terms of R&D and patents, and Korea, which has continued its fast, steady expansion.

In view of current economic conditions and the rather uncertain outlook, it is likely that in most OECD countries, notably those most strongly affected by the crisis (*e.g.* some southern and eastern European countries), growth in business R&D expenditure will be quite sluggish in the foreseeable future. In countries with relatively solid framework conditions prior to the crisis and which have proved quite resilient in terms of economic growth (such as those of northern Europe and Germany), innovation activities might follow a more positive path. In countries such as France, Japan, the United Kingdom and the United States, however, the perspectives for both economic growth and innovation are more uncertain.

In 2009, the initial shock affected all categories of firms, but while the innovative activities of large multinationals, especially those in high-technology sectors, were back on track in 2010, innovative entrepreneurship has not yet returned to pre-crisis levels. In 2011, both enterprise creation and venture capital investment were still well below pre-crisis levels. Following the dramatic rise in firm failures during the crisis, the renewal of industry and the corresponding reallocation of resources have yet to make significant progress toward enhancing overall economic performance.

Government funding temporarily surged sharply in 2009 in many countries, as innovation was an important component of recovery packages. Government budget appropriations or outlays for R&D (GBAORD) increased by about 9% in the OECD area, with most going to infrastructure investment and to businesses (credit guarantees for small firms, refunds of R&D tax credits, public procurement, etc.). As this partly compensated the reduction in business expenditure, the decline in OECD total R&D expenditure in 2009 was not as large as it would have been otherwise. However, in 2010 and 2011, as governments' budgetary constraints became more severe, many countries substantially moderated or reduced their R&D expenditure (OECD GBAORD declined by about 4% in 2010).

While the crisis triggered stagnation or decline in innovative activities in OECD countries, it did not have that effect in some emerging countries. China still had high GDP growth and a steady increase in innovation activities, as business R&D increased by 26% in 2009. As a result, China's share in global R&D, which climbed from 7% in 2004 to 10.5% in 2008, jumped to 13% in 2009; the crisis accelerated an existing trend. At the same time, developing countries such as India and Brazil are putting innovation higher on their policy agenda.

The changing context of STI policies

The economic crisis has affected the innovation policy agenda both in terms of objectives and instruments. Rather than leading to new objectives or instruments, however, it has changed the balance of those already in place, generally with a view to maximising their impact on economic growth and saving resources. More broadly, the current context has intensified tendencies which were already at work before: innovation policies have to be relevant (to address economic or societal goals), coherent (with each other and with other policies), and inclusive (in terms of scope and of the concerned actors).

More than ever, restoring growth and competitiveness is the main objective of innovation policies. OECD countries need more growth, not least to address the persistent sovereign debt crisis and to tackle unemployment. In knowledge-based economies innovation is a major driver of growth. Because emerging countries increasingly challenge developed countries on knowledge-intensive segments of markets, developed countries need to climb the value added ladder. This calls for innovation.

Government budgets are under pressure, as the public debt crisis has shown that market actors are reluctant to fund government deficits further. Savings need to be found, and in most countries STI budgets are not exempt from cuts. Government action must become more efficient and more effective through a rebalancing of the instruments used, changes in governance, and more extensive use of *ex ante* and *ex post* evaluation.

Policies to address societal and environmental challenges are also increasing in importance. Urgent environmental challenges include addressing climate change, moving towards green growth and tackling natural disasters. Pressing societal objectives include ageing and health. Given stringent budgetary constraints, governments are realising that innovation is needed to address these challenges in the medium to long term.

A broader view of innovation towards service activities, beyond science and technology, is also progressively pervading policies, including those concerned with public services (*e.g.* in education).

Addressing societal and global challenges

Green growth and the environment: Reducing global greenhouse gas (GHG) emissions and protecting environmental assets (clean air, water, biodiversity) call for innovation and the large-scale adoption of green technologies. Otherwise, it will be very difficult and very costly to sustain growth trajectories of the past decades while not depleting humanity's "green capital". OECD governments and emerging economies therefore view R&D activities and incentives for the diffusion and adoption of green technologies as a priority. Renewable energy programmes aim to reduce both GHG and dependency on oil (the price of which has recently risen sharply). Environment and energy feature high in the innovation strategy of most countries.

Ageing and health: Populations in most OECD countries and in some emerging economies are ageing, in many cases quite rapidly. An ageing workforce will likely constrain economic performance as well as increase strains on health services, long-term care systems and public finances. Science and technology, particularly ICT applications, will play an important role in helping the elderly remain as healthy, autonomous and active as possible. The health challenge is not only confined to meeting the needs of an ageing population, but also to the needs of the whole society. Innovation is needed to develop the best science, deploy effective treatment, and contain the surging costs of treatment and equipment.

Innovation for development: Once considered the preserve of developed countries, innovation is now conducted by many emerging countries and their share of innovation worldwide is increasing. A world-class science base is not a condition for innovating. The notion of innovation encompasses much more than high technology; it includes lower technology, service industries and social innovation, all of which are needed at all levels of development. Innovation can contribute to addressing urgent challenges such as providing access to drinking water, eradicating diseases and reducing hunger. "Inclusive" innovations have a more direct impact, as they make new products more affordable for low- and medium-income households or allow the poor to modernize their often "informal" and low-productivity business.

The changing instruments of innovation policies

Instead of a radical shift, the innovation policy mix has experienced a progressive evolution by which certain instruments are being used more widely while others have been receding. In a number of countries, targeted instruments are gaining importance as compared to generic ones: this is related to the emergence of important, targeted policy themes (*e.g.* new firms, social challenges), and to the budgetary crisis, which forces governments to concentrate spending under pressure.

Tax incentives: The general trend has been to increase the availability and simplicity of use of R&D tax incentives, which are now available in more than two-thirds of OECD countries as well as in many non-OECD countries.

Demand-side policies: Demand-side innovation policies – including public procurement of innovation, standards and regulations and lead markets and user-driven innovation initiatives – are gaining ground in OECD countries. They reflect the trend in innovation policy to address the full extent of the innovation system and cycle.

Entrepreneurship: Intensified financial and structural efforts (*e.g.* removal of administrative barriers) have been implemented by many countries in the context of the economic crisis.

Clusters and "smart specialisation": Clusters bring together firms, higher education and research institutions, and other public and private entities to facilitate collaboration on complementary economic activities. "Smart specialisation" is a policy framework to help entrepreneurs and firms strengthen scientific, technological and industrial specialisation patterns while identifying and encouraging the emergence of new domains of economic and technological activity.

Patents and IP markets: Patent subject matter (software, genetic material, business methods) and patent quality have been much discussed over the past decade. Important reforms have been implemented and patent offices have focused on improving quality. Intellectual property (IP) markets seem to be on the rise including various types of transactions (licensing, sales) and actors (intermediaries, funds, etc.). Government are involved through regulation (notably antitrust) and, in certain countries, through public patent funds.

Information and communication technology (ICT) infrastructure: Governments can facilitate the establishment of high-quality infrastructure (broadband networks) and ensure that its management (pricing, etc.) is conducive to adequate use.

Raising the effectiveness of public sector research

Commercialisation of public sector research: This goal has taken on greater urgency in the aftermath of the economic crisis as public funding has become scarcer. A major tendency is the professionalisation and increasing scale of technology transfer bodies (through the regrouping of smaller ones). Spin-offs (*e.g.* in the context of incubators), contract research, and patenting and licensing remain the main instruments, together with mounting attention to open science.

Open science: As science becomes more commercialised, and as ICTs make access to knowledge technically easier, many governments want science to diffuse broadly and flow to society and the economy. This implies providing the necessary technical infrastructures (databases, etc.) and legal framework (IP).

Internationalisation: Ensuring the insertion of national actors into global knowledge networks is an important policy goal. Relevant instruments include a legal framework and financial incentives that encourage the mobility of researchers and international research co-operation to address global challenges.

Management and funding: The higher education sector in most countries continues to evolve towards a more decentralised mode of organisation, in which universities are endowed with autonomy and responsibility. This trend is consistent with a model in which research funding is based more on competitive grants than on institutional funding.

Strengthening the governance of innovation policies

The increasing variety of objectives, instruments and actors (regions, specialised agencies, public-private partnerships, etc.) requires new ways of co-ordinating innovation policies to ensure coherence of design and implementation and to maintain government control.

Recent changes in the governance of STI systems include the tendency to put specialised, partly autonomous agencies in charge of various missions (*e.g.* allocating funding to public research institutes and universities) and the emergence of regional policies that supplement national policies and boost cross-regional competition.

National STI strategies have been developed and implemented in many countries. They articulate the government's vision of STI's contribution to social and economic development and the corresponding investment and reform agendas.

STI policy evaluation has attracted policy attention recently because governments are devoting significant resources to R&D and innovation at a time of fiscal crisis. Many governments have consolidated evaluation frameworks, streamlined evaluation procedures (sometimes through the establishment of a single dedicated agency) or reinforced co-ordination of evaluation units. Some countries have worked to harmonise practices by defining common methodologies and consolidating indicators, and a few are building data infrastructures and expert communities.

PART I

Innovation and the macroeconomic environment

PART I

Chapter 1

Innovation in the crisis and beyond

This chapter provides an overview of the impact of the global financial and public debt crises on innovation. The global financial crisis negatively affected business innovation and R&D. Enterprise creation seems not to have recovered and business bankruptcies have increased significantly. The chapter shows substantial differences in performance across countries, sectors, businesses and types of innovation.

Future trends in innovation in most developed countries are uncertain. In particular, long-term damages to innovation systems occur when long-term skilled unemployment rises and public support of innovation is weakened.

Finally, many countries have implemented policies to respond to the crisis that include innovation, although budgetary constraints have put pressure on governmental support of innovation.

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.

Key messages

1. **The economic crisis that started in 2008 has negatively affected business innovation and research and development (R&D) in all countries.** The size of the effect and the impact on business innovation has differed widely across countries, depending on their situation at the eve of the crisis and on the policies they subsequently implemented.
2. **Emerging countries in Asia, including Korea and China,** have used the opportunity to demonstrate their strengths in innovation. They continue to outperform developed countries, relying on structural strengths that helped them face the crisis. The crisis has also rewarded **large high-technology innovating firms**; markets for these innovations will continue to be strong.
3. **The crisis revealed the pre-crisis weaknesses of some countries** (*e.g.* Greece and some southern and eastern European countries), **sectors** (*e.g.* the automobile sector) and **types of innovations** (*e.g.* financial innovations). Future prospects for innovation in these countries and industries will greatly depend on broader economic restructuring, which does not place innovation at the top of the immediate policy agenda although innovation will have to play a role in driving growth in the future.
4. **Many OECD countries (northern Europe, Japan and the United States) have recovered somewhat**. Their future innovation performance remains uncertain; it will depend on macroeconomic conditions but also on their ability to maintain innovation as a policy priority.
5. To date there is no evidence of a reallocation of resources towards more innovative businesses. **While there have been more bankruptcies than before the crisis, new business entry has also been significantly depressed. Venture capital investment, which can help support entry of innovative firms, has yet to recover to its pre-crisis level.**
6. **Uncertainties over market conditions in the currently unstable global macroeconomic situation have inhibited investment in innovation.** Large companies and banks are engaged in a process of deleveraging and hoarding that is detrimental to all types of investment, including innovation. Financing constraints have also increased but are not the main explanation to date for the weakening of innovation activities.
7. Many countries have implemented policies in support of innovation during the crisis. This has given innovation new prominence on the policy agenda; government responses to the crisis **mainly focused on infrastructure investments for innovation and the provision of financial resources to businesses**. As the budgetary crisis has developed, a number of governments have more recently started reducing their expenditure on innovation.

Policy lessons

1. **Few innovation policies implemented in response to the crisis have addressed demand uncertainties effectively.** Most countries have relied on traditional infrastructure and financial support instruments, whereas instruments aimed at reducing demand uncertainties could have speeded up the recovery process. Experimenting further with these types of policy tools, notably in sectors where potential demand is high (*e.g.* health, ageing, etc.), would help improve innovation and growth prospects.
2. **The crisis has in many ways accentuated existing situations, including structural weaknesses in national innovation systems, and accelerated previous trends**. Recovery policies that supported failing sectors were likely mistaken: market forces will continue to weaken them and they will eventually face similar difficulties. Instead, resources should be provided to sectors with growth potential, in parallel to industrial policies that facilitate resource redeployment, *e.g.* retraining programmes and R&D and entrepreneurship programmes that reduce costs of such restructuring.
3. **Policies aimed at avoiding employment losses and supporting training are essential to avoid damage to innovation systems**. Such policies do not only matter from a social perspective. From the perspective of innovation *i)* the lack of enterprise creation to absorb unemployed workers, *ii)* the lower quality of matching skilled workers to adequate employment available during recessions as well as *iii)* the importance of employees' tacit knowledge for firms' innovation processes are the main arguments for employment support during downturns.

Introduction

The collapse of Lehman Brothers in September 2008 led to a major global economic crisis of a magnitude that had not been seen for at least half a century: world gross domestic production (GDP) and industrial production retracted, trade collapsed sharply, and unemployment increased in many of the world's major economies. A moderate short-lived recovery began by the end of 2009 and continued with some notable exceptions in 2010 and 2011. Market speculation regarding the sustainability of sovereign debt and the challenges of negotiating fiscal consolidation lowered expectations for a rapid, fully fledged recovery of the world economy. Some countries are now on a much more favourable trajectory. Because of the substantial impact on the output of the world's major economies, on global financial institutions (which play a central role as intermediaries for businesses and their innovation investments), and on public finances (which provide key support to innovation systems), the business cycle downturn has negatively affected innovation performance.

The chapter provides a first comprehensive overview of the effect of the global financial crisis and the subsequent public debt crisis on the world's innovation system and then considers potential future trends.[1] They had an overall negative effect on business R&D and innovation in 2008 in a wide range of countries. To date there is no evidence that they led to a reallocation of resources towards more innovative businesses. The impacts differed substantially across countries, types of businesses and types of innovation. The chapter identifies three different scenarios in terms of the impact on innovation. At one end of the spectrum, the evidence shows that emerging Asia, including Korea and India, has gained opportunities to demonstrate strengths in innovation, as have highly innovative firms; at the other end of the spectrum, some countries were weakened and their performance remains fragile (*e.g.* Greece, some southern and eastern European countries). The majority of countries have recovered somewhat, but uncertainties remain as regards future developments.

The chapter also discusses the three main factors which have influenced innovation performance during the crises: *i)* uncertainties about trends in demand regarding the recovery, *ii)* access to finance and *iii)* governments' innovation policy responses. Uncertainties over market conditions in the currently unstable global macroeconomic situation have strongly inhibited innovation. Large companies and banks are engaged in a process of deleveraging and hoarding that is detrimental to all types of investment, including in innovation. Financing constraints also increased but are not the main explanation for the decline in innovation activities. Moreover, many countries have implemented policies to support innovation during the global financial crisis giving innovation new prominence in the policy agenda. However, budgetary pressures have risen significantly in many countries and will likely continue to put pressure on public support for innovation.

The remainder of the chapter focuses first on the impact of the crises on innovation and then looks at what happened to factors that likely drove the observed performance. This is followed by a discussion of policy responses and finally of future trends in public spending, likely longer-term challenges and geographical impact.

The crises and their impact on innovation

What to expect of innovation as a result of the crises?

Joseph Schumpeter famously argued that the process of "creative destruction", while painful, fosters innovation and progress by discarding the old and familiar for the new and better. From this perspective, the downturn may be a source of opportunities for innovators and innovation systems. Before turning to what to expect in this respect, Box 1.1 briefly discusses the three dimensions of the global financial and sovereign debt crises that are most important for innovation.

The global financial and sovereign debt crises described in Table 1.1 have had four types of effects on the private sector: *i)* reduction in the demand for products; *ii)* reduction in liquidities in the financial system; *iii)* increased uncertainties as to future developments; and *iv)* impacts due to changes in innovation policy. These can affect innovation performance and investments via several mechanisms, as described in column 2 of Table 1.1. Column 3 shows that the implications for innovation can both be positive and negative. With few exceptions (Nickell *et al.*, 2001; Francois and Lloyd-Ellis, 2008), the pro-cyclicality of R&D and innovation has been observed over various business cycles and for a variety of countries (*e.g.* Griliches, 1990; Broda and Weinstein, 2010; Barlevy, 2002, 2007; Comin and Gertler, 2006; Fatas, 2000; Francois and Lloyd-Ellis, 2008; Rafferty, 2003; Walde and Woitek, 2004).

The global financial crisis and even more the public debt crisis affected countries differently. The global financial crisis most severely hit European countries such as Iceland, Ireland and Italy but also Mexico. Not all countries had negative growth rates in 2009; the BRIC countries (Brazil, the Russian Federation, India, and the People's Republic of China), Argentina, Colombia and Korea continued to grow. Their innovation systems were therefore much less exposed. Public debt challenges were particularly severe for certain

Box 1.1. **Effects of the global financial and sovereign debt crises of relevance to innovation**

Three aspects of the present context suggest that confidence that the current downturn will have had merely "marginal" impacts on innovation may be unwarranted:

- First, innovative businesses in many developed economies have suffered from lower demand for their products and substantial uncertainties over future trends in consumption. The magnitude of the global financial crisis even exceeded some negative records established by the Great Depression (Almunia *et al.*, 2009; Reinhart and Rogoff, 2009). Innovators have suffered and high-technology companies saw their revenues decrease markedly with the drop in demand for higher-quality innovative products that tends to occur during recessions (Lien, 2010; Piva and Rossi-Lamastra, 2011). Following the crisis, the recovery in most developed economies has often been short-lived and incomplete. By mid-2011 prospects for a rapid recovery had dimmed as a result of increased concerns over sovereign debt and the deleveraging that limited opportunities for consumption to recover quickly. The historical evidence also points to a slow recovery process (Reinhart and Rogoff, 2009).
- Second, public support for innovation faces potential challenges given the priority attached to fiscal consolidation. Fiscal consolidation has been at the forefront of policy discussions in Europe, the United States and Japan. High levels of sovereign debt and market speculation about potential sovereign default restrict the scope for policy interventions. Moreover, population ageing will likely place further pressure on pension and health budgets in the medium term and challenge governments' abilities to invest strongly in long-term growth, including in factors that support innovation such as education, infrastructure and innovation projects.
- Third, the global financial crisis exposed the vulnerabilities of the global financial system (Reinhart, 2011). Fragilities in the banking sector affect innovative businesses' opportunities to obtain external financing. With markets speculating in sovereign default risks, moreover, the banking sector in Europe and beyond remains at risk (IMF, 2011a, 2011b). In China, the quick expansion of investment credit for 2009-10 led some to question the quality of some of the projects financed, thus adding to other challenges to the Chinese banking system (IMF, 2011a).

southern European countries. In most countries the recovery has been sluggish with a return to the modest growth rates that characterised the pre-crisis period. The differing impacts of innovation across countries are worth bearing in mind.

The analysis of innovation performance during the global financial and public debt crises points to three different scenarios across countries, industries, firms and framework conditions for innovation. These are described in Table 1.2 with examples and potential future trends:

- In a first scenario the global financial crisis had strong negative impacts on innovation and there has been limited or no recovery. Examples include entrepreneurship/firm creation, venture capital financing and Greece. These areas require structural reforms. Certain trends threaten to damage innovation in the long run (*e.g.* reduced public financing of R&D).
- In the second scenario, probably the most prevalent, the global financial crisis resulted in a temporary negative shock to innovation but led to a subsequent recovery. Examples include many European economies, big R&D firms and trademarks. Future trends will depend on whether or not any long-term risks for innovation arise (*e.g.* a sluggish evolution of demand).

Table 1.1. **Potential effects of various aspects of the global financial and public debt crises on R&D, innovation and entrepreneurship**

Direct effects	Mechanisms affecting innovation	Impact on innovation
Reduced demand for goods and services	● Demand effects: Ambiguous impact as the downturn likely reduces demand for innovative goods, which are often more expensive, and/or durable goods whose purchase can be more easily postponed. Downturns may also increase demand for innovative products that offer lower prices and/or respond better to altered demand during recessions.	*Innovation:* Negative for certain product innovation but positive for process innovations as well as product innovations that reduce costs/prices (*e.g.* low-cost airlines grew out of the recession in the early 1990s). *Entrepreneurship/firm dynamics:* Fewer market opportunities exist for young innovative firms except those with a business model aimed at responding to demand for lower-priced goods. High-potential entrepreneurs react more to the presence of good business opportunities than marginal entrepreneurs who are more likely to respond to labour market conditions. This will affect innovation performance (Koellinger and Thurik, 2011).
	● Competition effects: Competition may increase because gaining other firms' market shares is the only way to maintain sales levels. However, the shock may also force the exit of small firms and thus decrease competition faced by big businesses.	*Innovation:* Impact on innovation depends on the link between product market competition and innovation, the trade-off between rents from less competition and incentives for innovation to "escape" competition (Schumpeter, 1942; Nickell, 1996; Aghion *et al.*, 2005a). *Entrepreneurship/firm dynamics*: ● Competition leads to "creative destruction" processes and the failure of less innovative incumbents. It can facilitate opportunities for entrepreneurship to improve aggregate innovation performance (Hall, 1991; Mortensen and Pissarides, 1994; Caballero and Hammour, 1994; 1996; Bailey *et al.*, 2001; Foster *et al.*, 1998). Disney, Microsoft, Hewlett-Packard, Oracle and Cisco were created during downturns. ● Young firms with substantial innovation capacities may be forced to exit during recessions before they have fully developed their potential with loss of any set-up costs spent in building up firms' innovation systems (Ouyang, 2011).
	● Cash flow effects: Firms' cash flow may be reduced, making fewer internal resources available to cover operational expenses.	*Innovation:* Negative if external financing is not available. Small and young firms may lower their investments as they face greater risks of being forced to exit and face stronger financing constraints. *Entrepreneurship/firm dynamics:* ● Exit of innovative businesses can result if external financing constraints exist (Barlevy, 2002; Nishimura *et al.*, 2005; Hallward-Driemeier and Rijkers, 2011). ● However, layoffs and lower wages and/or forced firm exit reduce opportunity costs of entrepreneurship, increase individuals' willingness to take on greater risks and increase the availability of qualified labour during downturns (Koellinger, 2008; Audretsch, 1991, 1995).
	● Inter-temporal resource allocation effects: Firms' opportunity costs for investing in innovation rather than spend on the production of output are lower when demand is low (Caballero and Hammour, 1996; Cooper and Haltiwanger, 1993; Aghion and Saint-Paul, 1998), Private payoffs for innovations are higher when demand is at its peak (Barlevy, 2007).	*Innovation:* Firms spend more on innovation and less on production during the downturn to reap higher payoffs at the peak of the recovery but keep innovations for the future. The time lag between investment and private payoffs to innovation ultimately determines whether the recession has positive or negative effects on innovation. *Entrepreneurship/firm dynamics:* Entrepreneurs might postpone entry of innovations until markets recover and demand is higher.
Reduced liquidity in the financial system	● Reduction in loans due to deleveraging affects all types of investments, notably those of SMEs (which rely more on financing from loans than large firms). Market failure in credit markets may worsen as lower cash flows mean firms have less collateral (Bernanke and Gertler, 1995). ● Investors have fewer resources to allocate across investment projects.	*Innovation:* Lack of financing negatively affects innovation during downturns (Aghion *et al.*, 2005b, 2008; Krozner *et al.*, 2007; Dell'Ariccia *et al.*, 2008). The volume of venture financing varies with the business cycle (Gompers and Lerner, 1998, 1999; Kaplan and Schoar, 2005). *Entrepreneurship /firm dynamics:* Reduced entry of innovative start-ups (Lerner, 2011). Negative firm dynamics due to insufficient entry (Caballero and Hammour, 1994; Parker, 2009). Lower financial capital lowers investments in riskier, potentially higher pay-off innovations (Nanda and Rhodes-Kropf, 2011).
Uncertainties affecting demand and finance	● Uncertainties can reduce the number of risky investments by investors, banks and firms, as sunk costs of such investments provide incentives to postpone them.	*Innovation:* Firms may be less willing to face uncertainties and risks associated with introducing new products and/or processes since their survival might be compromised if demand evolves unexpectedly (Fernandes and Paunov, 2011). *Entrepreneurship/firm dynamics:* Limited firm entry can be caused by uncertainties. Entrepreneurs prefer to wait until demand and financial markets have recovered.
Public budgetary situation	● Policy makers either do not address challenges posed by innovation, given other priorities and/or lower public resources, or they focus specifically on innovation. ● Recovery packages *vs.* fiscal discipline affects public expenditure as it relates to innovation.	*Innovation* and *Entrepreneurship/firm dynamics:* To the extent that business innovation and R&D are positively linked to public R&D and support, they will move in the same direction.

- In a third scenario, the best possible outcome, the global financial crisis had no substantial impact and innovation performance continues and/or even grows. China is a country to which this applies; other examples are IT firms and public R&D spending. Current trends suggest a positive evolution for those cases.

The following sections discuss these situations and provide evidence on trends.

Table 1.2. **Stylised description of scenarios on the crises and innovation**

Scenarios	Examples of countries, industries and firms	Outlook
1. The crises had negative impacts on innovation and there was no or little recovery subsequently. The global financial crisis revealed structural shortcomings that already existed in the pre-crisis period	● Greece and Spain (Figures 1.8, 1.15). ● Automobile industries in developed countries and other medium-technology sectors (Figure 1.4). ● Venture capital and other markets for risk financing (Figure 1.9) and, to lesser extent, access to bank credit (Figure 1.10). ● Some financial innovations (Figure 1.5). ● Entrepreneurship/firm creation (Figure 1.6). ● Some small and medium-sized and young companies.	● Long-term skilled unemployment might lead to depletion of human capital needed for innovation across firms and businesses (Figures 1.14, 1.15). ● Reductions in public funding of R&D (Table 1.5) further raise longer-term risks for countries and businesses. ● Changing global innovation landscape might threaten recovery processes in some countries (Figure 1.17). ● Recovery will depend on structural reforms implemented.
2. The crises had negative impacts on innovation but there was a notable recovery. The crises were a temporary shock for innovation but structural strengths facilitated some recovery.	● Many European countries and the United States, although recovery profiles have been substantially different (Figure 1.1, Table 1.3 and Table 1.4). ● Big R&D investing businesses (Figures 1.3, 1.4). ● Trademarks (Figure 1.2).	● Two distinct recovery paths for firms and economies in this group: 1. Recovery path likely in the long term in cases of limited impact on long-term skilled unemployment, continued public funding and a more pronounced recovery in demand. 2. Recovery at threat in cases of reduced public funding, long-term unemployment and weak recovery of demand.
3. The crises had little impact on innovation and innovation performance continues to be strong. The crises did not affect innovation performance.	● China, Korea (Table 1.3, Figure 1.17). ● Dynamic IT firms (Figures 1.4, 1.11). ● Most countries' government budget appropriations or outlays for R&D (GBAORD) (Table 1.5). ● Business enterprise researchers (Figure 1.16).	● Positive with limited evidence to date of slowdowns for firms and countries.

What happened to innovation?

Describing the impacts of the global financial and public debt crises requires timely and reliable statistics. However, several statistical series, including many official ones, are only available well after the reference period, sometimes several years. This is often necessary to ensure the quality of such statistics, but it reduces the list of indicators available for a timely analysis of the current context. The choice made here has been to use official statistics such as BERD and GBAORD where available, with estimates for some recent data points, along with more timely indicators, such as from *ad hoc* firm surveys conducted to assess the impacts of the global financial crisis, trademark filings, PCT patent applications and EU R&D Scoreboard data. Future work on the impacts of the crisis will make it possible to validate the evidence with more systematic official statistics.

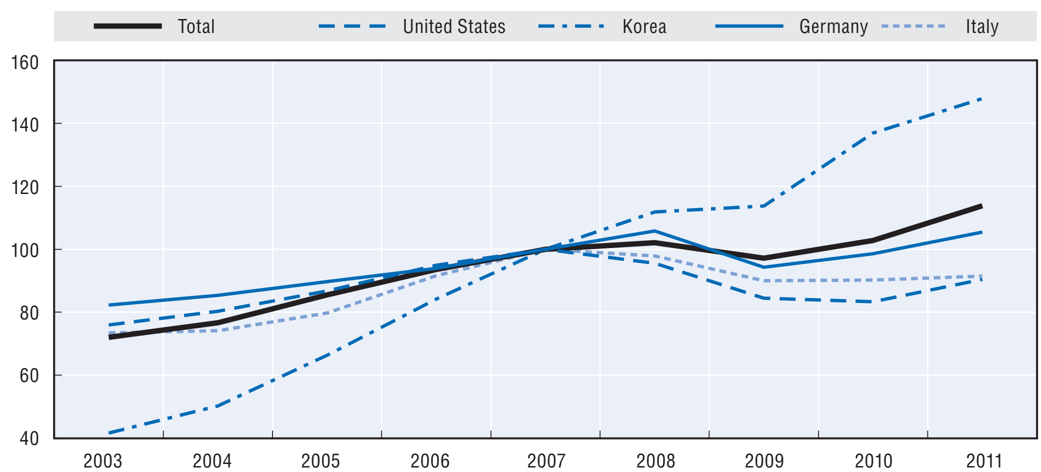
The available evidence on firms shows that innovation activities declined. Among 4 238 European firms, a large share decreased innovation spending at the onset of the global financial crisis compared to the pre-crisis period (26.7% *versus* 10.8%). However, more than half of the interviewed firms maintained their levels of innovation spending (Archibugi and Filippetti, 2011). Furthermore, evidence from the World Bank Financial

Crisis Survey for 2008-09 on firms in Bulgaria, Hungary, Latvia, Lithuania, Romania and Turkey shows that R&D investments were pro-cyclical during the global financial crisis (Männasoo and Meriküll, 2011). Also, among more than 1 500 Latin America firms, one in four stopped innovation investment projects in response to the crisis (Paunov, 2012). Kanerva and Hollanders found that 23% of innovative firms across 27 European countries decreased their innovation expenditures in response to the downturn. The same pattern is true for the world's top R&D investors; their R&D spending decreased by 1.9% in 2009. It recovered by 4% in 2010 to USD 563 billion (EUR 456 billion) (EC, 2011a).

Aggregate innovation performance indicators similarly reject the hypothesis that the downturn fostered innovation. Patenting activity based on trends in PCT filings declined considerably in 2009 compared to 2007. Figure 1.1 and Table 1.3 show worldwide trends

Figure 1.1. **Trends in the number of PCT patent filings for selected countries, 2003-11**

Index 2007 = 100



Source: WIPO Statistics Database, May 2012.

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Table 1.3. **Trends in the number of PCT patent filings for selected countries, 2003-11**

Index 2007 = 100

	2003	2004	2005	2006	2007	2008	2009	2010	2011
United States	76.0	80.3	86.7	94.9	100	95.6	84.4	83.3	90.4
Japan	62.8	73.1	89.6	97.4	100	103.7	107.4	115.9	140.1
Germany	82.3	85.4	89.7	93.9	100	105.8	94.3	98.6	105.4
China	23.8	31.3	45.9	72.3	100	112.2	144.8	225.4	300.7
Korea	41.6	50.2	66.3	84.2	100	111.8	113.7	136.9	147.9
France	78.9	79.0	87.5	95.4	100	107.8	110.3	110.5	113.4
United Kingdom	94.1	90.9	92.0	92.0	100	98.6	91.0	88.3	87.5
Switzerland	74.7	75.8	85.9	94.5	100	99.1	95.8	97.3	104.5
Sweden	71.3	78.0	78.9	91.3	100	113.2	97.6	90.7	94.7
Netherlands	101.0	96.6	101.5	102.7	100	98.4	100.7	91.7	79.0
Canada	78.8	73.0	80.4	89.4	100	103.4	87.8	93.7	100.3
Italy	73.5	74.1	79.7	91.6	100	97.9	90.0	90.2	91.5
Others	72.8	77.6	87.1	92.3	100	107.3	100.7	106.0	110.0
Total	**72.0**	**76.7**	**85.5**	**93.6**	**100**	**102.1**	**97.2**	**102.7**	**113.8**

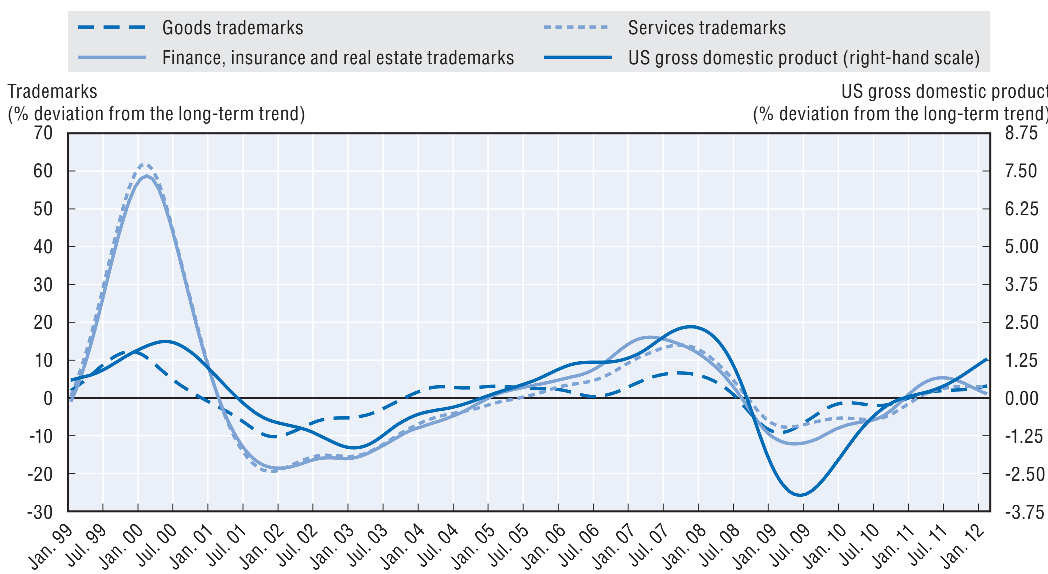
Source: WIPO Statistics Database, May 2012.

StatLink http://dx.doi.org/10.1787/888932691080

and trends for a selection of countries. The decline was particularly pronounced in Canada, Germany and the United States. In the United States, 2010 marked a further decrease relative to 2009, while Germany saw a recovery but did not attain 2007 levels until 2011. China and Korea, by contrast, continued to increase filings substantially in 2010. Statistics for 2011 indicate a continuing recovery, with the Netherlands, Italy, the United Kingdom and the United States as notable exceptions.[2] The global financial crisis also led to persistent below-trend trademark registrations (Figure 1.2). Similarly, businesses' R&D spending declined in 2009 compared to 2008 in some of the major economies (Figure 1.3). In the European Union business investment in R&D was more affected than public investment in 2009 (see below). In the EU's business sector, R&D expenditure decreased by 3.1% in nominal terms in 2009. This relatively limited decrease shows that business R&D expenditure has been relatively resilient (EC, 2011a).

Figure 1.2. **US gross domestic product and trademark applications at the USPTO, 1999-2012**

Comparing cycles, by type of trademarks, percentage deviation from the long-term trend



Note: Goods (resp. services) trademarks represent trademark applications designating only good (resp. services) classes; finance, insurance and real estate trademarks represent trademark applications designating class 036 of the Nice Classification. The US gross domestic product is based on the series of seasonally adjusted GDP, expenditure approach, in volume (chained volume estimates) contained in the OECD Quarterly National Accounts Database (June 2012). Raw GDP and trademark applications series were treated using the OECD's Composite Leading Indicators methodology. Monthly data were used for trademark applications and quarterly data for GDP, converted to a monthly frequency via linear interpolation and aligned with the mid-quarter month. This treatment removes seasonal patterns and trends (using the Hodrick-Prescott filter) in order to extract the cyclical pattern. The cyclical pattern presented on the graph is expressed as a percentage deviation from the long-term trend. Considering the filters applied, the remaining cycles are those with a period of between 18 months and 10 years. The analysis was performed on series from January 1990 to February 2012 for trademark applications and to January 2012 for GDP. For more information on the methodology, see OECD (2008), OECD System of Composite Leading Indicators, OECD, Paris, *www.oecd.org/dataoecd/26/39/41629509.pdf*. The graph shows a peak around 2004 for the trademark series which does not correspond to the economic activity. It corresponds to the accession of the United States to the Madrid Agreement in November 2003, which facilitated the filing procedure for foreign applications.

Source: USPTO, Trademark Electronic Search System (TESS), June 2012; OECD, Quarterly National Accounts Database, June 2012; based on OECD (2011), *OECD Science, Technology and Industry Scoreboard 2011, OECD, Paris.*

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However, in certain countries innovations aimed at improving efficiency have increased in response to the global financial crisis. Among respondents to a survey of about 1 500 Latin American firms, the number that introduced process innovations from 2008 to 2009 increased (Paunov, 2012). This may indicate that firms sought efficiency improvements in their production processes. Also, some respondents to a survey of 532 senior executives of large multinational enterprises said that while the crisis led to reductions in R&D it also led to efficiency improvements in the conduct of R&D. This included improved accountability for performance and spending, increased collaboration with outside R&D groups and the streamlining of core R&D processes (McKinsey, 2010).

Differential impacts across countries, industries and firms

The global financial crisis did not affect all countries to the same extent and recovery processes were very unequal. The intensity of the shock and the differences in countries' innovation systems also produced differential impacts on innovation performance. As Figure 1.3 shows, large R&D investors in the United States and Europe recovered substantially in terms of sales and, in consequence, increased their R&D investments in 2009-10. Evidence from leading R&D investors also suggests that the 2008 shock was greater for US companies than for European ones (EC, 2011a). With low rates of growth in R&D for the 2009/10 period, Japan did not show a corresponding recovery. The group of emerging countries was already much less affected in 2008/09.

Evidence on business R&D spending in Table 1.4 shows that the impacts varied. A group of countries suffered negative impacts, while others, among them many European countries, had weak performance up to 2010, while only a small group showed substantial performance, including several eastern European countries.

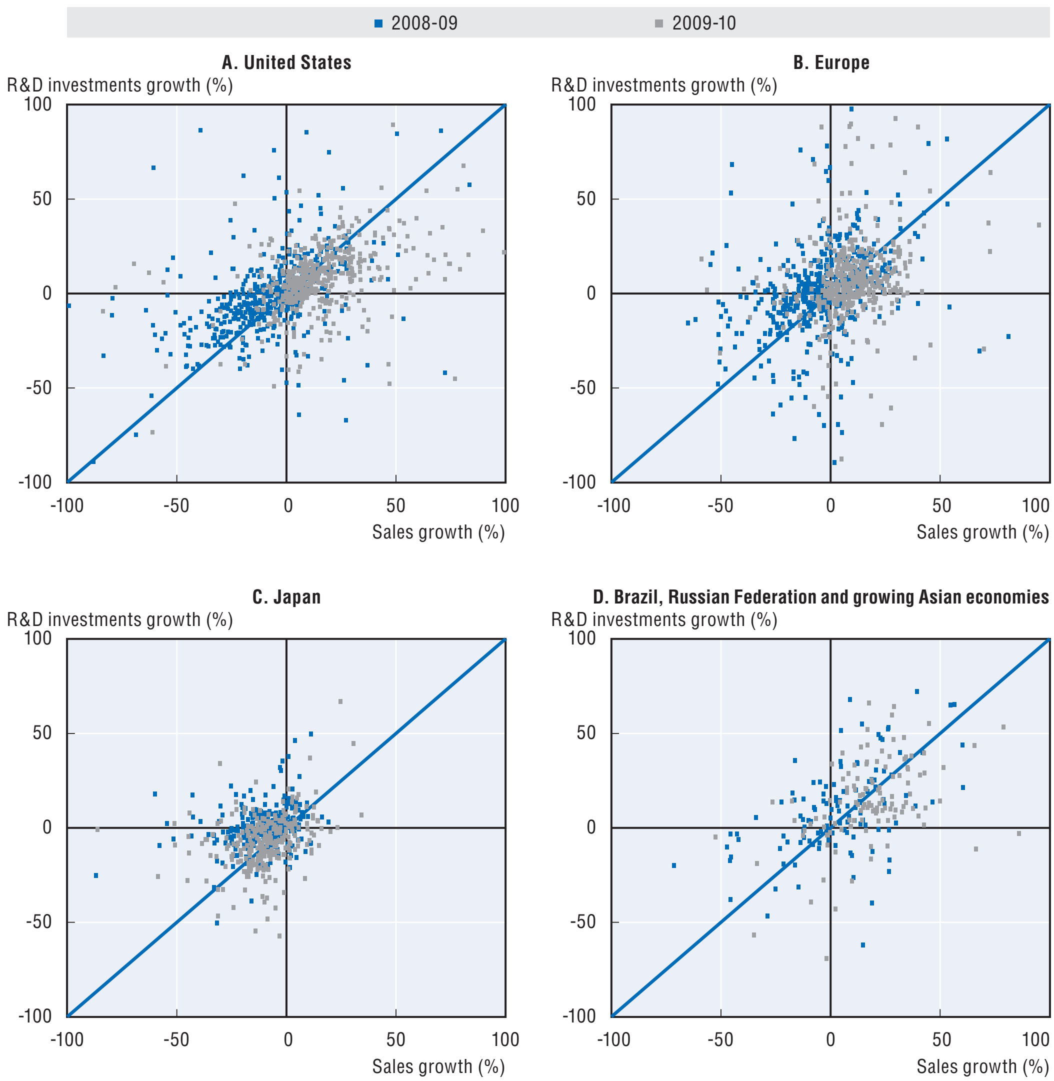
Not all industries were equally affected. While sales decreased for all segments, the medium-technology industry segment, which includes automobiles, was particularly hard hit. Among the top 1 400 R&D investors, sales dropped in 2008-09; declines in sales were much more modest for high-technology industries (*e.g.* aircraft, IT hardware, producers of medical instruments) and low-technology industries (including *e.g.* textile and food producers). In manufacturing, employment among top investors decreased exclusively in medium-technology industries, and this is the segment in which R&D took the largest hits (Figure 1.4). The health sector actually posted an increase in R&D investment in 2008/09 (EC, 2011a). Similarly, software companies raised R&D investments for 2008/09 (by 1.4%). This is also related to the fact that sales increased (by about 2.5%) over the period. For 2009/10 software firms reported sales and employment growth of 13.6% and 9.2%, respectively, along with R&D investments of 9.9% (EC, 2011a).

Evidence on European firms from the 2009 Innobarometer also points to substantial impacts on firms in the medium but also in the high innovation-intensive sectors (Kanerva and Hollanders, 2009). The differential effect of business cycles across industries has been previously observed. Sectoral data for 1975-2007 suggest their strong impacts on technology-intensive industries (such as business services, manufacture of electrical and optical equipment) (WIFO, 2011).

An interesting question that arises from the differences across industries is whether the shock of the global financial crisis affected types of innovation differently and may therefore produce a somewhat different mix of innovations (Figure 1.5). While it is necessarily a partial view, trademarks show somewhat different trends in the pre- and

Figure 1.3. **Top R&D firms' sales and R&D investment growth performance by countries and selected regions, 2008-09 and 2009-10**

Annual growth rate in percentage



Source: EC (2011), "Monitoring industrial research: the 2011 EU Industrial R&D investment Scoreboard", European Commission, Luxembourg.

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post-crisis period with a substantial upward trend in finance, insurance and real estate as well as services trademarks before 2008 while the post-2008 period shows a drop in finance, insurance and real estate trademarks which has persisted. Given the role of financial innovations in the build-up to the crisis this may suggest market corrections towards a different type of innovation in the post-crisis context.

Firms of different sizes and/or ages also differed substantially in terms of the effect of the global financial crisis on their innovation performance. Larger firms more readily accommodated shocks to sales because they have internal financial resources to rely on and larger access to external financial resources. Moreover, the evidence suggests that in 2011 European SMEs' profit margins continue to be more affected and they are more heavily engaged in deleveraging activities (ECB, 2011). Large firms used internal financial

Table 1.4. **Trends in business enterprise expenditure on R&D for a selection of countries, 2004-11**

Index 2007 = 100

	2004	2005	2006	2007	2008	2009	2010	2011
Business R&D is below pre-crisis (2007) levels in 2009								
Canada	99	99	101	100	94	88	85	86
Czech Republic	67	82	100	100	98	95	107	
Netherlands	98	97	102	100	94	88	92	
Israel	71	79	85	100	101	95	99	
Japan	83	90	95	100	100	88	90	
Luxembourg	92	91	102	100	93	91	86	
United Kingdom	87	90	94	100	99	95	93	
Sweden		97	108	100	110	97	95	
Business R&D is above pre-crisis (2007) level but weak								
Austria	78	90	94	100	106	102	106	
Belgium	90	89	95	100	103	100	100	
Denmark				100	110	108	109	
Finland	85	89	94	100	110	103	103	
France			99	100	101	103	103	
Germany	91	92	97	100	106	103	106	111
Italy	82	87	89	100	105	103	105	103
Norway	86	88	93	100	106	104	102	
Russian Federation	89	86	92	100	96	106	99	
United States	85	89	95	100	106	102		
Continued positive trends of business R&D throughout the crisis								
China	57	70	86	100	117	148	170	
Estonia	51	70	91	100	104	103	135	
Hungary	67	79	98	100	108	127	133	
Korea	73	79	90	100	106	111	124	
Ireland	82	87	93	100	108	124	125	
Poland	79	92	95	100	114	119	126	
Portugal	43	48	75	100	126	127	119	
Slovak Republic	108	116	104	100	118	109	153	
Turkey	35	60	69	100	108	109	125	

Notes: The following data points are provisional: Austria-2008-10, Belgium-2010, Canada-2010-2011, France-2010, Germany-2011, Israel-2009-2010, Italy-2010-2011, Luxembourg-2010, Portugal-2010, United Kingdom-2010. The following data points are based on national estimates or projections: Austria-2008-2010, Denmark-2010, Sweden-2008-2010, Portugal-2004-2006. Data points for Denmark, France and Sweden are excluded for years prior to 2007, 2006 and 2005, respectively, due to breaks in the series. Data for the United States exclude most or all capital expenditure and data for Israel exclude defence spending in all years.

Source: OECD, *Main Science and Technology Indicators (MSTI) Database*, June 2012.

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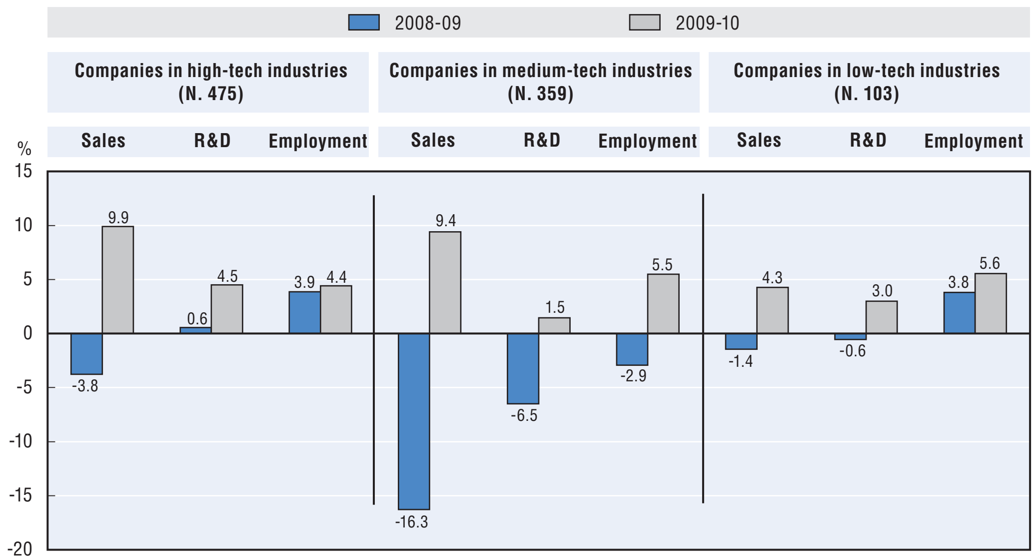
resources to make fewer cuts to innovation investments during the downturn and thus smooth their innovation investments over time. This is more efficient because discontinuing investments substantially involves costs: tacit capital embodied in human capital may be lost in case of project interruptions. Also, benefits will accrue over the over time after efficient working environments for innovation have matured.

The evidence suggests that large firms were less hard hit; while the top 1 400 R&D-investment firms reduced their R&D spending, it decreased much less than sales in firms headquartered both in the United States and in the EU (EC, 2011a). For small and young firms, Paunov (2012) finds that in a sample of Latin American firms small firms were not more likely to discontinue investment in innovation but younger firms were more at risk, likely because they have shorter credit histories and therefore difficulty accessing finance.

Figure 1.4. **Sales, R&D and employment growth for firms in high-technology, medium-technology and low-technology industries, 2008-09 and 2009-10**

Annual growth rate in percentage



Note: Firms are classified following the Eurostat/OECD taxonomy based on industries' R&D intensities.

Source: EC (2011), "Monitoring industrial research: the 2011 EU Industrial R&D investment Scoreboard", European Commission, Luxembourg.

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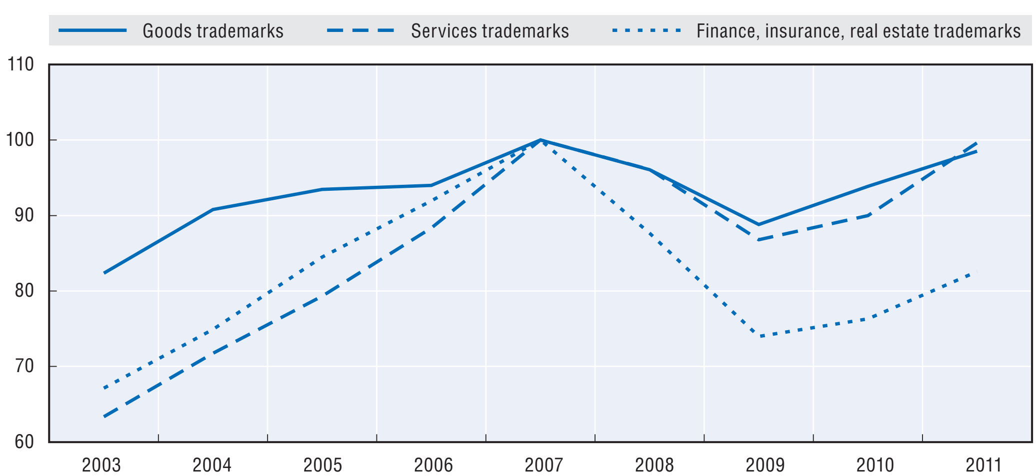
Figure 1.5. **Trends in trademarks by category, 2003-11**

Index 2007 = 100



Source: OECD, based on USPTO, Trademark Electronic Search System, June 2012.

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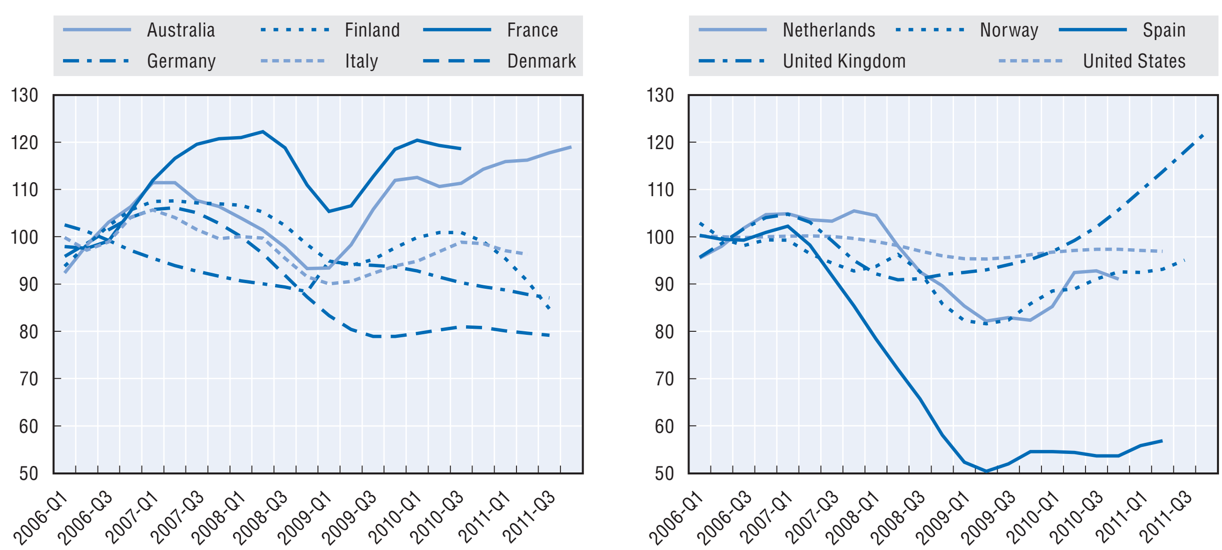
R&D trends suggest that small companies considerably reduced their R&D investments in many countries (EC, 2011a). On a more positive note, a survey of manufacturing companies in Austria, France, Germany, Hungary, Italy, Spain and the United Kingdom finds that innovative firms, independently of their size, saw a less substantial decline in sales (Békés *et al.*, 2011). This might have lowered to some extent negative impacts on innovation performance, including for smaller firms.

The global downturn and "creative destruction"

"Creative destruction" – the process whereby economic downturns force less innovative incumbents to exit and allow more innovative firms to enter – can play a powerful role in improving overall innovation performance (see Table 1.1) and therefore matters substantially for growth (Aghion and Howitt, 1992). The available evidence suggests that the "creative destruction" process broke down with the onset of the global financial crisis. Figures 1.6 and 1.7 provide information on enterprise creation and bankruptcies from official business registries for a selection of countries. They show a clear decrease in the rate of enterprise creation which tends to be most pronounced in the first half of 2009. The declines are larger in Australia, Denmark, France and Spain than in Finland, Germany, Italy and the United Kingdom. Only a few countries have managed to return to pre-crisis levels: the rate of enterprise creation is still below the 2006 rate in the United States and firm creation does not appear to have recovered in Denmark and Spain. Bankruptcies also increased substantially in some of the countries with weak firm entry; the United States and Denmark stand out as clear examples.

Figure 1.6. **Enterprise creation, quarterly data, 2006-11**

Index 2006 = 100



Notes: The data series on French enterprise creation which are taken from *OECD Entrepreneurship at a Glance 2010* in order to avoid a break in series in 2009Q1, showing a substantial increase in individual start-ups in response to the introduction of a simplified procedure. The substantial decrease from a historically high level in Norway from 2006 onwards followed changes to the tax code that sparked a wave of new firms in 2006.

Source: OECD (2010), *Entrepreneurship at a Glance, OECD, Paris;* OECD (2012), *Entrepreneurship at a Glance 2012*, OECD, Paris.

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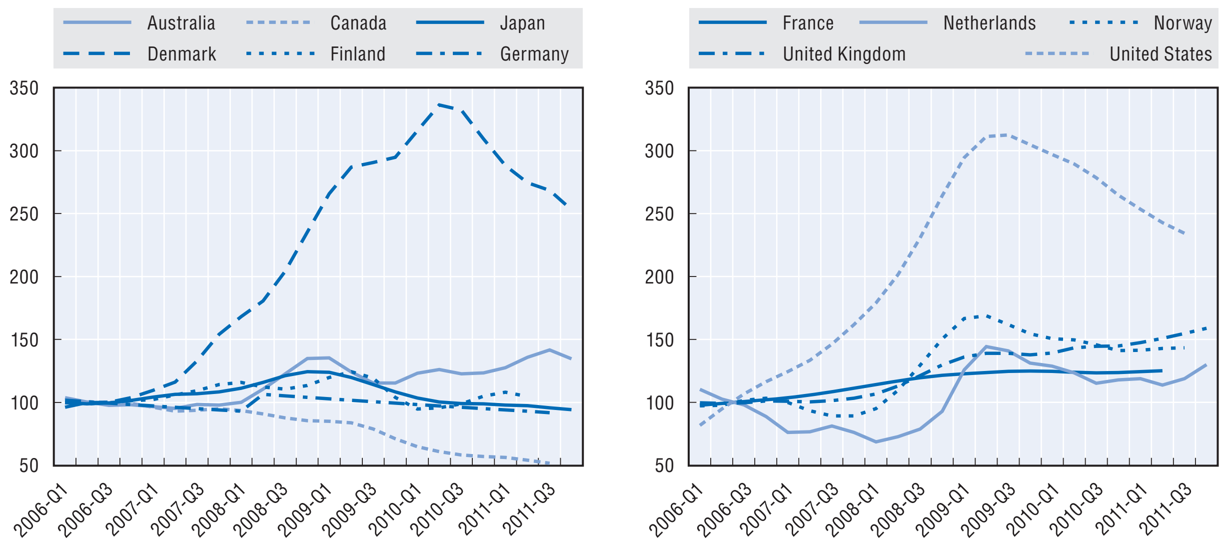
If large numbers of businesses exit, this will lead to unemployment unless other businesses, and notably new businesses, are created to re-employ those workers. Otherwise, high exit accompanied by low entry results in a substantial increase in unused resources, notably of labour. This represents a costly downside to recessions. The global financial crisis brought a rise in unemployment rates, and there are no or only partial or moderate returns to pre-crisis unemployment levels. Greece, Hungary, Ireland and Spain have had double-digit unemployment rates since mid-2009. Workers with tertiary education, who tend to be important for innovation, are affected in some countries. The

Figure 1.7. **Number of bankruptcies, quarterly data, 2006-11**

Index 2006 = 100



Source: OECD (2012), *OECD Entrepreneurship at a Glance 2012*, Paris, OECD.

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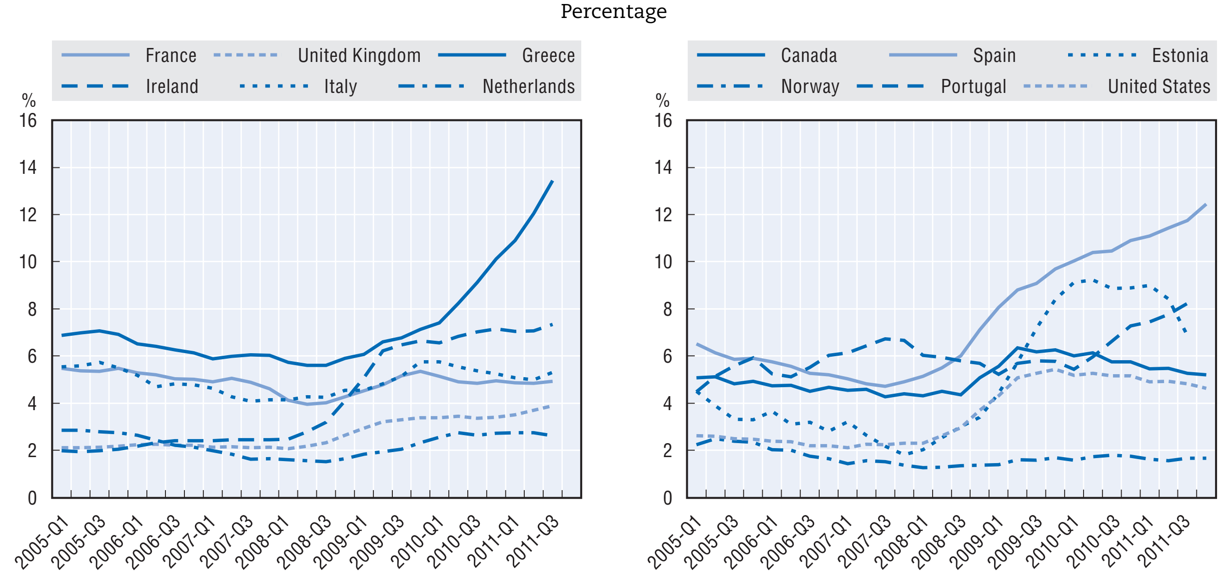
rise in unemployment of skilled workers was very substantial in Greece and Spain and relatively strong in Estonia, Ireland and Portugal. The Netherlands, Norway and the United Kingdom showed low increases, and there are small increases in the United States and Canada (Figure 1.8).

Figure 1.8. **Quarterly unemployment rate for highly-skilled workers for selected countries, 2005-11**

Percentage



Notes: Reported unemployment rates are smoothed using three-quarter centred moving averages for the age group 25-64. High-skilled is defined as ISCED 5/6. See source notes for further methodological detail.

Source: OECD estimates based on *OECD Main Economic Indicators Database* and national labour force surveys, March 2012.

StatLink http://dx.doi.org/10.1787/888932689465

The impact on different factors relevant for innovation

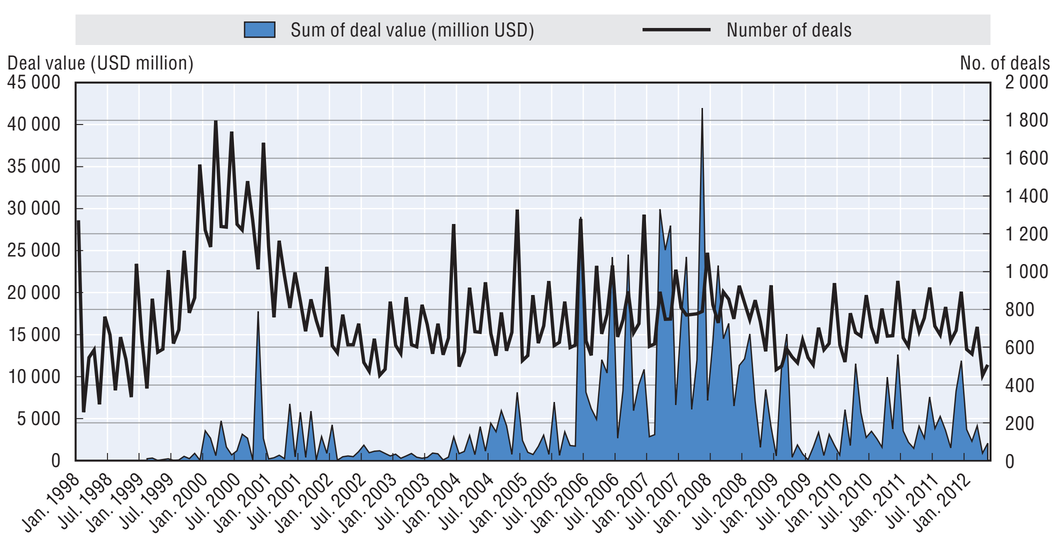
Impacts on the financing of innovation

A lack of available external resources to finance innovation activities, especially when cash flows decline, is one of the major reasons for pro-cyclical innovation investment patterns (Table 1.1). It is well known that it is more challenging to obtain external financing for innovation investments than for other business investments (see Hall and Lerner, 2009, for a comprehensive overview). Lerner (2011) suggests that the efficiency of venture capital investments would be improved if the reverse were true, since these investments appear to be deployed much less effectively during boom periods.

With regard to venture capital markets, Figure 1.9 shows a sharp decline in the number and value of venture capital deals with the onset of the global financial crisis, after what had been a very successful period of growth in venture capital markets. Venture capital investments have not fully recovered and Europe had only a slight rebound in 2010 and 2011 (Kraemer-Eis and Lang, 2011). Funding for new entrepreneurial endeavours from other sources during the credit crunch proved nearly impossible as a consequence of the collapse of financial markets, with pension funds, (university) endowments and wealthy individual investors reluctant to fund ventures. Moreover, increasingly risk-adverse investors hesitated to commit to new obligations (Lerner, 2011). While a recovery process had set in by the last quarter of 2009 the market has not returned to its 2008 performance levels. Data for the United States suggest that the pattern is similar in different industries.

Figure 1.9. **Venture capital investments: Number of deals and total value, January 1998 - March 2012**

Sum of deal value in million USD and number of deals



Source: Thomson ONE, May 2012.

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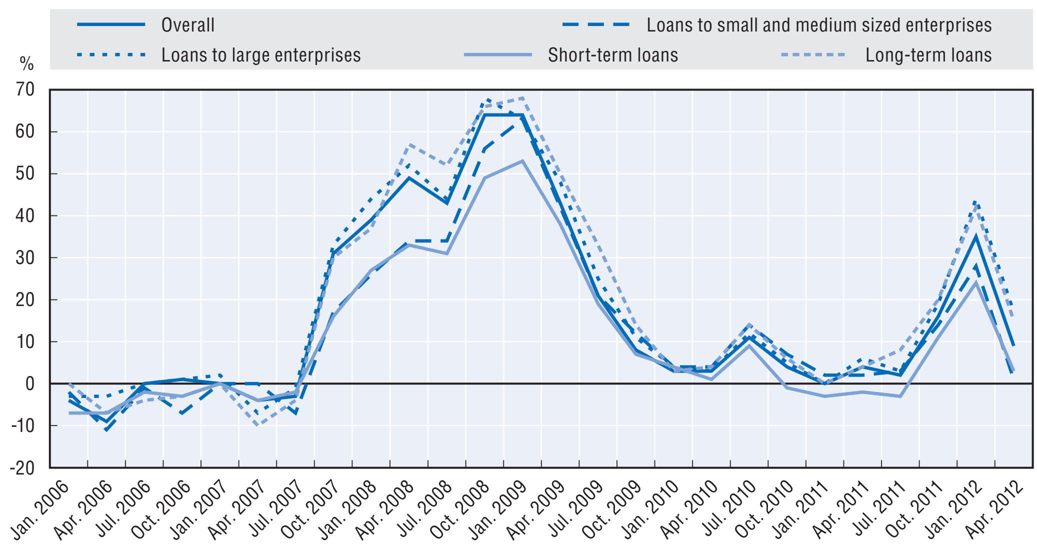
Banks' lending activities changed during the global financial crisis, and the October 2011 European Central Bank's (ECB) Bank Lending Survey indicates that banks' enterprise credit standards have tightened. The upward trend in the third quarter of 2011 (Figure 1.10) which was halted in the first quarter of 2012 is worth noting, as it will be important to understand the reasons for the changes in banks' lending behaviour when designing policies to support innovation financing. The survey responses indicate that one reason is banks' liquidity position, as deleveraging continues to be important as banks build resilience to the potential continuing risk of sovereign default. New regulatory requirements under Basel III can also affect banks' credit offers. Uncertainties about the general economic situation play a role as well.

Figure 1.10. **Changes in credit standards applied to the approval of loans or credit lines to enterprises, January 2006-April 2012**

Net percentage of banks reporting tightening of credit standards



Source: European Central Bank, Bank Lending Surveys, April 2012.

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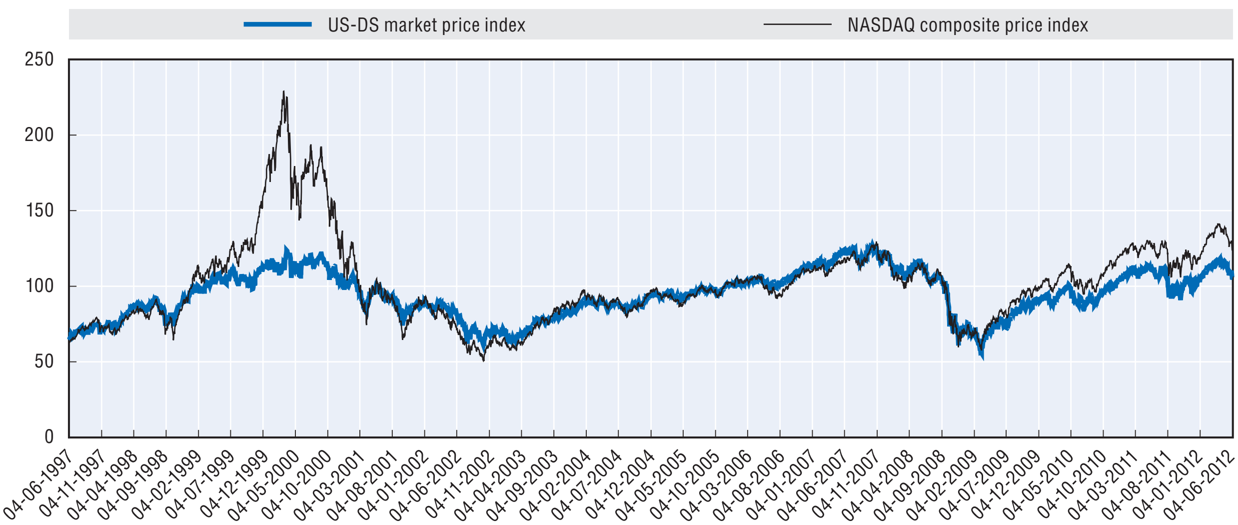
There is no evidence as yet on the impacts of financing constraints on innovation. To the extent that similar factors affected innovation and export performance, findings that US exports declined more in sectors with greater financing needs (Chor and Manova, 2011) support the hypothesis that financing constraints have played some role in constraining firms' activities.

Beyond questions of access to banking credit, uncertainty and volatility in stock markets in the current business cycle raise challenges for alternative financing opportunities as well. Using the NASDAQ as a proxy for the evolution of equity prices for technology companies, the evidence indicates that this market and the general market suffered in a similar way at the onset of the global financial crisis but that the shock was much smaller than for the dotcom bubble (Figure 1.11). Interestingly, the post-crisis recovery was stronger for NASDAQ firms than for the overall market, a sign of market confidence in at least some of the most dynamic large technology-based companies. The differential should, however, be interpreted with caution as a few dominant players may at some point in time have a significant impact on NASDAQ trends while the general indices include the financial industry which has suffered since the onset of the crisis.

Figure 1.11. **Equity price indices of the NASDAQ and the total US market, 4 June 1997-4 June 2012**

Price index 1/1/2006 = 100



Source: Datastream, June 2012.

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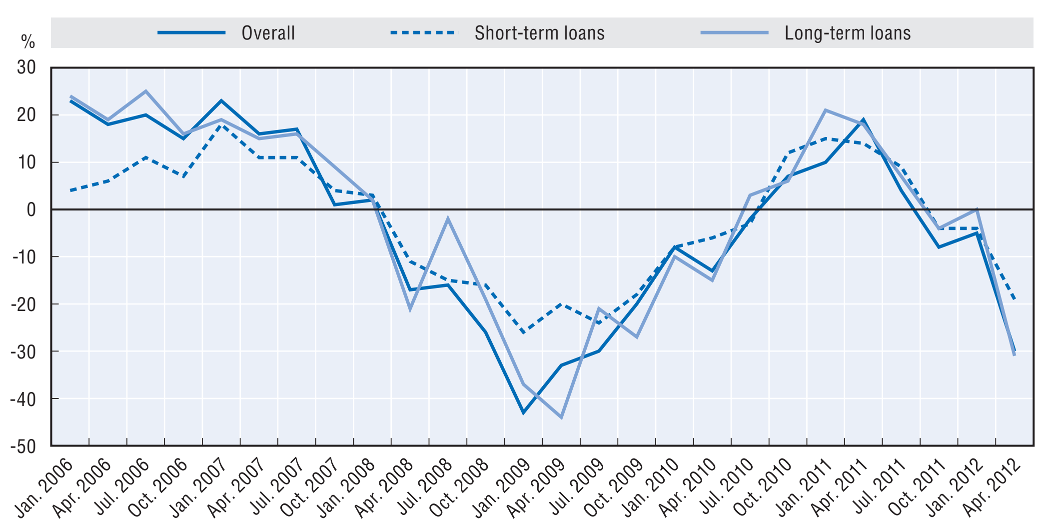
The role of depressed demand and substantial uncertainty

Declines in consumer demand and uncertainties as regards the recovery are probably significant reasons for weak innovation performance. Responses to the ECB's Bank Lending Survey suggest firms' demand for bank loans decreased substantially during the global financial crisis (Figure 1.12); the recovery in demand seems to have halted by end 2011/early 2012. Also, more than 70% of firms in each of the six eastern European countries (Bulgaria,

Figure 1.12. **Changes in demand for loans and credit lines to enterprises, January 2006-April 2012**

Net percentage of banks reporting positive loan demand



Source: European Central Bank, Bank Lending Surveys, April 2012.

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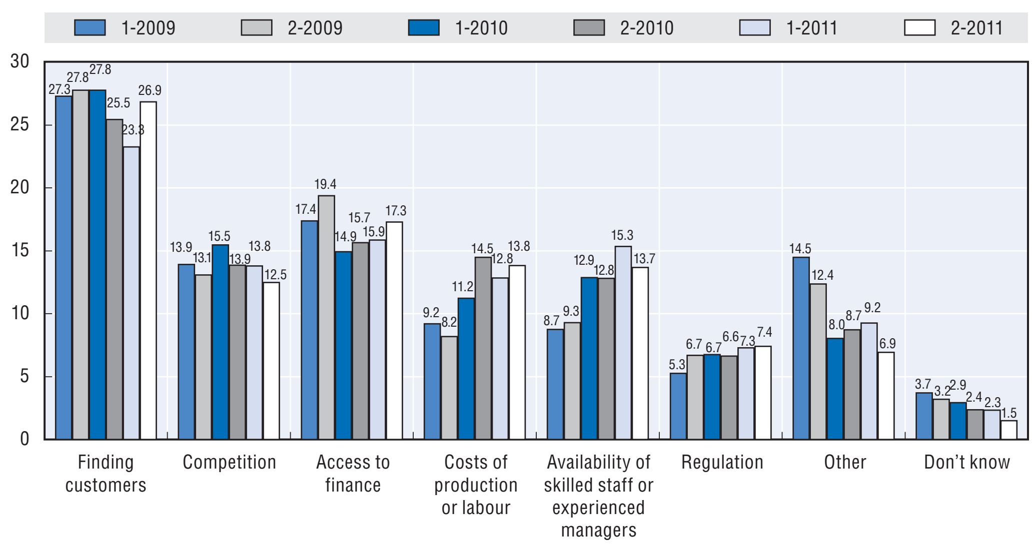
Hungary, Latvia, Lithuania, Romania and Turkey) interviewed for the World Bank's Financial Crisis survey said the primary impact of the crisis was a drop in demand for their products (Ramalho *et al.*, 2009). Finally, when asked about major challenges a larger percentage of firms was preoccupied about factors related to product markets – *i.e.* finding customers and competition – over access to finance. Evidence from a survey of US start-ups confirms this: for about two-thirds of these firms slow or lost sales and unpredictable business conditions were perceived to be the biggest challenges over 2008-10 (Robb and Reedy, 2012). Interestingly, a larger share of firms reported concern over business conditions in 2010 than in 2009. Figure 1.13 shows responses for SMEs; the evidence on large firms is similar on that dimension. In any case, access to finance appears to have been much more difficult as the global financial crisis unfolded. However, demand appears a much bigger challenge.

Figure 1.13. **Most pressing problem faced by SMEs in the euro area, 2009-11**

Percentages



Source: ECB, Surveys on the Access to Finance of Small and Medium-Sized Enterprises in the Euro Area, March 2012.

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Innovation policy responses to the global financial and public debt crises

Requirements and challenges for innovation policy

Innovation policies at present need to focus on two objectives: the first is to promote positive long-term trends in innovation performance. However, as described above, the downturn has affected innovation. The second objective, therefore, is to avoid possible long-term damage to innovation systems caused by the crises themselves. In fact, in the United States the slowdown in new business entry predates the global financial crisis (Haltiwanger, 2011). Across the OECD a productivity slowdowns set in well before (Dupont *et al.*, 2011). Again before the global financial crisis, economic performance in most EU countries was weaker than in the best-performing OECD countries in terms of GDP per capita (OECD, 2011c). Therefore, today's low economic growth may partly reflect deterioration in fundamentals and point to a need for structural support policies. Similarly, low growth in some southern European economies may reflect well-known weaknesses in prevalent innovation systems.

This chapter focuses specifically on crisis response policies that were closely related to innovation. However, it is worth noting that the global financial crisis, partly owing to efforts at fiscal consolidation, led to needed structural reforms. These notably included labour market reforms. For example, work-sharing arrangements were introduced or expanded as an immediate response but reforms were also introduced in retirement schemes, job protection, severance pay and wage bargaining systems. In some countries needed reforms were introduced to raise competition in previously protected sectors such as network industries and services. More generally, the worst-affected countries made efforts to remove barriers to entrepreneurship (OECD, 2012). These reforms obviously have impacts on innovation systems and should be considered in a full assessment of countries' responses to the crisis.

Trends in public spending on R&D and innovation

It is not easy to adopt policy tools to address these priorities for a variety of reasons. A first obvious challenge is the availability of public financial resources to invest in innovation. Recessions imply fewer tax receipts and prolonged recessions can require long-run support policies, so that such interventions lead to increasing levels of public debt and thus raise questions of sustainability. Trends in government budget appropriations or outlays for R&D (GBAORD) have shown considerable resilience to the global financial crisis (Table 1.5). By 2009, only Italy's spending had decreased relative to 2007. In spite of the increased fiscal pressure imposed by a lack of recovery, the evidence on spending in 2010 continues to show considerable resilience. This shows governments' firm commitment to public R&D support. Nonetheless, in 2010, in response to increased fiscal pressures, GBAORD in real terms was below the pre-crisis 2007 rate in Hungary, Ireland, Italy and the United Kingdom. This carried over to 2011. France and Slovenia decreased their 2009 spending rates. Responses from the *OECD Science, Technology and Industry Outlook 2012* policy questionnaire suggest that this also holds for Israel, in this case owing to a scaling back on temporary crisis-response measures with the end of the global financial crisis.

Innovation policies adopted in response to the crises

The impact of the global financial and public debt crises on innovation policies differs substantially across countries. In response, many governments announced recovery packages which often included substantial measures in support of innovation (OECD, 2009). Where recovery policies were implemented the response often consisted in supporting ongoing initiatives, responding strongly to financing constraints due to the global financial crisis (measures that would be phased out afterwards), and undertaking structural reforms that would not have an immediate impact. Table 1.A provides detailed information on policy responses to the crises based mainly on the *OECD Science, Technology and Industry Outlook 2012* policy questionnaire. Argentina, Austria, Belgium, Chile, Colombia and New Zealand report that they introduced few changes in response to the crises. In some cases, the economies were not severely affected and in others the governments did not believe changes were needed in innovation policy. In Estonia, Germany and Sweden the crisis mainly led to additional resources for existing programmes in support of innovation. Countries in which the crisis led to new innovation initiatives and projects include Greece and Spain but also Australia and Canada.

Table 1.5. **Trends in government budget appropriations or outlays for R&D (GBAORD), selected countries, 2008-11**

Index 2007 = 100

	2008	2009	2010	2011
Luxembourg	123	136	154	167
Slovak Republic	139	144	146	120
Portugal	115	119	134	132
Russian Federation	104	137	134	143
Korea	112	123	133	143
Estonia	127	119	126	130
Australia	103	117	123	122
Austria	110	118	123	127
Germany	104	109	120	121
Denmark	106	116	116	121
Slovenia	101	127	114	124
Finland	101	106	113	109
Sweden	100	109	112	109
Norway	101	109	112	106
Belgium	113	109	111	
Netherlands	103	109	111	107
France	117	120	111	113
Israel	108	109	109	
Czech Republic	98	108	108	122
Japan	103	103	106	110
Spain	103	106	101	
Ireland	104	106	96	95
United Kingdom	99	101	94	
Italy	98	94	91	87
Hungary	110	112	87	120
Romania	115	83	76	70

Notes: Data series for Israel exclude defence spending; for Australia, Austria and Japan only federal and central government is included; for Japan R&D in social sciences and humanities is excluded. All data for 2011 are provisional except for those of Finland, France, Italy, Japan, Korea, the Netherlands, the Russian Federation and Portugal. For UK-2010, they are based on national estimates or projections.

Source: OECD, *Main Science and Technology Indicators (MSTI) Database*, June 2012.

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Six main trends can be distinguished in the policy measures adopted:

- First, support for public research institutions and educational programmes were a clear priority in many countries. A non-exhaustive list includes Australia, Canada, China, Estonia, Greece, Hungary, Italy, Portugal, Switzerland and the United States. This shows that public authorities recognised the relevance of human capital and the contributions to knowledge of public institutions.
- Second, another priority was to help firms affected by lack of access to credit, particularly for riskier projects. Public authorities reacted by providing financial support and/or taking on risks by providing loan guarantees in Finland, Israel, the Netherlands, the Slovak Republic, Sweden, the United Kingdom and the United States, among others.
- Third, in several cases the types of tools used have undergone some adjustment; this includes the use of tax subsidy schemes. Extending tax breaks for firms, often related to their R&D spending, was a measure popular in Australia, Finland, France, Italy and the Netherlands. Other measures that involved less direct and more indirect spending were also adopted.

- Fourth, countries emphasised "smart specialisation" by focusing on sectors identified as central for national competitiveness and for welfare more generally. Sectors receiving wider support include health-related analysis as well as support for environmental innovations. Such sector orientation is also reflected in crisis responses in Belgium, Canada, China, France, Hungary, Japan, the Netherlands, Portugal and the United States.
- Fifth, many countries strengthened support for SMEs in recognition of the greater challenges they faced as the global financial crisis set in. This not only included support for SMEs to access to finance but also support for R&D and innovation projects, including the hiring of qualified staff to engage in such projects. Canada, Finland, France, Germany, Hungary, Italy and Slovenia adopted such measures.
- Sixth, more emphasis was placed on structural measures to address weaknesses of national innovation systems, including efforts to reform public research institutions in Italy and Greece, to enhance public-private collaboration projects in France, to reduce red tape for business in Spain, and to work towards more pay-off for public spending on R&D and innovation in the United Kingdom.

How successfully did innovation policy respond to the challenge posed by the global financial crisis?

A first policy challenge was a timely response to the global financial crisis, with the impact on employment a key priority. This poses considerable challenges for innovation policy as public projects in support of innovation often require long-term support before they have returns. The strategy adopted by many countries was to introduce clear short-term measures – notably providing credit or loan guarantees to firms directly affected by the crisis – jointly with longer-term reform measures. A strong focus on education and infrastructure is also related to addressing short- and long-term objectives, by offering short-term perspectives for laid-off workers while building a bigger stock of human capital for innovation.

A second policy challenge is that good projects often require long-term planning and were therefore not "shovel-ready" and able to be launched and have a rapid impact (OECD, 2011d). New projects implemented quickly have less chance of succeeding especially if there is too little time to prepare them optimally. This explains why many countries did not substantially alter their innovation policies. An approach widely adopted was to strengthen existing programmes and projects rather than launching altogether new ones. Where new programmes were launched, for example with new approaches to innovation, the time frame envisaged was much longer and the crisis served as a catalyst for reform.

A third policy challenge involved the private investments firms did not undertake because of uncertainties about the evolution of demand. The problem is that even if public support is provided for innovative projects, firms might not avail themselves of it, preferring to wait and see and thus prolonging a slow-growth period. One approach towards encouraging investment is public procurement of certain innovations (*e.g.* those serving environmental objectives) as a means to guarantee future markets for them. Canada, for example, combined recovery packages with commitments to environmentally friendly innovations. Another alternative is to offer prizes for innovations so as to potentially increase firms' investments in innovation (and possibly add public benefits to private ones) and signal the inherent value of innovation. There is less evidence of the use of such instruments, and the somewhat cautious recovery in some countries might point to future consideration of this issue.

A final appraisal of recovery policies will require evaluating how reforms affected innovation performance and welfare at large. Since many of these reforms were implemented recently, any judgements can only be preliminary and partial. Countries' own evaluations have rendered a positive verdict in terms of employment preservation: for instance, Canada's Economic Action Plan (CEAP) may have helped maintain roughly 220 000 jobs. Other outcomes have been improvements in digital infrastructure with the extension of the coverage of broadband in Portugal. Paunov (2012) and Kanerva and Hollanders (2009) also found that firms with access to public funding were less likely to cut innovation investments. A more thorough discussion of impacts will be provided in Guellec and Paunov (forthcoming).

Impacts on future innovation performance: Looking ahead

Is there a risk of long-term effects on innovation-based growth?

The costs of the global downturn will be much higher if innovation systems are more permanently affected. The sluggish recovery is likely to create substantial uncertainties about potential long-term consequences (referred to as hysteresis effects). The fact that downturns specifically related to financial crises can have long-term economic costs has been established in a variety of studies (*e.g.* Abiad *et al.*, 2009; Cerra and Saxena, 2008; Calvo *et al.*, 2006; Rafferty, 2003). Evolutionary approaches to the economics of innovation following Nelson and Winter (1982) describe the potentially substantial hysteresis effects of shocks (Metcalfe *et al.*, 2006; Dosi *et al.*, 2010).

Five factors have long-run effects on innovation systems: *i)* negative effects on human capital; *ii)* disruptions to investments that affect future innovation efforts; *iii)* negative impacts on technological leadership; *iv)* changes in attitudes towards innovation projects in financial markets; and *v)* permanent changes to public support systems for innovation. At present it is difficult to provide a verdict on the last two aspects since financial markets and public innovation policy are currently the subject of debate; potential implications for trends in innovation should be considered when policy decisions are taken.

First, in terms of negative long-run effects on skills – a central factor for innovation (OECD, 2010) – the crises have led to higher unemployment rates, including among the skilled workforce involved in innovation (in firms that decide to downsize innovation-related activities in addition to innovative businesses that are forced to exit). Longer-term innovation effects from lay-offs can arise in two ways:

- There may be less skilled human capital if capacities and "up-to-date" knowledge are lost, as occurs for the long-term unemployed. In fast-paced high-technology sectors such as biotechnology, aeronautics and information and communication technologies (ICTs) long spells of unemployment lower exposure to technology and therefore deplete workers' skills. High unemployment rates of college graduates also pose a challenge since early-career unemployment can permanently affect integration in the workforce along the entire career path.
- At the business level dismissals can lead to permanent "scars" for innovation processes at the concerned firms if laid-off employees hold tacit knowledge that is lost to firms as a result. There may then be a much slower recovery in innovation performance as new employees first need to acquire such knowledge, *i.e.* sunk costs have to be incurred before innovation activities can be taken up again.

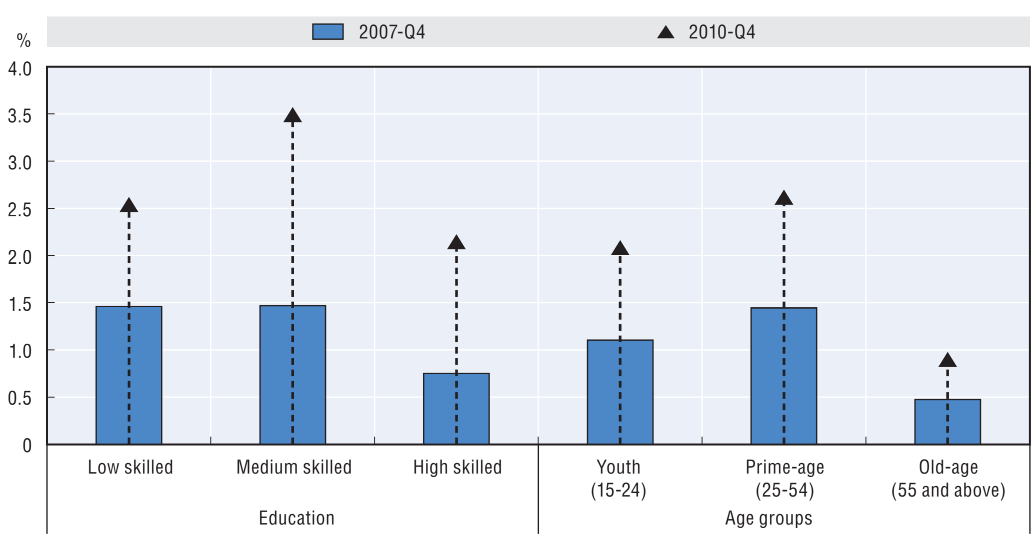
A factor that might act as a counter-weight is an increase in training for those unemployed.

Substantial uncertainties over recovery processes suggest that employment will not recover quickly; the potential risks for long-term effects due to unemployment are therefore important. In a survey of 532 senior executives some respondents worried that changes to R&D could weaken available talent for future R&D activities (McKinsey, 2010).

Long-term unemployment (LTU) rates for the OECD presented in Figure 1.14 show that while LTU tends to mainly affect low- and medium-skilled workers there was a substantial increase from pre-crisis levels for skilled workers as well. Difficulties also rose for young people, whose successful job entry matters for their entire employment careers as well (Oreopoulos *et al.*, 2012). Skilled LTU has increased up to the present in Estonia, Greece, Portugal and Spain and, to a much lower extent, in Ireland and the United States (Figure 1.15, A). Similar trends are observed for LTU of medium-skilled workers (Figure 1.15, B). Germany has opposite trends while in the majority of other OECD countries LTU of skilled workers was not substantially affected. It is worth noting, however, that this evidence may underestimate the depletion of skilled human capital due to the global financial crisis: this is because skilled workers who lost their jobs may have taken less skilled jobs because of limited employment opportunities during the global financial crisis in order to avoid unemployment. This would also lead to a depletion of the types of skills needed for innovation. Trends in the number of researchers (Figure 1.16) remain positive in that there is little evidence of a substantial decrease in their numbers in response to the crisis, and Korea stands out with a substantial increase.

Figure 1.14. **Long-term unemployment by education and age groups, 2007 and 2010**

Persons unemployed a year or longer as a share of the working-age population, OECD average



Notes: OECD is the weighted average of 27 OECD countries (excluding Australia, Chile, Israel, Japan, Mexico, New Zealand and Switzerland).

Source: OECD (2011), *OECD Employment Outlook 2011*, OECD, Paris.

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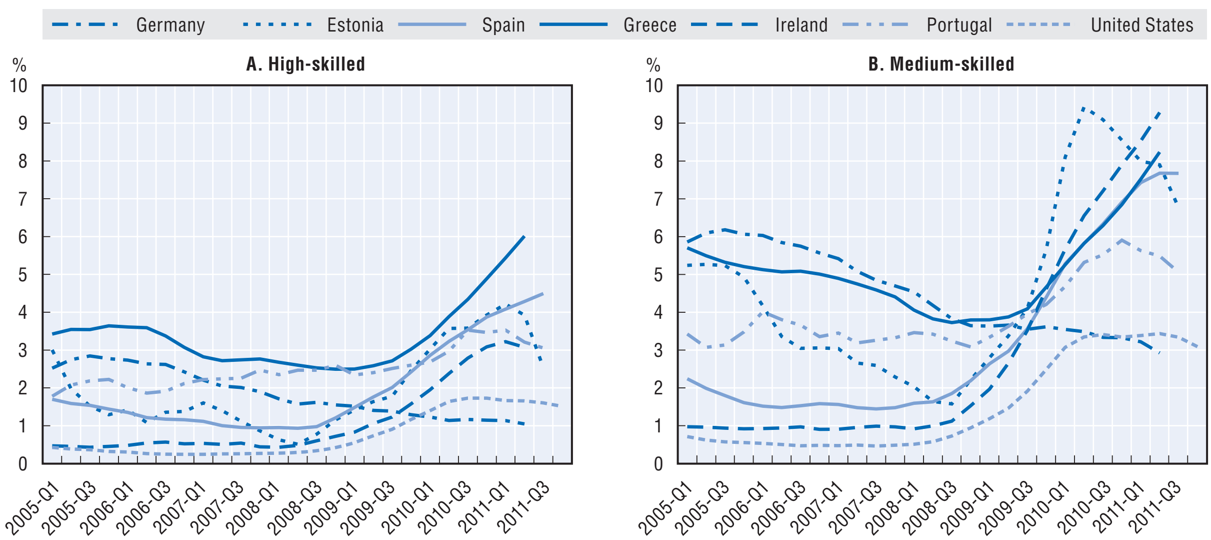
Figure 1.15. **Long-term unemployment rate by skills level, selected countries, quarterly data, January 2005-April 2011**

Persons unemployed a year or longer as a share of the population aged 25-64



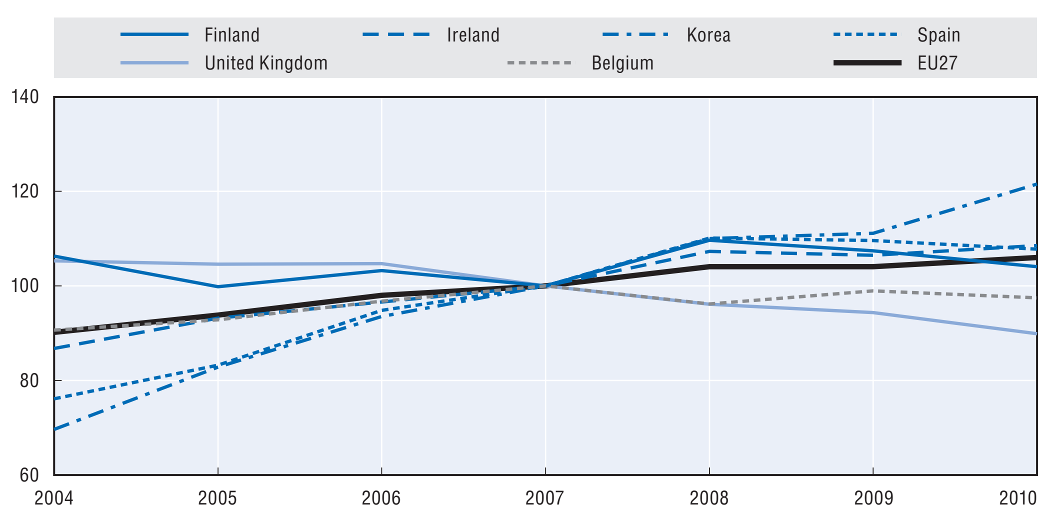
Notes: Reported long-term unemployemnt rates for age group 25-64. High-skilled is defined as ISCED 5/6 and medium-skilled as ISCED 3/4. Please refer to the notes for *OECD Main Economic Indicators Database* for further methodological detail.

Source: OECD estimates based on *OECD Main Economic Indicators Database* and national labour force surveys, February 2012.

StatLink http://dx.doi.org/10.1787/888932689598

Figure 1.16. **Business enterprise researchers (FTE), selected countries and EU27, 2004-10**

Index 2007 = 100



Source: OECD, *Main Science and Technology Indicators (MSTI) Database*, June 2012.

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The current downturn may accelerate long-term trends towards more flexible employer-employee relationships. As has been widely noted, ICTs have altered work processes. Specifically, they increasingly allow segmenting production processes, including highly skilled tasks that can be executed through short-term assignments. An advantage of such processes is that if businesses do not face labour termination costs, they may be much less hesitant to re-hire. The issue of the conditions under which such flexible employment relations support and/or weaken innovation needs to be tested.

Second, innovation investments not made in the present may have effects on innovation performance in the near future, as limited investments reduce the pool of opportunities for successful innovations: foregone innovations have a cumulative effect on innovation. Moreover, if businesses interrupt but later resume innovation investment projects they may face higher upfront costs. This can lead to a slower recovery in innovation investments. The loss of tacit knowledge and the costs involved in establishing new arrangements for innovation can also slow investments. At least for the world's leading R&D innovators, the substantial recovery of 2010 suggests that the shock of 2009 did not affect underlying innovation investment capacities (EC, 2011b). Yet the uncertainties of 2011-12 may create difficulties, particularly for smaller businesses. Finally, to the extent that some innovative firms exited, overall innovation investments may be lower, at least until comparable innovative businesses enter. This has not yet happened.

Third, technological leadership would be at risk if key businesses relocated abroad in response to prolonged low demand in local markets, difficult financing conditions and other challenges for operating their business. Such relocations might have an effect beyond the downturn if businesses do not find returning to their previous location advantageous even after the recovery. Private companies already seek to explore options to access growing Chinese and Asian markets, and the increasingly global nature of innovation and ICTs facilitate partial relocation. The crises may have accelerated these ongoing trends.

Fourth, another factor that will shape the magnitude and duration of the impacts relates to countries' policy responses. The fact that the large majority of countries affected by the global financial crisis decided to maintain their innovation investments and, in some cases, undertake additional projects has certainly been a boost, but for those that will struggle to keep spending in the future (as described below and in Table 1.6) there are further risks. While it is beyond the scope of this analysis to discuss regulation in the financial sector, it is important to note that decisions that affect firms' access to credit can also fundamentally shape innovation performance beyond the crisis.

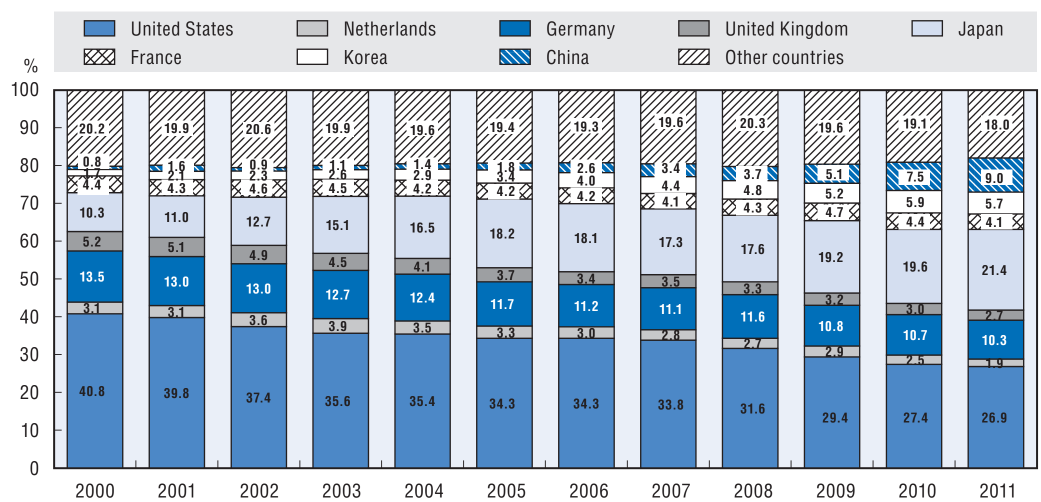
Outlook for the global distribution of leadership in innovation

As described above, while the global financial crisis certainly had repercussions in developed and developing economies alike, Asian economies and countries such as Brazil continued to grow in 2009. The sovereign debt crisis had an even more pronounced effect on developed than on developing economies, with corresponding differences in the impacts on innovation systems. Moreover, OECD growth forecasts predict that Brazil, China, India and Indonesia will have much higher growth rates than the OECD area in 2011 and 2012 (OECD, 2011e). The differential in macroeconomic circumstances facilitates further catch-up, specifically in terms of the BRIICS' innovation performance. Indeed, the European Commission's Innovation Union Competitiveness Report concludes that: "The overall R&I [Research and Innovation] competitive position of the EU has been progressively declining in the last decade. This decline is mainly due to the sharp rise of Asia, a trend likely to continue given the ambitious R&D targets of South Korea, Japan or China; and the inability of the EU to address some important weaknesses of its R&D system" (EC, 2011b).

A comparison of the world's leading R&D investors shows that the 2010 recovery in R&D was highly unequal. Growth in R&D investments was much higher in China (29.5%), Korea (20.5%), India (20.5%) and Chinese Taipei (17.8%) than in the US (10%) and the EU (6.1%) (EC, 2011a). Moreover, while the statistics in Figure 1.17 should be interpreted with caution, they show evidence that China's and Korea's performance differs substantially from that of the United States which has seen a substantial decrease in its share of PCT filings from the onset of the global financial crisis. Evidence on triadic patents available until 2010 confirms this trend for China; while its share is still low (triadic patents are more selective than PCT patents in terms of novelty), it increased substantially (from 0.9% in 2007 to 1.8% in 2010). The strong performance of Japan is related to regulatory changes introduced in the late 1990s that led to very recent use of the PCT by Japanese firms.[3] Forecasts based on current trends suggest that by 2020 the shares of PCT patent applications may be 18% for the European Union, 15% for the United States and 55% for leading Asian countries (EC, 2011b).

Figure 1.17. **Country shares in total PCT filings, 2000-11**

Percentages



Source: WIPO Statistics Database, May 2012.

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There is some evidence of catch-up in a few emerging Asian economies and strong performance and continued policy support for innovation in Latin America. For their part, several southern and eastern European countries that were hard hit by the global financial crisis have subsequently struggled to manage their public debt; this puts pressure not only on current but also on future public funding (see below). Based on firm data from the Innobarometer 2009 survey, Kanerva and Hollanders (2009) found that firms in European countries that had experienced the fastest rates of improvement in their innovation performance were most affected by the economic crisis. The impact on future public funding of R&D and innovation, on long-term unemployment of the skilled as well as on trends in their firms' innovation performance raises their risks of suffering longer-term scars from the global financial and public debt crises.

Moreover, at sub-national level the global financial crisis hurt many industries and regions that were already struggling before the crisis; one example is the US car manufacturing sector. The post-crisis period thus potentially intensified diverging performance trends within countries that might well intensify if public resources for support are limited (leaving aside the question whether such support is justified from an efficiency perspective).

Outlook for future public spending on R&D and innovation

As stimulus packages are phased out and countries pursue fiscal consolidation, there is a possibility that long-term public investment, a basis for future economic growth, will be sacrificed to short-term budgetary pressures. Indeed, several countries have specified that projects implemented during the global financial crisis will be phased out. Moreover, as Table 1.6 indicates, when asked about future public spending on R&D and innovation countries such as Greece, Ireland, the Slovak Republic, Slovenia and Spain foresee a possible decrease. By contrast, many countries, including those where the impacts of the global financial crisis were limited, such as Argentina and China, but also Denmark, Estonia and Sweden, plan to increase their spending in the near future. Therefore, the picture is not altogether negative. A question, however, is whether the different spending patterns in Europe will stall the catching up of eastern and southern Europe and, therefore, widen gaps within the European Union in terms of innovation performance. The Europe 2020 strategy adopted in 2010 responds to this challenge by setting out high-level policy objectives at EU level including the investment of 3% of the EU's GDP in R&D.

Table 1.6. **Forecasted changes in the overall levels of public R&D funding in coming years**

Spending will increase	
Argentina	Budget of the Ministry of Science, Technology and Productive Innovation increased from 2010 (USD 510 million, EUR 387 million) to 2012 (USD 732 million, EUR 527 million).
Austria	Planned increase.
Chile	Objective to increase spending on R&D in Chile from 0.4% to 0.8% of GDP; public budget for science, technology and innovation reaches USD 500 million.
China	12th Five-Year-Plan for S&T Development established an increase in government S&T appropriation over the next five years.
Colombia	Expected increase of GBAORD from USD 622 million (COP 807 billion) in 2012 to USD 917 million (COP 1 189 billion) in 2014 based on government targets established in the National Policy for STI, the National Development Plan 2010-14 and the strategic development programme "Visión 2019".
Denmark	Planned increase.
Estonia	Plans to raise R&D to 2% of GDP by 2015.
Germany	Plans to increase public R&D funding. Between 2010 and 2013 the federal government invests an additional USD 14.8 billion (EUR 12 billion) in key areas of education and research.
Luxembourg	Objective to reach 2.3%-2.6% of GDP by 2020.
Poland	Possible increase.
Russian Federation	2012 budget provides 10% increase in civil science spending for 2013 compared to previous budget, renewal of Russian armed forces likely increase in military-oriented R&D.
South Africa	Planned increase.
Sweden	Possible increase.
Turkey	Objective of increasing R&D intensity to 3% by 2023.
Spending levels will be maintained at their current level and increased in some domains	
Belgium	Federal government programme decided tax credit would not be subject to budget cuts of the coming years; Flanders budget for R&D to increase by USD 69 million (EUR 60 million) for 2012 and another USD 80.5 million (EUR 70 million) in 2013 as well as in 2014; Brussels Capital Region plans increase in coming years and of 9% for 2013.
Israel	Increase in budget for reform of higher education system, other budgets unchanged.
New Zealand	Additional budget for developing institutions to support business innovation and address science challenges, other funding unchanged.
Spending levels will be maintained at their current level	
France	Encouraging innovation remains a high priority for the government (*e.g.* R&D tax credit).
United Kingdom	Scientific research budget maintained and ring-fenced until 2014.
United States	National budget legislation (*Budget Control Act* of 2011) requires unchanged totals for most federal budget categories over the next decade; overall US federal R&D investments see possible decline from USD 147 billion (2010) to USD 140.8 billion (2013) with reduced funding for military spending) but US federal government support for basic and applied research possible increase from USD 59 billion (2008) to USD 65 billion (2013)

Table 1.6. **Forecasted changes in the overall levels of public R&D funding in coming years** *(cont.)*

Spending levels are likely to decrease	
Greece	Efforts to achieve more efficient use of resources (see Table 1.A on policies), European Union structural funds only possible source of increase of government funding for research.
Ireland	Investment in research likely to remain under severe pressure in years ahead due to budgetary constraints, objective to focus on investments in areas with higher medium-term pay-off opportunities.
Slovak Republic	Possible negative impact on public innovation support due to fiscal consolidation measures.
Slovenia	Drastic cuts in budget expected in 2012 and subsequent years with expected decrease in GBAORD from USD 343.2 million (EUR 216.2 million) in 2011 to USD 326.6 million EUR 202.5 million in 2012.
Spain	Measures adopted to manage public deficits include preliminary decrease of USD 845.1 million (EUR 600 million) for R&D activities for 2011 possibly also for 2012.
The evolution of spending is still uncertain	
Australia	The uptake of the R&D tax incentive is demand-driven and total business investment in R&D is difficult to foresee. "Powering Ideas", the government's innovation agenda 2009-20 highlights the importance of public research programmes. Recent trends show that support for public research programmes has increased with some decrease in direct business assistance programmes.
Canada	Science, technology and innovation features prominently in the 2012 federal budget, with corresponding budgetary commitments. The government will also streamline and improve the Scientific Research and Experimental Development tax incentive programme with savings expected to be directed towards direct R&D programmes. Other STI budgets are expected to remain steady although some may be affected by a government-wide effort to return to balanced budgets.

Note: The table is mainly based on country responses to the question: "How are public R&D budgets forecasted to change in the coming years?"

Source: Country responses to the *OECD Science, Technology and Industry Outlook 2012* policy questionnaire.

Conclusion

The global financial crisis which started in 2008 has negatively affected business innovation and R&D in all countries, and to date there is no evidence of a reallocation of resources towards more innovative businesses. The effects of the crisis differed substantially across countries, sectors, businesses and types of innovation. Emerging Asia, including Korea and China, have shown their dynamism as players in the international innovation system. They continue to outperform developed countries and are likely to continue to do so in the future. The crisis has also rewarded large high-technology innovating firms for which markets will continue to be strong.

By contrast, the global financial crisis has revealed pre-crisis weaknesses in some countries (*e.g.* Greece and some southern and eastern European countries), sectors (*e.g.* the automobile sector) and types of innovation (*e.g.* financial innovations). Future prospects for innovation in these countries and industries will depend on broader economic restructuring, which does not place innovation at the top of the immediate policy agenda although innovation will have to play a role in driving growth in the future. The majority of developed countries (northern Europe, Japan and the United States) have recovered somewhat. Their future innovation performance and future global innovation trends remain uncertain. Important factors include macroeconomic conditions, public innovation support policies, and the ability to maintain innovation as a priority. Avoiding long-term impacts of the crisis on innovation should have high priority; this requires ensuring limited long-term skilled unemployment and strong public support of innovation.

Finally, many countries have implemented policies to respond to the crisis that put substantial emphasis on innovation. Innovation-related responses to the crisis have mainly focused on infrastructure investments for innovation and the provision of financial resources to businesses. However, budgetary pressures have in several countries led to a public debt crisis and will likely continue to put pressure on public support for innovation.

Notes

1. It draws on a variety of sources: the OECD Thematic Workshop on Financing R&D and Innovation in the Current Macroeconomic Context held in December 2011; and responses to the *OECD Science, Technology and Industry Outlook 2012* policy questionnaire. It also builds on the OECD's "Policy Responses to the Economic Crisis: Investing in Innovation for Long-Term Growth" (OECD, 2009).
2. Triadic patent statistics reported until 2010 in the OECD MSTI Database 2012/1 confirm the trends described above, notably the slowdown in 2008 and 2009 and the weak recovery paths in several countries including the United States, the Netherlands and the United Kingdom.
3. The evidence on pre-crisis years shows that the decline of the United States pre-dates the downturn. However, it remains to be seen whether the crisis effectively facilitated China's positioning. China's specialisation in lower-quality production helped reduce the negative impacts of the global downturn, but this might cause more substantial losses during the recovery (Berthou and Emlinger, 2010). This potential negative demand shock on Chinese goods might (due to the mechanisms described in Table 1.1) then have negative effects on innovation in China.

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ANNEX 1.A

The economic crisis and STI policy: National policy examples

Table 1.A. **The economic crisis and STI policy: national policy examples**

Argentina	Innovation support was maintained in spite of the 2008 crisis.
Australia	Nation Building and Jobs Plan announced in February 2009 with a budget of USD 29 billion (AUD 42 billion) is key component of the "National Building – Economic Stimulus Plan" and included funding for investment in education, infrastructure and energy efficiency with innovation-related measures including: ● USD 566.8 million (AUD 821.8 million) to secondary schools for the building or refurbishing of science and/or language-learning facilities among other infrastructure investments within the USD 11.2 billion (AUD 16.2 billion) Building the Education Revolution Package. ● Additional USD 1.9 billion (AUD 2.7 billion) temporary tax break to small and other businesses buying eligible assets as *e.g.* tangible capital used in R&D. ● Support for Australia's business innovators included USD 57.2 million (AUD 83 million) for the Innovation Investment Follow-on Fund to foster early-stage companies' research activities and efforts at commercialisation in spite of lack of available capital due to global crisis.
Austria	No immediate response with respect to innovation policy.
Belgium	No new measures taken at federal level in 2010-11 except for annual growth in tax credits but commitment to maintain R&D/GDP rate. Global financial crisis raised focus on innovation policies for smart specialisation in Flanders (White Paper on New Industrial Policy [Witboek Nieuw Industrieel Beleid]) with impact on new policy initiatives such as the Transformation and Innovation Acceleration (TINA) Fund established in December 2010 with capital of USD 232.6 million (EUR 200 million) to support projects by groups of enterprises (jointly with investors, knowledge-based institutions, research and/or technology partners) and the Spin-Off Financing Instrument (SOFI) established in 2011 with USD 11.5 million (EUR 10 million) to support spin-offs.
Brazil	Minor impacts on national STI policies, credit volume for private R&D operated by national financing agency FINEP doubled in 2009 partly as a crisis response.
Canada	In 2009, the Government of Canada put in place a two-year economic stimulus package: Canada's Economic Action Plan (CEAP). The CEAP included USD 4.1 billion (CAD 4.9 billion) for science, technology and innovation including: ● The Knowledge Infrastructure Program (KIP) with USD 1.7 billion (CAD 2 billion) for university and college infrastructure projects, including repair, maintenance and construction. ● The Canada Foundation for Innovation (CFI) with additional funding of USD 625 million (CAD 750 million) to accelerate investment in state-of the art research facilities and equipment. ● Almost USD 208.3 million (CAD 250 million) allocated to upgrade and modernise federal laboratories doing research in a wide array of fields, including health, safety, security, transport, environmental protection, and heritage. ● A USD 662.5 million (CAD 795 million) Clean Energy Fund to support clean energy R&D and demonstration projects. The CEAP also included an additional USD 72.9 million (CAD 87.5 million) over three years, starting in 2009-10 to the federal granting councils to expand temporarily the Canada Graduate Scholarships programme, which supports Canada's top graduate students. This included USD 29.2 million (CAD 35 million) each for the Natural Sciences and Engineering Research Council of Canada and the Canadian Institutes of Health Research, and USD 14.6 million (CAD 17.5 million) for the Social Sciences and Humanities Research Council. In addition, Industry Canada received USD 187.5 million (CAD 225 million) over three years to develop and implement a strategy to extend broadband coverage to as many unserved and underserved households as possible. In 2009, the Canadian government also launched the Canada Skills and Transition Strategy which included: USD 1.6 billion (CAD 1.9 billion) to strengthen benefits to give workers more time to find the right job and get training, to give companies using work-sharing arrangements more time to restructure and better position themselves to emerge from the economic downturn, and to better protect workers' wages and severance packages in the event of their employer's bankruptcy; USD 1.6 billion (CAD 1.9 billion) were provided to enhance the availability of training by providing unprecedented levels of short- and long-term skills upgrading opportunities for workers in all sectors of the Canadian economy, including investments in the long-term potential of under-represented groups.
Chile	No changes of national STI policies in response to the global financial crisis.

Table 1.A. **The economic crisis and STI policy: national policy examples** *(cont.)*

China	Economic Recovery Plan of USD 1.0 trillion (CNY 4 trillion) (including USD 392.7 billion, CNY 1.5 trillion, for infrastructure) in response to 2008 financial crisis focused on investments in fixed infrastructures and human capital in ten industries including machinery-manufacturing, electronics and information industries, as well as light industries and petrochemical sectors. State Council of February 2009 proposed by the Ministry of Science and Technology decided to strengthen science, technology and innovation (STI) in response to the global financial crisis. In the following two years, the central and local governments invest USD 26.6 billion (CNY 100 billion) to strengthen STI infrastructure including development of high-technology clusters, support of firms' innovation capacities and university support of private innovation. Chinese Academy of Sciences' Scientific and Technological Innovation Action Plan to address the global financial crisis included building pilot programmes (such as a broadband wireless media network) and commercial application of major S&T results (*e.g.* laser display technology).
Colombia	No substantial changes in national STI policies in response to the global financial crisis.
Estonia	Spending on R&D funding instruments (targeted, grant and base-line financing) decreased by 4% and general budget of the Ministry of Education and Research reduced by 8.4% in 2009; further reductions in STI support policies in 2010 (*i.e.* grant financing: 9.1%, targeted financing: 3.6%, base-line financing: 7.4%, infrastructure subsidies: 3%). No changes in 2011-12. TULE programme offered opportunity to around 800 people who previously interrupted university education programmes to return to such programmes in 2010-13.
Finland	2009 stimulus package of USD 6.56 billion (EUR 5.97 billion) included measures aimed at supporting transport and broadband infrastructure, education and training (including notably raising the availability of vocational training and education for adults) and R&D. About USD 159.3 million (EUR 145 million) for R&D, education, infrastructure as well as firm and energy support. Main tools consisted in tax cuts and related measures rather than increased public spending. Finnish Funding Agency for Technology and Innovation (Tekes) received additional resources to allocate for research, development and innovation and lowered temporarily share of company funding required in public research projects. Finnvera started to grant counter-cyclical loans and guarantees at the beginning of March 2009; the government raised ceilings on Finnvera's outstanding financial commitments twice during 2009. 2012-13 STI policies affected by consolidation of public finance, continued support of R&D and innovation but changes in targets of support. Finnvera introduced as part of recovery strategy counter-cyclical loans and guarantees to finance working capital of small enterprises whose profitability or liquidity declined because of crisis, loans continued until end 2011.
France	Firms could request immediate refunding of their Research Tax Credit in 2009 and 2010, only true for micro enterprises and SMEs from 2011. Injection of funds into OSEO Garantie to provide guarantees, co-financing, direct loans (October-December 2009), government increased eligibility for firms with more employees and coverage of guarantee to 90% among other measures strengthening capacity for intervention by USD 11.5 billion (EUR 10 billion) and guaranteed loans increased 64%; OSEO estimates impact equivalent to 30 000 jobs saved in France as a result of these crisis response measures. Investments in the Investments for the Future Programme (Programme des investissements d'avenir) of USD 40 billion (EUR 35 billion) over 2011-13, in response to the economic crisis aimed at strengthening national innovation capacities with investments across nine programmes including: centres of excellence (USD 13.8 billion – EUR 12 billion); knowledge transfer to industry (*valorisation de la recherche*) (USD 4 billion – EUR 3.4 billion); health and biotechnologies (USD 2.8 billion – EUR 2.4 billion); digital economy (USD 5.2 billion – EUR 4.5 million); and enterprise funding (USD 3.6 billion – EUR 3.1 billion).
Germany	No major impact on German STI policy but short-term measure with Central Innovation Program for SMEs (ZIM) receiving additional support of USD 1.1 billion (EUR 900 million) for 2010/11.
Greece	In early 2012 new strategic framework law under public consultation by National Council and General Secretariat of Research and Technology to set out a long-term vision for the Greek R&D system, including objectives setting and associated milestones. Preparation and implementation of Business Friendly Action Plan aimed at identifying and removing barriers to entrepreneurship plus policy shift from direct funding of business R&D to tax relief for R&D considered with need of appropriate policy design beforehand. Adoption of measures to avoid brain drain: starting grants for young research (USD 169 million, EUR 120 million, for 2012-15) and new scheme for employing young researchers in successful Greek businesses (USD 21 million, EUR 15 million, for 2012). Other initiatives include stronger focus on supporting bilateral and international collaboration, efforts aimed at re-organisation of fragmented public research centres to achieve critical mass with a disciplinary and/or geographical focus and strengthening linkages between research and innovation.
Hungary	Crisis management programme with little emphasis on innovation, mainly focused on defining R&D spending targets, identifying strategic sectors and the disbursement of the Research and Technological Innovation Fund. Funding programme in 2009-10 for projects to facilitate the development of human resources for R&D by creating jobs at SMEs, publicly financed or non-profit R&D organisations as well as by employing highly qualified personnel whose jobs at medium-sized and large industrial enterprises were lost due to the global financial crisis.
Ireland	Innovation support has broadly been maintained in spite of the crisis.
Israel	MANOF Fund, series of joint investment funds established by government and institutional investors, introduced to counter credit crunch of the global financial crisis with government taking most of the risk. A downside-protection programme aimed at attracting institutional investors to invest in high-technology companies, through the venture capital industry and other mechanisms, offering investors downside protection of up to 25% in case of loss, programme promoted knowledge-based industries and was intended to deal with the entire production chain (from academic concept stage all the way through transitioning start-ups to large companies with government risk-taking).

Table 1.A. **The economic crisis and STI policy: national policy examples** *(cont.)*

Italy	2008/09: introduction of an anti-crisis export promotion plan, with USD 237 million (EUR 185 million) in 2009, managed by the Institute for Foreign Trade (ICE); new tax benefits to enterprises including for contracts aimed at boosting productivity with USD 3.7 billion (EUR 2.9 billion) for 2009/11; in January 2009 a refinancing of the Central Guarantee Fund for SMEs was put in place (USD 2.1 billion, EUR 1.6 billion) until 2012, and State guarantee as a last-resort guarantee provided; measure helped about 50 000 firms providing more than USD 6.7 billion (EUR 5.2 billion) guarantees for USD 11.7 billion (EUR 9.1 billion) worth of loans; no cuts in public R&D expenditure and business support, but a slowdown in the launch and implementation of some instruments and programmes. One-year debt moratorium for SMEs allowed firms (with no bad debts, restructured loans or ongoing foreclosures) to suspend repayment of the bank loan principal to obtain an extension of the duration of loans for credit advances; by December 2010, 200 000 applications had been accepted, and USD 16 billion (EUR 13 billion) worth of debts rolled over. In 2010 and 2011: reductions in public administrations' spending do not affect universities and diverse research bodies, but regulation facilitating temporary hires at universities of researchers, USD 500 million (EUR 400 million) must be dedicated to support public universities and USD 25 million (EUR 20 million) private ones recognised by the state and an increase of USD 187.5 million (EUR 150 million) in the fund dedicated to fellowships and prizes for excellent students; tax credit of 90% for activities developed by enterprises working in joint ventures with universities and public research institutions.
Japan	Supplementary budget about USD 487.8 billion (JPY 57 trillion) to address the global financial crisis in 2008 with over USD 8.6 billion (JPY 1 trillion) was allocated to S&T. 4th S&T Basic Plan shows policy shift from discipline-oriented to issue-driven approach and towards recovery after the devastating tsunami in March 2011. 2011 budget introduced budgetary reductions excluding for budgetary lines related to science and research, Ministry of Education, Culture, Sports, Science and Technology, whose overall budget decreased by 0.9%, the budget for science increased by 3.3%.
Korea	No substantial impact on innovation policies but continued public support for R&D activities.
Luxembourg	No changes of national STI policies in response to the global financial crisis.
Mexico	No major changes to national STI policies in the immediate aftermath of the global financial crisis, STI budgets were mostly maintained in spite of budgetary constraints. Overall recovery packages included several measures with implications for innovation such as programmes in support of SMEs and infrastructure investments.
Netherlands	Programme of USD 214 million (EUR 180 million) aimed at supporting about 2 000 researchers employed by the private sector at potential risk of job loss by providing financing for secondments to public research institutes. Existing R&D tax credit enlarged in 2009 and 2010 by USD 179 million (EUR 150 million). Growth Facility offered banks and private equity enterprises a 50% guarantee on newly issues equity or mezzanine loans, extended during the crisis allowing up to USD 29.8 million (EUR 25 million) in equity per enterprise to be guaranteed; also Guarantee for Entrepreneurial Finance launched in March 2009 provided banks with a 50% guarantee on new bank loans ranging from USD 1.8 million (EUR 1.5 million) to USD 179 million (EUR 150 million).
New Zealand	No public initiatives were explicitly created to target STI as a result of the financial crisis.
Norway	No substantial long-term impact on innovation policies. Continued support for R&D activities.
Portugal	Investment and Employment Initiative (Iniciativa Para o Investimento e Emprego) introduced in December 2008 of USD 3.4 billion (EUR 2.2 billion) involves improvements of the education system (public investments of USD 781 million, EUR 500 million, in 2009); renewable energy sources and energy efficiency (public investments of USD 391 million, EUR 250 million in 2009); broadband infrastructure (tax expenditure of USD 78.1 million, EUR 50 million in 2009). New stimulus package in December 2010, Initiative for Competitiveness and Employment (Iniciativa para a Competitividade e Emprego) with priority to education systems and STI. 50 measures were approved and developed in five fundamental areas including focus on competitiveness and support for export trade; administrative simplification and reduction of red tape for business enterprises and labour market reforms. 2012 budgetary consolidation efforts with no cutback on former spending on STI and increased government budget appropriations for advanced training and scientific employment (jointly 34% in 2012 compared to 31% in 2011) and support for scientific employment. Government prioritised support of the automobile industry via proposal to scrap light vehicles older than 8 to 13 years and buy new ones and prepared a new stimulus to introduce electric vehicles on the market by 2010, project of USD 313 million (EUR 200 million); energy investments encouraged in the anti-crisis package in support of innovation and sustainability.
Russian Federation	A short-term negative impact on the overall budget effort but no substantial impact on STI policy; over last years civil science funding has increased 3.8 times which has reduced negative influence of crisis on the industrial sector and compensated for the decrease in funding from extra budgetary sources.
Slovak Republic	Government loan guarantees available to banks and financial institutions increased temporarily by 21% to USD 429 million (EUR 219 million) in 2009, direct loans from state-owned banks more than doubled.
Slovenia	Significant strategic reorientation in national STI system introduced in response to the financial crisis, in many cases the crisis was the catalyst that fostered shifts and new instruments. Stimulus package included several R&D support measures as reflected in the 2009 revised budget representing 2.1% of GDP including co-financing of SMEs, support for start-ups, provision of loan guarantees, co-funding of firm R&D and investment projects and support for research among other measures.
South Africa	No major policy changes to the national STI policy; Framework for South Africa's Response to the International Economic Crisis re-emphasised some aspects of the national challenges that required scientific and technological input such as energy security, food security and new industrial development and led to some refinements in the implementation plan of the National Industrial Policy Framework adopted in 2008.

Table 1.A. **The economic crisis and STI policy: national policy examples** *(cont.)*

Spain	Plan to Stimulate the Economy and Employment of 2009 included USD 690 million (EUR 490 million) directly related to R&D and innovation (representing more than 16% of total budget).
	Strategy for a Sustainable Economy (November 2009) introduced new regulatory framework to promote innovation through the development of a new Law on Science, Technology and Innovation (June 2011) and the State Innovation Strategy E2i (July 2010) which includes budget actions undertaken by the General Secretariat for Innovation of the former Ministry of Science and Innovation of USD 4.3 billion (EUR 3.2 billion) in 2010 (an increase of 48% from 2009).
	Centre for the Development of Industrial Technology (CDTI) reorganised structure and operation in 2008-11, increased the amount of its direct aids to companies by 75.4% and improved temporarily (until March 2012, depending on budget availability) financial conditions of its business R&D support (*e.g.* reduction of guarantees for small companies, increase of support coverage for R&D projects from 75% to 85% of the budget and increase of the advance of the payment of aid for SME from 25% to 30%).
	State Fund for Employment and Local Sustainability of 2010 with USD 6.8 billion (EUR 5 billion) did not include a specific fund for R&D but USD 742.2 million (EUR 549.2 million) allocated by municipalities to innovative projects aimed at fostering local employment.
Sweden	Increase in university budget by 25% with 1/3 of free funding, 1/3 target areas identified as of particular interest to industry and society, 1/3 to research infrastructure and to industry-related research.
	Fouriertransform AB, a venture capital firm in the automobile industry, established in late 2009 with USD 335 million (SEK 3 billion) of capital to invest in viable R&D projects in the vehicle cluster.
	A capital injection by the government of the Swedish Development Bank (ALMI) increased lending capacity in 2009 compared to 2008, combined with allowing a higher share of co-financing, lending volume back to normal in 2010 (about 65% of the 2009 level and 120% of the 2008 level).
Switzerland	Recovery package of additional expenditures of USD 461 million (CHF 705 million) with about USD 31 million (CHF 48 million) on research and innovation: ● Swiss National Science Foundation (SNSF) responsible for basic research funding increased by USD 6.9 million (CHF 10.5 million) (= 28 additional R&D projects). ● Budget of federal universities and research institutions (ETH) increased by USD 8.8 million (CHF 13.5 million). ● Innovation policy promotion budget increased by USD 13.7 million (CHF 21 million) with: an increase in the budget of the Commission for Technology and Innovation (KTI/CTI), the main funding agency for applied research, by USD 12.7 million (CHF 19.5 million); a pilot scheme with innovation cheques that intends to encourage SMEs to engage in technology transfer has been launched with USD 0.64 million (CHF 1 million); and USD 0.3 million (CHF 0.5 million) information campaign targeted at the academic and private sectors on the subject of funding opportunities offered by the KTI/CTI.
Turkey	Precautionary measures related to R&D and innovation to address global financial crisis included shift towards direct public financial support via the additional allocation of USD 217.4 million (TRY 200 million) to the Scientific and Technological Research Council of Turkey.
United Kingdom	Spending Review of 2010 aimed to prioritise the capital investments that support long-term economic growth: USD 7 billion (GBP 4.6 billion) scientific research budget was maintained and ring-fenced until 2014, represents a cut in real terms of around 10% (given inflation).
	Commitment to increase the efficiency of the science budget by saving USD 491 million (GBP 324 million) a year by 2014/15 reinvesting these efficiency savings in science.
	Enterprise Finance Guarantee Scheme, introduced in January 2009, assisted enterprises affected by credit crunch, upper limit for loans of USD 1.5 million (GBP 1 million) providing assistance to enterprises with a turnover of up to USD 38.5 million (GBP 25 million), *i.e.* a three-fold increase in volume of guaranteed loans in 2009 compared to 2007/08 with previous scheme.
United States	Recovery and Reinvestment Act of 2009 implemented to provide short-term economic stimulus for research and for research infrastructure and strengthen knowledge base for future economic growth in areas of clean energy, biomedicine, and new industrial technologies. It approved USD 18 billion for new discoveries in energy, climate and future technologies.
	Within the Department of Health and Human Services (HHS), the National Institutes of Health (NIH) received USD 10 billion for biomedical research and laboratory renovation and construction. USD 1 billion was included for comparative effectiveness research at NIH and the Agency for Healthcare Research and Quality.
	USD 5.2 billion investment in key science agencies, including: USD 3.0 billion at National Science Foundation for basic research, education and human resources, research facilities construction, and research instrumentation; USD 1.6 billion at DOE's Office of Science for energy frontier research collaborations, and infrastructure investments at the national laboratories; and USD 580 million at the Department of Commerce's National Institute of Standards and Technology (NIST) for standards research, advanced measurement equipment, and construction of NIST research facilities. This investment by itself is an almost 50% increase for these programmes over the 2008 enacted level and represents a significant down payment toward the President's plan to double the funding for these agencies over a decade.
	National Aeronautics and Space Administration (NASA) received USD 1 billion for activities such as an acceleration of Earth science climate research missions, and development of the next-generation air transport system.
	National Oceanic and Atmospheric Administration (NOAA) received USD 170 million for climate modelling, and USD 660 million that includes support for maintenance and construction of research vessels and facilities.
	US Geological Survey received USD 140 million for facility renovation and construction and for seismic and volcanic monitoring systems.
	American Recovery and Reinvestment Act also allowed the government to temporarily increase its loan guarantee to 90% and reduce or eliminate processing fees for these loans. US Small Business Administration (USSBA) received USD 730 million to finance these measures, additional funding of USD 125 million provided subsequently extending assistance until February 2010.
	US Treasury intends to increase SME lending by providing low-cost capital to community banks, and President Obama in his State of the Union address pledged USD 30 billion for this purpose. This measure was incorporated into the "jobs" bill for SMEs that intended to give USD 12 billion in tax breaks, as well as expanding existing lending programmes (the law passed in September 2010).

Source: Country responses to the *OECD Science, Technology and Industry Outlook* policy questionnaires 2012, 2010 and 2008; *OECD SME and Entrepreneurship Financing Scoreboard 2012*; OECD Economic Survey; EU Erawatch country reports; EU country TrendChart reports; and national sources.

PART II

Innovating for global and societal challenges

PART II

Chapter 2

Transitioning to green innovation and technology[1]

OECD countries and emerging economies alike are seeking new ways to accelerate the transition to green growth through technology and innovation. This chapter argues that the transition to green innovation will require more than supply-side, technology-push approaches. It will also require demand-side measures and careful organisational and institutional changes. A key challenge is to align 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 its dimensions. Strategic policy intelligence can help to enhance policy learning and to avoid government failures.

Introduction

Government efforts to promote greener growth through R&D and innovation have intensified in recent years in the OECD area and beyond. The European Union's Growth Strategy for 2020, Korea's National Strategy and Five-Year-Plan for green growth, the green development focus of China's Five-Year-Plan and South Africa's New Growth Path and Green Economy Accord are just a few initiatives to make green innovation a crucial impetus for competitive and sustainable economies.

Innovation plays a key role in greening growth. One of the key messages of the OECD Green Growth Strategy is that innovation, together with market-based incentives and appropriate regulation and taxation, can accelerate the transition to greener growth and help decouple environmental degradation from economic growth (OECD, 2011a). The OECD Green Growth Strategy therefore called for countries to take a coherent, co-ordinated policy approach to green growth based on a sound overall framework for innovation policies which includes both supply- and demand-side innovation policies and a range of policy tools to create, diffuse and apply knowledge.

While the rationale for public intervention in this area is well established, owing to market and systemic failures, the challenge for science, technology and innovation (STI) policy is to use and combine supply-push and demand-pull instruments to accelerate the development and diffusion of the green innovations needed for a system-wide transition to greener growth.[2]

Making the case for green innovation and technology

The need for innovation to meet the challenge of sustainability

Recent OECD analysis suggests that without intensified policy action, global greenhouse gas (GHG) emissions are likely to increase by 70% by 2050. Other environmental and social challenges are equally urgent: improving the quality and availability of water, dealing with the use and disposal of toxic products, and maintaining or increasing biodiversity. The green growth agenda, however, is wider: its goal is to pursue economic growth and shared prosperity while preventing environmental degradation.

Green growth implies policies that either reduce resource use per unit of value added incrementally (relative decoupling) or keep resource use and environmental impacts stable or declining while the overall economy is growing (absolute decoupling). Over recent decades, OECD countries have been able to achieve absolute decoupling of GDP growth and emissions of certain acidifying substances, such as sulfur oxide (SO_x) and nitrogen oxide (NO_x). However, they have only been able to achieve a relative decoupling of GDP growth from GHG emissions, as these have continued to rise. Indeed, in many areas environmental pressures have continued to increase as economies have grown, notably in non-OECD countries (OECD, 2010a).

A pre-crisis, business-as-usual growth route that undervalues environmental capital will at some point deplete and/or degrade the natural resource base. This will limit growth prospects in the long term. Decoupling growth from environmental pressure requires establishing incentives and institutions that lead to significant green innovations and their widespread adoption and diffusion.

Barriers to development and uptake of green technology and innovation

Policies for green innovation should take account of barriers. Many barriers to technological innovation and diffusion are known and have been studied. The usual entry point for government intervention occurs when market forces provide inadequate incentives for entrepreneurs and firms to invest in either the development or the diffusion of green technologies. The main rationale for public support for R&D is spillovers – large, broadly dispersed societal benefits – that may occur as a result of research. As firms are unable to capture fully the results of R&D, they tend to underinvest in the socially optimal level.

In the case of green innovation, the policy rationale is what is usually referred to as the "double externality" problem (Jaffe *et al.*, 2004). One argument concerns the underperformance of private research owing to knowledge externalities and the disincentives provided by free riding (Arrow, 1962; Nelson, 1959). Other market failures, such as credibility problems or learning-by-doing effects, can also inhibit the development and diffusion of green technology. A second argument arises from the negative externalities of climate change and other environmental challenges and has implications for both the creation and diffusion of technologies. Because 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 (Jaffe *et al.*, 2005; Newell, 2010).

Other barriers to innovation may arise from systemic failures (OECD, 1998) that hinder the flow of knowledge and technology and reduce the overall efficiency of the system-wide R&D and innovation effort (OECD, 1999). These include capability failures, institutional failures, network failures and framework failures (Arnold, 2004). The issue is less the divergence between private benefits and social benefits than the insufficient development of the innovation system itself. Such systemic failures can arise from mismatches between different parts of an innovation system, such as incompatible incentives for market and non-market institutions, *i.e.* firms and the public research sector (Faber *et al.*, 2008). This is particularly the case for research and technology infrastructure, such as data collection and dissemination or the training of scientists and engineers, which the market is unlikely to provide fully on its own. From the perspective of transformative change – here defined as a drastic change in governance practice – further types of policy failure that are relevant for green technologies in the context of transition policy can be identified, such as directionality, demand articulation, policy co-ordination and reflexivity failures (Weber and Rohracher, 2012).

Specific barriers to the development and uptake of green technologies

Apart from typical market failures related to innovation, some market failures and barriers to innovation and adoption may be unique to, or more prevalent in, markets for green innovation (UK Committee on Climate Change, 2010; Stavins, 2003; Popp *et al.*, 2009; Geroski, 2000; Gillingham *et al.*, 2009; Aghion *et al.*, 2011). These include dominant patterns in energy and transport markets, uncertainty of success, long timescales for infrastructure replacement and development, a lack of options for product differentiation, liquidity constraints, path dependency, uncertainty and behavioural failures.

Barriers may also relate to firm size. These include a lack of financing and qualified personnel and, in some countries, the relatively small size of the domestic market (OECD, 2011b). Even for large firms, whether multinationals or national corporations, with scale, scope and experience, adapting to rapidly changing market environments and the high costs of R&D are challenges for commercialising new green technologies. Results from the Eurobarometer survey (EC, 2011) show that uncertain market demand, uncertain returns on investment and lack of funds are the three biggest obstacles to the uptake of green innovation.

Implications for science and innovation policy

Potential market and systemic failures suggest that, on its own, the market may not develop green technologies in a timely way and deploy them sufficiently. The OECD Green Growth Strategy shows that a business-as-usual innovation policy is ultimately unsustainable, involving risks that can impose costs and hamper future economic growth and development (OECD, 2011a). A new policy agenda for turning green innovation into a new source of growth is therefore needed. Successful innovation policies will have to address the performance of the system as a whole through a range of policies and customised approaches.

Getting the prices right

For most countries, instruments that directly affect price signals are a necessary, though not always sufficient, condition for greener growth. The main strength of market-based environmental policies is that, if properly designed, implemented and enforced, they implicitly or explicitly make environmental inputs more expensive so that they internalise environmental externalities (*e.g.* pollution). Such price signals enhance firms' and consumers' incentives to adapt and develop green innovations. Pricing mechanisms enhance efficiency and flexibility in allocating resources as they provide incentives to choose the best way to meet the policy goal (OECD, 2011a).

However, while market-based instruments, such as carbon pricing or cap and trade systems, may induce innovation that will lead to green technologies, better pricing of environmental externalities will not be sufficient to deliver green innovation. In order to have a significant impact on technological innovation and diffusion, it will be necessary to pursue additional policies to strengthen green innovation.

The case for broader-based support for green technology innovation and diffusion

The presence of market and environmental externalities suggests that both environmental and science and technology (S&T) policies are needed (Popp *et al.*, 2009, Newell, 2010).[3] However, there are fundamental differences between these policy areas: environmental policies aim at tackling environmental damage caused by past industrial activities, while innovation policies are generally forward-looking and aim to increase productivity (Kivimaa, 2008). Moreover, the policy mix for innovation can be improved through instruments to stimulate the adoption and diffusion of green innovation (*e.g.* demand-side innovation policies), whereas environmental policies stimulate innovation as a side effect (Jaffe *et al.*, 2005). To the extent that adoption and diffusion are limited by more than market failures, environmental policy measures that increase incentives to adopt green technologies or put a price on environmental externalities are necessary, but insufficient. In addition, policies focused directly on enabling and influencing the demand side can reduce the risk inherent in R&D investments through the creation of potential markets.

Policies that focus on one element of the system or one sector are unlikely to enhance overall performance, as different green technologies face different barriers. In particular, the radical and systemic innovations often targeted by policy makers require broad-based modifications on the supply and demand side and in institutional/organisational settings (Box 2.1). Shifting towards a more systemic or horizontal approach is far from straightforward, but holds the promise of greater coherence and better performance. At a minimum, effective long-run green innovation policies require both supply- and demand-side innovation policies which aim both at the overall rate of innovation and at its direction, *i.e.* the environment.

Box 2.1. **The search for radical innovation in the green technology area**

Incremental innovation is the dominant form of innovation and has enabled substantial progress in environmental performance in recent decades. To achieve a sustainable transition to green growth, many observers call for a policy framework able to foster more radical innovation. Radical innovation is generally a complex process, rather than a discrete event. It is often pioneered by smaller firms, or new market entrants, and generally implies a difficult, lengthy and risky process. System-wide adoption and diffusion of radical innovations nearly always depends on incremental improvements, refinements and modifications, the development of complementary technologies, and organisational change and social learning.

Nevertheless, supporters of government action often call for a one-time technological breakthrough in terms of a "Manhattan Project" or an "Apollo Mission" type of programme. Some observers (*e.g.* Mowery *et al.*, 2010) have argued that this is appropriate only when the way forward is relatively clear and when the necessary development work is intrinsically large-scale (*e.g.* ITER fusion reactor); otherwise centralised decision making can suppress innovation.

The uptake of radical innovations, whether the result of a supply push or a demand pull, can be restricted by market dynamics. In some industries radical innovation may be limited because of high rates of concentration and market dominance that provide little incentive for radical and systemic changes. The high cost of capital and barriers to market entry can also limit the entrance of new players with superior technologies. In the electricity supply sector, radical innovation is difficult, often requires clusters of complementary innovations, and tends to occur over long periods of time. In the case of power plant technology, *ex post* analysis shows that radical innovations – unlike incremental innovations – did not succeed owing to strong path dependency (Rennings *et al.*, 2009). In the case of the wind turbine industry, research suggests that that a high-technology breakthrough approach stifles learning processes (learning by doing) that allow new technological paths to emerge. While Denmark's wind technology system followed an incremental path, actors in the United States and other countries may have failed, not despite, but because of, the pursuit of radical innovation (Garud and Karnøe, 2003).

Recent national strategies and priorities in support of green innovation

National plans serve to articulate priorities for research and innovation and to set policies and instruments. A growing number of OECD and non-OECD countries are establishing green growth strategies or prioritising 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 across countries, depending on their scientific and economic specialisation, competiveness goals and societal objectives. Priorities can be expressed through targeted funding instruments such as R&D programmes or through specific sectoral and scientific initiatives. National strategies also include quantitative objectives in terms of R&D spending and monitoring. Some OECD governments have introduced plans through ministry agendas, mainly environment or energy ministries. In practice, however, the mapping and the identification of green growth strategies purely based on STI is difficult, given that most national plans are characterised as "strategy and policy mixes" (Table 2.1).

Revisiting supply-side technology and innovation policies

Supply-side innovation policies play an important role in orienting innovation efforts to help address green growth challenges. Current policy approaches to address market and systemic failures for green innovation generally focus on the supply side; they seek to generate new knowledge or innovations, either by making it less expensive for firms to undertake the relevant research or by performing the research in public institutions. Supply-side policies for innovation include public funding (direct and indirect) to public and business R&D, public support to venture capital funding, creation of research infrastructure, investment in higher education and human resources.

Funding and management of green research at the level of research institutions

Using public research funding as a catalyst to exploit new technology pathways

Science is an essential aspect of greener innovation, but very little attention has been given to the appropriate research funding model and the selection criteria to foster green technology. Indeed, it is difficult to identify specific disciplines as the sources of the scientific knowledge that will make major scientific contributions to green innovation and thus to green growth.[4] A mapping of scientific fields reveals that "clean" energy technologies draw on a diversity of scientific knowledge bases which have a broader focus than research on energy and the environment, such as materials science, chemistry and physics (OECD, 2011c).

The coming together of different fields of science and technology through collaboration among research groups and the integration of approaches originally viewed as distinct can also facilitate radical innovations as it opens up new avenues for technology development. Scientific breakthroughs are typically achieved by small interdisciplinary and multidisciplinary groups. For example, Heinze *et al.* (2009) find that there is less exploration when research groups are large and hierarchically organised. Therefore to advance the frontiers of knowledge will require better interaction across disciplines and appropriate funding systems that encourage such interdisciplinary research at the level of institutions (universities, research centres), departments, and single research units.

Table 2.1. **Green innovation performance and recent country plans in OECD and selected non-OECD countries**

	R&D in energy and environment	Green technology patents[3, 4]								Green regional hotspots[9]	Plan and strategic objectives[10]	Environmental tech/innov. programmes
	As a % of total government R&D budgets[1, 2]	Energy generation[5]		Transportation[6]		Environmental management[7]		Technologies with potential to emissions mitigation[8]				
		Country share in total world (%)	Relative speciali-sation[11]	Country share in total world (%)	Relative speciali-sation[11]	Country share in total world (%)	Relative speciali-sation[11]	Country share in total world (%)	Relative speciali-sation[11]			
Australia	8.7% ●●●○	2.0% ●○○○	✓	0.7% ●○○○		2.9% ●○○○	✓	0.7% ●○○○			**Clean Energy Future Plan:** pricing carbon; investing in renewable energy; improving energy efficiency; long-term investments; research into clean energy technologies.	✓
Austria	4.0% ●○○○	1.0% ●○○○	✓	1.2% ●○○○	✓	1.1% ●○○○	✓	0.6% ●○○○		Steiermark	**Energy Strategy:** energy services; energy security; environmental and social sustainability; cost- and energy-efficiency; competitiveness.	✓
Belgium	4.0% ●●○○	0.7% ●○○○		0.3% ●○○○		1.0% ●○○○		0.2% ●○○○		Vlaams Gewest, Region Wallone	**Marshall Plan 2. Green:** environmental technology hub; specific innovation grants; eco-designs; energy-, transport and materials-efficiency; water and air quality. **Flanders in Action:** Smart grid intelligent electricity network; smart living; renewable energy; sustainable materials; eco-friendly transport; socially caring cities.	✓
Canada	10.3% ●●●○	2.4% ●○○○	✓	1.4% ●○○○		2.9% ●○○○	✓	3.1% ●○○○	✓	Ontario, British Columbia	**Mobilizing Science and Technology to Canada's Advantage:** environmental science and technologies; natural resources and energy.	✓
Chile	n.a.	0.0% ○○○○		0.0% ○○○○		0.0% ○○○○		0.0% ○○○○				✓
China	n.a.	2.9% ●○○○		1.2% ●○○○		2.1% ●○○○		2.1% ●○○○			**12th Five-Year-Plan:** reduce fossil energy consumption; promote low-carbon energy sources; and restructure economy; "strategic and emerging" industries.	✓
Czech Republic	5.6% ●●○○	0.1% ○○○○		0.1% ○○○○		0.2% ●○○○		0.1% ○○○○				✓
Denmark	6.9% ●●○○	3.6% ●○○○	✓	0.3% ●○○○		1.1% ●○○○	✓	0.5% ●○○○		Midtjylland, Hovedstaden		✓
Estonia	13.8% ●●●●	0.0% ○○○○		0.0% ○○○○		0.0% ○○○○		0.0% ○○○○				
Finland	12.5% ●●●●	0.8% ●○○○		0.5% ●○○○		1.4% ●○○○	✓	0.3% ●○○○		Etela-Suomi, Lansi-Suomi	**Government Programme:** Cleantech technologies; environmental business; natural resources.	✓
France	7.7% ●●○○	3.4% ●○○○		7.1% ●●○○	✓	5.2% ●●○○	✓	3.4% ●○○○		Ile-de-France	**Ambition Ecotech 2012:** eco-industries; SME support; deployment of green technologies; reinforce EU ETAP-Plan.	✓
Germany	7.1% ●●○○	13.0% ●●○○	✓	31.6% ●●●●	✓	13.1% ●●○○	✓	11.2% ●●○○		Baden-Württemberg; Bayern	**BMBF Framework Programme Research and Sustainable Development (FONA):** earth system and geo-technologies; climate and energy; sustainable management and resources; social development. **Masterplan Environmental Technologies:** lead markets; resource efficiency; climate protection; water technologies.	✓
Greece	4.5% ●●○○	0.2% ●○○○		0.0% ○○○○		0.1% ○○○○		0.1% ○○○○				✓
Hungary	3.8% ●○○○	0.1% ○○○○		0.1% ○○○○		0.3% ●○○○		0.1% ○○○○			**National Sustainable Development Strategy (2007) – National Environmental Technology Innovation Strategy (2011-2020) – National Energy Strategy (2030).**	✓

Table 2.1. **Green innovation performance and recent country plans in OECD and selected non-OECD countries** *(cont.)*

	R&D in energy and environment	Green technology patents[3, 4]								Green regional hotspots[9]	Plan and strategic objectives[10]	Environmental tech/innov. programmes
	As a % of total government R&D budgets[1, 2]	Energy generation[5]		Transportation[6]		Environmental management[7]		Technologies with potential to emissions mitigation[8]				
		Country share in total world (%)	Relative speciali-sation[11]	Country share in total world (%)	Relative speciali-sation[11]	Country share in total world (%)	Relative speciali-sation[11]	Country share in total world (%)	Relative speciali-sation[11]			
Iceland	2.7% ●○○○	0.0% ○○○○		0.0% ○○○○		0.0% ○○○○		0.0% ○○○○				
Ireland	4.0% ●●○○	0.4% ●○○○		0.0% ○○○○		0.2% ●○○○		0.0% ○○○○			**National Climate Change Strategy:** meeting Kyoto targets.	✓
Israel	1.3% ●○○○	1.3% ●○○○	✓	0.2% ○○○○		0.9% ●○○○		0.6% ●○○○			**Water Management Master Plan:** natural water sources; sewage system; **National initiative to Develop Technologies That Reduce the Global Use of Oil in Transportation**.	✓
Italy	9.8% ●●●○	2.3% ●○○○	✓	1.5% ●○○○		2.3% ●○○○	✓	0.9% ●○○○		Lombardia		✓
Japan	14.4% ●●●●	14.5% ●●○○		26.8% ●●●●	✓	18.6% ●●●○	✓	34.5% ●●●●	✓	Southern-Kanto; Hokuriko	**New Growth Strategy:** new systems design and regulatory reform; expansion of environmental technologies and products; low-carbon investment and financing; smart grid; expansion of renewable energy market; green cities.	✓
Korea	7.6% ●●○○	3.7% ●○○○	✓	1.1% ●○○○		3.6% ●○○○	✓	5.0% ●○○○	✓	Capital Region	**Five-Year-Plan for Green Growth**: mitigation of green house gases; reduction of fossil fuel use; capacity to adapt to climate change; green technologies; greening existing industries; green transportation infrastructure.	✓
Luxembourg	3.9% ●○○○	0.0% ○○○○		0.0% ○○○○		0.0% ○○○○		0.0% ○○○○			**National Pact for climate and sustainable development:** mobility, housing, energy, nature and biodiversity, eco-technologies and research; **National Energy Efficiency Action Plan.**	✓
Mexico	10.1% ●●●○	0.2% ○○○○		0.1% ○○○○		0.2% ●○○○		0.0% ○○○○			**Green Agenda:** sectoral funds for R&D in water and forestry; investments in environmental studies; ecosystems.	✓
Netherlands	2.8% ●○○○	2.2% ●○○○		0.6% ●○○○		1.7% ●○○○		1.0% ●○○○		Zuid-Nederland, West Nederland	**New industrial policy To the Top:** energy, water, high-tech materials; logistics, agro-food.	
New Zealand	13.5% ●●●●	0.3% ●○○○		0.1% ○○○○		0.4% ●○○○		0.1% ○○○○		North Island		
Norway	5.6% ●●○○	1.3% ●○○○	✓	0.1% ○○○○		0.9% ●○○○		0.2% ●○○○		Oslo Og Akershus	**Energi 21:** solar cells; offshore wind power; utilisation of resources using balance power; flexible energy systems; smart grids; conversion of low-temperature heat into electricity ; carbon capture and storage (CCS). **An innovative and Sustainable Norway:** strategic council for environmental technologies.	✓
Poland	5.6% ●●○○	0.2% ○○○○		0.1% ○○○○		0.2% ●○○○		0.1% ○○○○			**National Reform Programme:** adaption to climate change; materials- and resource-efficiency; clean coal technologies. **National Environmental Policy:** R&D for environmental protection.	✓
Portugal	4.4% ●●○○	0.3% ●○○○		0.0% ○○○○		0.1% ○○○○		0.0% ○○○○			**National Energy Strategy 2020:** competitiveness and growth; renewable energy; energy efficiency and security; **National Low Carbon Roadmap to 2030 and 2050:** R&D and innovation.	✓
Slovak Republic	5.5% ●●○○	0.1% ○○○○		0.0% ○○○○		0.1% ○○○○		0.0% ○○○○			**Innovation strategy:** eco-innovation	✓

Table 2.1. **Green innovation performance and recent country plans in OECD and selected non-OECD countries** *(cont.)*

	R&D in energy and environment	Green technology patents[3, 4]								Green regional hotspots[9]	Plan and strategic objectives[10]	Environmental tech/innov. programmes
	As a % of total government R&D budgets[1, 2]	Energy generation[5]		Transportation[6]		Environmental management[7]		Technologies with potential to emissions mitigation[8]				
		Country share in total world (%)	Relative speciali-sation[11]	Country share in total world (%)	Relative speciali-sation[11]	Country share in total world (%)	Relative speciali-sation[11]	Country share in total world (%)	Relative speciali-sation[11]			
Slovenia	7.0% ●●○○	0.1% ○○○○		0.0% ○○○○		0.0% ○○○○		0.0% ○○○○				
Spain	7.7% ●●○○	2.6% ●○○○	✓	0.4% ●○○○		1.1% ●○○○	✓	0.3% ●○○○				✓
Sweden	7.2% ●●○○	1.5% ●○○○		2.9% ●○○○	✓	2.1% ●○○○	✓	0.7% ●○○○		Västverige, Stockholm	**Research and innovation bill A boost for research and innovation:** technology, sustainable use of resources, energy and research of marine environments	✓
Switzerland	1.1% ●○○○	1.3% ●○○○		0.6% ●○○○		1.0% ●○○○		0.7% ●○○○		Espace Mittelland	**Cleantech Masterplan:** research/knowledge and technology transfer; regulation and market-based programmes; international markets; cleantech innovation environment. **Energy Strategy 2050:** energy security.	✓
Turkey	n.a.	0.2% ●○○○		0.1% ○○○○		0.1% ○○○○		0.1% ○○○○				✓
United Kingdom	3.2% ●○○○	4.6% ●○○○		2.9% ●○○○		4.8% ●○○○	✓	2.6% ●○○○				✓
United States	2.0% ●○○○	27.4% ●●●●		16.0% ●●●○		25.6% ●●●●		27.5% ●●●●			**A strategy for American Innovation:** smart grid, energy efficiency, renewable technologies, advanced vehicle technologies, energy innovation hubs, energy standards.	✓

1. Based on government budget appropriations or outlays for R&D (GBAORD) data for 2011. Data refer to 2010 for Belgium, Estonia, Hungary, Israel, Spain, The United Kingdom and the United States. Data refer to 2009 for Iceland. Data refer to 2008 for Canada, Greece, New Zealand and Poland. Data refer to 2006 for Mexico.
2. Scale: X < 4 low R&D spenders; 4 < X < 8 moderate R&D spenders; 8 < X < 12 medium R&D spenders; 12 < X < 16 high R&D spenders.
3. As a percentage of world PCT patent applications, 1999-2009.
4. Scale: X < 0.2 = none or very low patent applications; 0.2 < X < 5 = low patent applications; 5 < X < 15 = moderate patent applications; 15 < X < 25 = medium patent applications; 25 < X < 35 = high patent applications.
5. Renewable energy generation, energy generation from fuels of non-fossil origin (*e.g.* biofuels).
6. Technologies specific to propulsion using internal combustion engine (ICE); technologies specific to propulsion using electric motor; technologies specific to hybrid propulsion; fuel efficiency-improving vehicle design.
7. Air pollution abatement; water pollution abatement; soil remediation; environmental monitoring.
8. Energy storage; hydrogen production (from non-carbon sources), distribution, and storage; fuel cells.
9. PCT patent applications in green technologies; TL2 regions, 2005-07. Only regions with more than 30 patents over the period and accounting for more than 22% of total country PCT patent applications in green technologies are included.
10. *OECD STI Outlook* policy questionnaire and national sources. EU's eco-innovation initiatives are not included.
11. 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 at least 1% of world patents are considered. Data are drawn from the OECD Patent Database.

Source: OECD Patent and RDS Databases, February 2012 and country responses to the 2012 *OECD Science, Technology and Industry Outlook 2012* policy questionnaire.

Funding systems have generally favoured scientific specialisation, but governments are increasingly adapting their research-financing mechanisms in order to facilitate funding of interdisciplinary research relating to green innovation, *e.g.* by making greater use of competitively awarded project funding

At the operational level, national research priorities for green innovation can be also expressed via the missions of research institutions or through more flexible structures such as centres of excellence. But there are limits and risks associated with a top-down approach to steering and managing university research. A too top-heavy approach is unlikely to provide a cumulative and diverse stream of green innovation because it reduces researchers' freedom and the experimentation that could lead to important but unexpected breakthroughs. At the same time, setting priorities only from the bottom-up can lead to research that is fragmented and lacks a critical mass. Ensuring a broader stakeholder involvement in priority setting can guard against the risk that public research crowds out private research in emerging technologies.

Turning science into green business

As PRIs and universities have become more entrepreneurial, there has been an increase in technology-based economic development initiatives, by improving institutional environments and capacities at national and university level, by the promotion of collaborative industry-science linkages (ISL) to hasten the transfer process, and by efforts to nurture university spin-offs.

There are large differences across countries in the degree to which the public research system (PRIs, higher education, hospitals) contributes to green patenting (Figure 2.1). In Portugal and Singapore, for example, the research system accounted for over 20% of all green patents between 2004 and 2009. Research commercialisation and knowledge transfer are considerably broader than patenting, however. Knowledge transfer channels such as industry-science linkages or publications have been found to be more important (Cohen *et al.*, 2002; Foray and Lissoni, 2010).

Redefining public support for business R&D

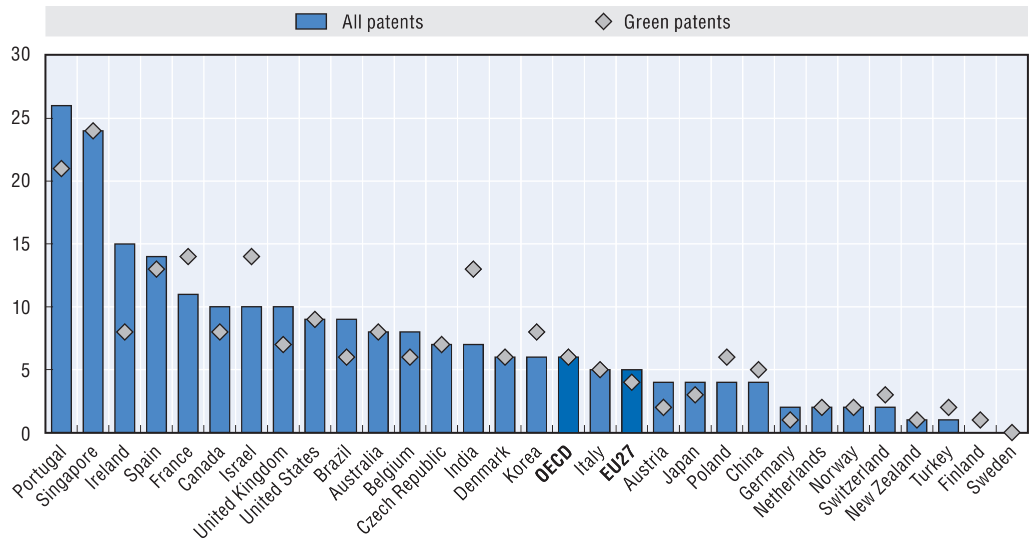
Vertical R&D support policies

While horizontal R&D policies have an impact on the overall rate of innovation, vertical R&D policies have the advantage of addressing precisely defined sectoral and technological opportunities by increasing the rate as well as the direction of innovation. If they favour green technologies, they can, in principle, both facilitate knowledge spillovers and address environmental externalities. However, there is the risk that too narrowly specified requirements will screen out potentially more radical innovations. For example, a funding agency will only fund a proposal if it meets the funder's requirements. To be eligible for funding, therefore, a firm is likely to submit a proposal that is more narrowly defined and likely to be incremental in nature.

Besides targeting less radical innovations, vertical R&D policies and long-term support usually imply higher transaction and administrative costs. Although targeted R&D policy is necessary for a system-wide transition, instruments to offset the weaknesses of this policy approach are also needed. For example, it would have been difficult for policy makers and experts alike to foresee the early uptake of wind technologies compared to solar or biofuels.

Figure 2.1. **Patenting by public research institutions, 2004-09**

As a percentage of patents filed under the PCT



Note: Data relate to patent applications filed under the PCT, at international phase, by priority date and applicant's country of residence (using fractional counts). PRIs include the government sector, higher education and hospitals. Patent applicants' names are allocated to institutional sectors using a methodology developed by Eurostat and Katholieke Universiteit Leuven (KUL). Due to important variations in the names recorded in patent documents, applicants may be misallocated to sectors, thereby introducing biases in the resulting indicator. Technology fields are defined using combinations of codes of the International Patent Classification (IPC) and European Classification (ECLA). For the classification of green patents, see *www.oecd.org/environment/innovation/indicator*.

Source: OECD, Patent Database, March 2012.

StatLink http://dx.doi.org/10.1787/888932689674

Support to SMEs and entrepreneurship

Another supply-side policy area concerns support for small and medium-sized enterprises (SMEs). SMEs often have weak innovation capabilities, and it is harder for them to generate green innovations. Policy can help to improve their access to finance, enable them to participate in knowledge networks, strengthen the skills that can lead to innovation, and reduce the regulatory burden on these firms. Opening (green) public procurement to SMEs may also help strengthen green innovation in such firms.

Evidence shows that small innovative companies have the potential to create new markets and introduce more radical innovations (Veugelers, 2009; Baumol, 2004). New and young firms may exploit technological or commercial opportunities that have been neglected by more established companies, often because they challenge their business models. However, most OECD countries face significant challenges for fostering the growth of new firms. Many have taken steps to simplify and reduce start-up regulations and administrative burdens to entry and have made bankruptcy laws less dissuasive. Consequently, many instruments that support innovative SMEs are being adjusted to favour or encourage green innovation (*e.g.* the US Department of Energy's SBIR/STTR programmes).

Prizes as incentives for private R&D

R&D can also be promoted through programmes that specify demand. Some governments have begun using technology prizes to induce R&D and innovation activities in green areas ignored by business. They can thus address a wide range of potentially relevant technologies and the uncertainties involved in both the technologies and their applications. For example, the US government promotes H-Prizes to seek breakthrough technologies in the hydrogen economy. The prizes can be modified in various ways to alter the outcomes and innovation effects. For example, to increase knowledge spillovers, the winning technology can be made available for licensing and diffusion. Prizes can also be made available for non-technological achievements, such as service innovations that enable firms to restructure their value chains or generate new types of producer-consumer relationships and also enhance environmental performance.

Although prizes may serve a useful role, their impact should not be exaggerated. They can also lead to duplication of R&D efforts, and up-front liquidity constraints can lower firm participation (Newell and Wilson, 2005; Scotchmer, 2004).

Instruments such as matching grants, where it is industry matching the government subsidy rather than the contrary, may allow public funders to screen proposals and to ensure that firms invest appropriately. Also, by inducing competition among applicants – through the use of various auction mechanisms – more information can be obtained about the proposals and some unnecessary funding can be avoided (OECD, 2010b).

Financing green innovation and technologies

While all of the supply-side policies mentioned have a financial aspect, discussions of finance-related technology policy commonly refer to instruments aimed at improving the supply of risk capital via equity, debt, venture capital or changes in capital markets. Access to finance is particularly severe for actors pursuing green innovation, especially new entrants and start-ups. It is difficult to obtain funding at reasonable cost for an immature market with high capital intensity and relatively high risk. Apart from policy relating to debt and equity finance, governments can provide incentives through risk-sharing arrangements or public-private co-investment partnerships in order to overcome investors' resistance.

Institutional investors can provide much of the capital required for green technology and innovation. They use different investment vehicles to access green projects via equity (including indices and mutual funds), fixed income (notably green bonds), and alternative investments (such as direct investment via private equity or green infrastructure funds). To tap into these large assets, governments need to provide clear and consistent policies and regulatory frameworks to signal credibility to potential investors. Institutional investors are not venture capitalists, however. They may look for potential investments with steady income streams and are therefore more likely to invest in established and mature technologies (Della Croce *et al.*, 2011).

Complementary means of increasing the supply-side response

Skills and infrastructures

Government support for training and skill enhancement is central to the development of a highly trained workforce with the technical and scientific expertise needed for green technology and innovation. Several studies and programmes have addressed the need for "green" labour in downstream sectors through the upskilling of the workforce (OECD, 2011d). Meeting the complex challenges of green technologies and innovation will also require efforts on the upstream side: researchers who understand several disciplines, even if they are more specialised in some than in others. The challenge is to adapt or adjust graduate training programmes and curricula to create ecosystem thinking in science. The Green Innovation Management Educational Unit at the Center for the Promotion of Interdisciplinary Education and Research of Japan's Kyoto University may serve as an example of ecosystem thinking in science.

Infrastructure is a prerequisite for the production of knowledge. Research infrastructure has many dimensions, both tangible and intangible. It supports the design, deployment and use of technology. As integrating knowledge from different disciplines becomes essential for green research, large national and international research infrastructures will play an increasing role. Existing multidisciplinary and basic science research infrastructures, for example, have already permitted essential advances in material sciences and in the comprehension of fundamental physics mechanisms, which are the basis of innovation in some green R&D activities. In addition, scientific research can lead to technological advances, but technology also affects advances in science. Large databases have become increasingly important and advances in quantum photonics have significantly affected the mechanisms for moving data faster, as exemplified in the accelerating use of supercomputers (Stephan, 2010).

The sharing of equipment and research materials will play a considerable role as research infrastructure investments are costly. Several initiatives have attempted to leverage resources and achieve economies of scale. In the European Energy Research Alliance, one of the SET Plan initiatives, the research infrastructure issue is central to the development of joint research activities. Policy options also include provision of funding to the research infrastructure facility to subsidise free access, or provision for funding access as part of research grants in the form of technology vouchers. In Australia, for example, the New South Wales government has implemented a system of TechVouchers to encourage collaboration and use of research infrastructure.

Networks and partnerships

Clusters, networks and technology platforms can also be viewed as mechanisms for increasing the supply-side response but also for bringing supply and demand together. In general, agglomeration effects arise when proximate economic activities benefit companies because of access to skilled labour and to specialised suppliers and because of inter-firm knowledge spillovers. They can bring together innovating firms, university laboratories and downstream users, and thereby internalise positive network externalities that might otherwise be lost. For example in northern and southern California, inter-firm and inter-sectoral knowledge spillovers facilitated and nurtured the emergence of green clusters from agro-food, information and communication technology (ICT) and biotechnology industries (Burtis *et al.*, 2006).

For such reasons, knowledge-intensive firms locate in localities/regions with high-quality scientific infrastructure (*e.g.* universities and PRIs) and will co-locate with other knowledge-intensive firms. Clusters and agglomerations may therefore account for a large share of a country's innovative efforts in green industries. For example, about 60% of Finland's environmental business is covered in the Finnish clean tech cluster, and 80% of the sector's R&D is conducted in this framework (Nordic Innovation, 2012).

Public-private partnerships (PPPs) can provide effective ways to mobilise private and public resources for green innovation by drawing on the respective advantages of the private and public sectors. The formation of strategic government-industry R&D consortia has intensified in recent years in OECD and non-OECD countries. The aim is to address the lack of core technological competences and long-standing problems involving general purpose technologies that can hamper promising development paths (*e.g.* Germany's National Platform for Electric Mobility or China's industry-research strategic alliances). Private-private partnerships such as the Electric Power Research Institute (EPRI), which pools the research capacities of US utility firms, illustrate the importance of R&D co-operation in a sector in which no actor has adequate capacity on its own (Lee *et al.,* 2009).

Intellectual property rights and knowledge dissemination

Intellectual property rights (IPRs) play a crucial role in new product development and diffusion of knowledge. On the one hand, they encourage investment in innovation by allowing firms to recover their investment costs. On the other, tensions can arise between technology diffusion and maintaining appropriate incentives to invest in innovation. For green technologies, IPRs can take various forms. For example, in wind-power technology IPRs may include patents for the wind turbine; a copyright for software related to aerodynamics, generators and blade controllers; a design for the turbine; and a registered trademark for the brand. Furthermore, the manufacturing process is covered by the concept of "trade secret".

Various proposals have been made to expand green innovation by using the IPR system as a channel for technology development and diffusion. Some OECD governments have sought to encourage actors to learn about the IPR system and apply for green patents. Still others push for changes to accelerate technology transfer to developing countries.

The effectiveness of an IPR regime relies on effective institutions and procedures such as effective enforcement. Competition authorities play an important role in ensuring that patents are not used anti-competitively (*e.g.* through standard setting). To accelerate the development and diffusion of green technologies, innovation incentives can include lower application fees, prioritised examination, expedited examination, approval procedures and diminished standards in the "green" area (see Maskus, 2010, for an overview). Fast-track programmes for green patents have recently been introduced in some national IP offices (Box 2.2). These vary widely in their eligibility requirements and process parameters (Lane, 2012). Some national and regional patent offices offer access to search and patent mapping services. The Korean Intellectual Property Office (KIPO), for example, launched the Green IP Information Project to collect and analyse various green technologies.

By facilitating access to prior inventions and providing incentives for the disclosure of new inventions, the sharing of public sector knowledge (*e.g.* through "open science") serves as a powerful framework for disseminating knowledge relevant for green technologies. The rationale for public policies that support "open science" focuses on the economic and social efficiency aspects of rapid and complete information disclosure for the pursuit of knowledge (Aghion *et al*., 2009). Open science initiatives that support access to research data and knowledge networking initiatives (*e.g. OECD Guidelines on Access to Research Data from Public Funding*) can help foster the exchange of proprietary knowledge.

Box 2.2. **Examples of green fast-track examination systems**

Canada: In March 2011, the Canadian Intellectual Property Office's (CIPO) initiative to expedite the examination of patent applications related to green technology came into force. No additional fee is required for advancing the examination of patent applications related to green technologies. To have access to the expedited examination service for green technologies, a patent applicant must submit a declaration stating that the application relates to a technology, whose commercialisation would help to resolve or mitigate environmental impacts or conserve the natural environment and resources. In addition, CIPO will be setting new service standards to speed up the prosecution of all patent applications that benefit from expedited examination. The amendments also eliminate undue delays that are contrary to the objectives of the accelerated examination provision.

United Kingdom: The UK Intellectual Property Office has developed a strategy specifically to facilitate the protection, management and appropriate exploitation of intellectual property connected with low-carbon technologies. On 12 May 2009, a Green Channel for patent applications was established. The service is available to any patent applicant whose invention has some environmental benefit. There is no specific environmental standard to meet in order to benefit from the Green Channel, and it is recognised that inventions with an environmental benefit can arise in any area of technology.

United States: In December 2009, the US Patent and Trademark Office (USPTO) launched a pilot programme to accelerate the review of green technology patent applications. It was established to take patent applications that pertain to environmental quality, energy conservation, development of renewable energy or greenhouse gas emissions reduction to the front of the line for expedited examination. Patent applications are examined by filing date. The Green Technology Pilot Program was modified several times. As of the end of April 2012, 3 533 petitions had been granted. The USPTO announced that the programme will be terminated in March 2012. Alternatively, the USPTO instead invites applicants to make use of the *Prioritized Examination (Track I) programme* or the *accelerated examination programme*.

Source: OECD Science, Technology and Industry Outlook 2012 policy questionnaire.

Beyond technology-push: Innovation policies for diffusing green technologies

Many OECD countries increasingly recognise that traditional supply-side innovation policies – despite their importance – cannot on their own improve innovation performance and productivity. Demand-pull theories suggest that the ability to produce innovations is often widespread and flexible but requires market opportunity (*i.e.* demand). Innovative solutions to meet the green growth challenge are hampered not only by technological barriers but also by the lack of supporting market conditions. This is very much an issue for achieving economics of scale.

The range of policies that affect the demand side vary widely and take many forms. It can be argued that demand-side innovation policies should encompass the whole national innovation system, from direct measures such as green public procurement policy to indirect measures such as pricing policies (OECD, 2010c; OECD 2011e). Policies that affect demand for innovation include income policies that affect consumers' purchasing power, market regulations and market mechanisms. Carbon pricing, taxes and subsidies such as feed-in tariffs can induce demand for renewable energies; consumer policy can incite changes in behaviour (*e.g.* municipal recycling rules). Regulation can spur demand for green innovation, although the impact of regulation varies across sectors, industries and technologies. Standards also affect demand for innovation, especially in industries characterised by economies of scope. Networks can facilitate the creation of a critical mass of users to enable technologies to penetrate the market. At the micro level targeted demand-side policies would include green public procurement which can help foster market demand for green products and services.

Demand-side innovation policies

Green public procurement

Public procurement has played a key role in the development of high-technology sectors and industries. In the United States, demand from the military – in conjunction with military R&D programmes – contributed to the development and diffusion of technologies such as the Internet and the Global Positioning System (GPS). As public procurement accounts for 15% of GDP in OECD countries, many governments today aim to include innovation in general public procurement, for example through awareness-raising measures and training of procurement agency personnel, and to stimulate innovation through more direct measures such as specific functional or performance standards in public tenders.

Many OECD countries have introduced programmes to encourage green innovation by providing and enlarging core public demand. Public procurement can create a market for green technologies that face cost disadvantages and can facilitate feedback between experimental users and technology providers. It can also promote diffusion of such technologies and services by overcoming information asymmetries and a potential consumer bias against green products and technologies.

The general procurement framework can have an indirect demand-pull impact if (environmental) regulations and industry standards help make public procurement more innovation-friendly and if green innovation becomes a by-product of general procurement. It can also encourage technological innovation more directly by specifying green innovative goods and services. In 2003, the European Commission called on member states to adopt national action plans for green public procurement. Although they are not legally binding, 21 member states have adopted such plans. The measures and criteria vary.

Studies on semiconductors and other electronic innovations suggest that public procurement contracts can serve the same function as a prize and induce innovative efforts by business (Mowery *et al.*, 2010). Some OECD governments, for example, have guaranteed public procurement for award-winning technologies in energy-efficiency competitions.

Reverse auction is yet another procurement tool that can be used to support the commercialisation of green technology. This would require procurement of green technology outputs (*e.g.* second generation biofuels) up to a given cost, at prices determined through competitive bidding. The US Department of Energy issued in mid-2010 a notice for a first reverse auction, with a budget of USD 4.6 million. It aims to stimulate the production of cellulosic bio-fuels, with a target of 1 billion gallons for 2013.

Regulation

Regulation, the implementation of rules by public authorities and governmental bodies to influence the behaviour of private actors in the economy, has been identified as an important mechanism in terms of diffusion and adoption of green technologies. Regulation influences innovation indirectly, since it affects the framework conditions for firms and involves no direct outlay of public funds (Geroski, 1990). For example, energy efficiency or environmental pollution regulations are used in the absence of market mechanisms to influence agents' behaviour and to achieve certain social or economic objectives. Germany's *Promotion of Renewable Energies Heat Act* (2009) encourages the diffusion of green innovations because it obliges owners of new buildings to use renewable energies.

However, the effects of economic regulation on innovation are far from straightforward. Some of the literature suggests in fact that regulation can both inhibit and stimulate innovation. The impacts of regulation on innovation are also likely to be highly technology- and industry-specific. OECD analysis shows that anticipation of regulatory change has induced innovation in some sectors (OECD, 2011f). To assess the appropriateness of regulatory policy targeting a specific sector, analysts also need to explore whether the market would introduce appropriate technology in the absence of regulation.

Regulations interact with market-based incentives and it can be relatively difficult to isolate the specific effects of regulation. This is due to the complex ways in which regulation may shape innovation, the possibility of long lead times between a regulatory stimulus and an industry response, the simultaneous impacts of an array of supply-side factors, as well as the inherent uncertainties in the dynamics of innovation (including exhaustion of the research frontier).

In the context of green technologies, policy makers have made significant use of environmental regulation in recent years and the effects on innovation have been extensively analysed. The evidence shows that environmental regulation has had positive impacts on green innovation and its adoption (Blind, 2012; OECD, 2011f). Conventional approaches to regulating the environment are often referred to as "command-and-control" (*i.e.* performance- and technology-based) as opposed to market-based environmental regulations and standards. In general, market-based policies provide incentives for constant incremental improvements, whereas "command-and-control policies" punish polluting firms that do not meet the standard, but they also do not reward those that perform better than mandated (Popp *et al.*, 2009, Stavins, 2003). Environmental policy design has thus been used more to reduce environmental externalities than to make targeted use of regulation for innovation purposes.

Standards

At their root, standards are documents based on various degrees of consensus which lay out rules, practices, metrics or conventions used in technology, trade and society at large (OECD, 2010c). Standards can be categorised in many ways and the driving forces include network effects, switching costs, government policy and intellectual property regimes, as well as other environmental factors (Blind, 2004; see Narayanan and Chen, 2012, for an overview). Even if they are developed for a single purpose they often serve several.

Standard-setting activities and organisations need to be understood and monitored by policy makers. The setting of standards is mainly the responsibility of different types of organisations: industry bodies (private), governmental (public) and non-profit technical bodies (hybrid) (Funk and Methe, 2001). Governments can act as facilitators and co-ordinators while industry bodies must be supported by firms as well as by governments. Firms commonly use standards strategically by steering and facilitating the adoption of *de facto* technology standards (Narayanan and Chen, 2012).

Standards may be developed by technical experts working in government agencies but in most cases they adopt standards developed by industry bodies for reasons of expediency and because of a lack of technical expertise (*e.g.* California Air Resources Board). Depending on the nature of the standards, in particular for environmental standards, some are enacted through legislation and are mandatory, whereas others are voluntary but are adopted by entire sectors (*e.g.* EU emission performance regulation) (Contreras, 2011).

A limit on the role of government in standards setting is the fact that for many technologies, standards are set openly at the international level. Efforts to impose national standards through public procurement, for example, are risky and costly as it is difficult to determine in advance what will become the dominant standard in a rapidly evolving area such as green innovation and may lead to technology lock-in. Procedures in standards bodies can also be slow and bureaucratic and may be influenced by large players.

The economic benefit of standards has become clearer to policy makers in recent years. Standards can affect incentives for diffusing green innovation in several ways. They provide information that facilitates the diffusion of innovation and economies of scale and they remove bottlenecks. Technical standards facilitate the organisation of network industries (*e.g.* by promoting interoperability or facilitating the substitution of old technologies or their co-existence with new ones) and value chains. It is sometimes argued that standardisation acts as much to enable as to constrain diffusion.

Technical standards are likely to play an increasingly prominent role in the development, adoption and regulation of green technologies. Most environmental policy and public procurement relies on standards. In the environmental area, performance-based environmental regulation and procurement promote minimum levels of performance for innovators and foster confidence among consumers. The UK government decided to support standardisation in biometrics, with technical standards that support interchangeability and interoperability. A 2009 review of standardisation and innovation programmes in the United Kingdom found that this had facilitated the diffusion of technology in the marketplace, made procurement more cost-effective and eased SMEs' access to the procurement market (OECD, 2010c).

Catalysing the demand-side response

Consumer policies

As consumers and users become catalysts for innovation, by creating demand and facilitating the diffusion of innovation, consumer policy takes on growing importance. Consumer policy regimes and consumer education play a role in promoting innovation in key innovative markets and can help ensure that confident consumers make informed choices. Potential private adopters of green technologies may be uncertain about the technology's quality and performance. It is therefore necessary, for example, to address behavioural biases to foster "greener" consumer choices and to enhance the quality and reliability of information on green goods and services, for example through green labelling. The potential savings to be achieved through resource-efficient technologies depend on scenarios which are uncertain and rely on many assumptions. This may lead firms and consumers to postpone the purchase of the technology.

Consumer policy can be used to counter inertia and scepticism towards new goods and services and help improve the flow of information between users and developers. One way to lower information barriers and to reduce information asymmetries is to improve the quality of claims made by firms that have expanded the use of self-declared "green claims" as a corporate marketing tool. To improve the value and effectiveness of such claims, some governments have prepared guides to help business develop and/or use green claims. The US Federal Trade Commission's *Green Guides* are a case in point. Finland and Norway have developed sector-specific guidance on the use of terms such as "carbon-neutral" and "energy-efficient" (OECD, 2010d).

Adoption and deployment policies

OECD governments provide a wide range of financial or price support mechanisms to business and/or consumers to encourage the adoption of green products and services. These measures are intended to help stimulate adoption and diffusion by reducing the price of the technology being adopted or by affecting behaviour (OECD, 2012a):

- Fiscal and financial incentives to reduce prices can be direct subsidies such as feed-in tariffs, consumer grants or financial transfer payments or tax incentives such as tax reliefs or tax credits (Table 2.2 provides recent incentive schemes for green vehicles).
- Fiscal and financial disincentives (environmental taxes and charges) are designed to influence the behaviour of producers and/or consumers while raising government revenue and covering the costs of environmental services *(e.g.* petrol tax, congestion charges).

In addition, several governments have used tax measures and subsidies to support growth and exports to new markets abroad. As world demand increasingly values green technologies, governments speculate that this could lead to future benefits, more internationally competitive sectors and more innovation.

OECD governments also provide support for large-scale demonstration projects or pilot plans to overcome the "valley of death", with its high technological and financial risk. The aim is to gain first-hand information about operation, maintenance and opportunities for incremental innovation and to create social acceptance. As part of its Economic Action Plan, Canada's Clean Energy Fund is investing in large-scale carbon capture and storage (CCS) demonstration projects and smaller-scale demonstration projects on renewable and alternative energy technologies. A key example is the federal government's CAD 120 million investment in the CCS Shell Quest project. In the same vein, Austria's new Energy Research Initiative (ERI) provides support for the creation of prototypes that use hydrogen and carbon dioxide as energy sources.

A common problem with adoption policies, notably direct subsidies, is that they involve large budgetary costs per unit of effect (including high transaction and monitoring costs). Without adequate phase-out schedules they can trap resources in subsidised "green" sectors. In addition, subsidies can provide perverse incentives that may lead to an increase in energy use ("rebound effects"). Evaluation is required to assess the sustainability claims of the respective sectors and to limit the risk of costly but ineffective intervention.

In practice, adoption policies are often used as an extension of industrial policy. Most OECD countries' support for renewable technologies amounts to industry policy instruments. They may build local manufacturing capacity to support deployment of renewable electricity technologies or provide support to local vehicle manufacturers. Government support may be in conflict with World Trade Organization (WTO) rules if it involves subsidies that can disadvantage foreign competitors and distort competition. However, whether or not subsidies, such as feed-in tariffs, constitute a breach of WTO rules depends on the actual design and implementation of the policy programme.

Table 2.2. Recent trends in the provision of fiscal and financial incentive schemes for green vehicles in selected OECD countries

Belgium	Electric vehicles (EV) benefit from a tax deduction of 30% of the purchase price, up to EUR 9 000 in 2011 and EUR 9 190 in 2012. An additional measure provides for a tax deduction of 40% of the investment for the installation of a charging station outside private houses (up to EUR 250 in 2011 and 2012). Further tax incentives are given at the regional level, both in Flanders and in Wallonia
Canada	Several incentive schemes exist at provincial level. For example, Ontario established an Electric Vehicle Incentive Programme in 2010, with incentives from CAD 5 000 to CAD 8 500 for the purchase or lease of a highway-capable plug-in hybrid or battery electric vehicle (EV).
Estonia	Private, commercial and public buyers of fully electric passenger cars are eligible to receive an incentive of 50% of the vehicle price. The maximum amount of the grant is EUR 18 000 per car (in addition to EUR 1 000 for setting up a Mode 3 home charger). The car can be purchased in any EU country, but second-hand vehicles are not eligible. The financial envelope allocated to the scheme allows incentives for 500 electric vehicles.
France	Since 2007 a "bonus-malus" (*i.e.* reward-penalty) scheme has provided any new car buyer a combination of financial incentives and disincentives which depend on the vehicle's CO_2 emissions. This one-time purchase tax (subsidy) levies a malus from EUR 200 to EUR 3 600 or provides a bonus from EUR 300 to EUR 5 000. In addition, there is a "super bonus" of EUR 200 which consists of an additional premium paid in case of the disposal of an old vehicle (more than 15 years old) and the purchase of a new green car.
Israel	Reduced vehicle tax rates apply to electric and hybrid cars (10% and 30%, respectively). In June 2012 new legislation came into force extending the incentives and making them more generous.
Italy	In 2011 the government offered incentives for the conversion of gasoline-powered engines to LPG and methane-powered engines. At the end of April 2011, EUR 23.4 million of incentives had been requested, for the conversion of 45 308 LPG engines and 5 474 methane engines. In addition, holders of EVs are exempted from the motor vehicle ownership tax for a period of five years, after which EVs are taxed at the 25% rate applied to non-electrically powered vehicles in the same category.
Japan	As part of its Next Generation Vehicle Strategy 2010, Japan's government earmarked USD 356 million in fiscal year 2011 for the installation of infrastructure but also incentives for purchasing EVs and PHEVs (plug-in hybrid EVs). Part of this financial envelope aimed at subsidising half of the difference between the price of an EV or PHEV and the base vehicle model.
Korea	The 2010 Strategy for Green Car Development foresees the introduction of a bonus-malus scheme and other incentives for consumers to purchases green vehicles in 2012. In addition, a tax incentive of up to KRW 3.1 million per vehicle is offered for the purchase of hybrid-electric vehicle (HEV).
Netherlands	A package of tax measures creating incentives for energy-efficient vehicles was submitted to Parliament in June 2011. It is proposed to apply a 0% rate to all vehicles with CO_2 emissions of 50 g/km or lower, a standard currently met only by pure EVs and some range-extended EVs and PHEVs. All fuel-efficient cars are exempted from the motor vehicle tax until 2014, but vehicles with emissions of 50 CO_2 g/km and lower will be exempt until 2015, in practice giving electric vehicles an advantage over other fuel-efficient propulsion technologies. Criteria for exemption from the Private Motor Vehicle and Motorcycle Tax (BPM) will gradually become stricter, so that the exemption will remain fully in effect until 2018 only for EVs, PHEVs and range-extended EVs.
Norway	Incentives to promote the use of EVs include: exemptions from the first-time registration tax, VAT and road tolls; reduction of the annual motor vehicle tax; and permission to use lanes otherwise reserved for public transport.
Portugal	In 2010, Portugal introduced financial incentives specific to electric propulsion: EUR 5 000 for the first 5 000 buyers of light-duty EVs; EUR 1 500 for scrapping an old vehicle and acquiring an EV.
Spain	In 2012, the government confirmed the regulatory framework for incentives for EV purchases introduced in 2011, and fixed the maximum budgetary allocation at EUR 10 million. The Ministry of Industry, Energy and Tourism will subsidise 25% of the sales price of the vehicle (before taxes), up to EUR 6 000 for individual users and fleets, and up to EUR 30 000 for large vehicles (*e.g.* buses). If the vehicle does not include the battery, the individual subsidy can reach 35% of the sales price.
United Kingdom	In the United Kingdom, the government, through the Office for Low Emission Vehicles, made GBP 300 million available over the lifetime of the current Parliament for a Plug-In Car Grant (PiCG) for ultra-low-emission vehicles. Motorists purchasing an eligible vehicle (of which there are currently ten, from a range of manufacturers) can receive a grant of up to 25% of the cost of the vehicle, capped at GBP 5 000.
United States	In 2009, a new scheme of green car incentives was introduced as part of the American Recovery and Reinvestment Act, which offers much more generous incentives to PHEVs and EVs. Under the new scheme, buyers of PHEVs or EVs benefit from a tax credit of USD 2 500 to USD 7 500, depending on the equipped battery size. The credit begins to be phased out for each manufacturer after 200 000 qualified vehicles have been sold by that manufacturer, rather than phased out once the total number of qualified vehicles sold by all manufacturers reaches 250 000. In March 2012 the administration proposed to amend the tax credit along these lines: expand the eligibility of the credit to a broader range of advanced vehicle technologies; increase the amount from USD 7 500, up to USD 10 000; make the credit available at the point of sale, so that consumers can benefit from it when they purchase the vehicle rather than when they file their taxes; remove the cap on the number of vehicles per manufacturer eligible for the credit and, instead, decrease and eventually eliminate the credit towards 2020

Source: Beltramello, A. (2012), "Market Development for Green Cars", *OECD Green Growth Papers*, OECD, Paris, forthcoming.

Enabling governance structures to facilitate transition

Governance will play a key role in transitioning to green technology and innovation. The OECD area provides ample evidence that countries' innovation performance depends in part on the quality of the governance of STI, *i.e.* the set of largely publicly defined institutional arrangements, incentive structures, etc., that determine how the various public and private actors engaged in socioeconomic development interact in allocating and managing resources devoted to STI.

Much of the debate on green innovation has focused on the relative importance of supply- and demand-side factors, sometimes opposing "supply-push" innovation induced by public R&D and "demand-pull" innovation induced by competitive market forces. While both frameworks provide insight into how innovations arise, both have shortcomings for analysing the complexity and non-linearity of innovation systems. Technology-push fails to account for market conditions, while demand-pull ignores technological capabilities. As a result, it is argued that both supply- and demand-side factors are necessary for innovation. It is not simply that they both contribute; they also interact. Recognition of the essential interaction between the two is reflected in the broader academic literature,[5] which finds that demand-side innovation policies need to complement supply-side policies rather than replace them. The policy challenge in OECD countries therefore seems increasingly to find means of bridging and linking supply-push instruments with demand-pull instruments in order to influence the rate and direction of green innovation in a decentralised manner. Effectively linking supply- and demand-side innovation policies is a governance challenge at various levels, both horizontally (across ministries, agencies and with industry) and vertically (central *versus* regional governments and with industry).

The challenge of linking supply-side and demand-side innovation policies through governance

Central to governance frameworks are the co-ordination mechanisms that bridge the various policy areas that can foster green innovation. Policy co-ordination is an essential part of a green innovation system. It ensures the coherence of measures to reduce environmental degradation through market mechanisms and regulation and those that aim to do so through innovation measures. Various developments have made this difficult to achieve (OECD, 2010e). Policy co-ordination of separate policy areas (*e.g.* S&T policy, economic policy, environmental policy, transport policy, agricultural policy, industrial policy) encounter hurdles such as inertia of actors, incompatibility of policies or dominance of certain ministries/agents. Even in sub-parts of the system, such as the R&D system, the lack of a shared vision regarding the transition can lead to misaligned or conflicting research agendas and sector/ministerial goals and to excessive competition and unnecessary duplication of effort. Institutional path dependencies can also be an obstacle to adapting governance structures to meet the green growth challenge.

Furthermore, demand-side policies are not always distinct from supply-side policies. Yet, responsibility for demand-side policies such as tax incentives for green technology use, regulations, standards, public procurement or consumer policy is often far removed from the ministries and agencies responsible for promoting R&D and entrepreneurship or for meeting demand from public missions (*e.g.* transport ministries). There are some attempts to integrate demand-side policies, such as public procurement, in the design of supply-side policies such as R&D grants or, as in some countries, the simultaneous use of feed-in tariffs while supporting green R&D. At the same time, not all potential failures and barriers make government intervention necessary or desirable. There is no guarantee that government policy will be able to address a market or systemic failure in a way that effectively improves the outcome, *e.g.* in welfare terms.

However, although the idea of simultaneous use of demand- and supply-side policies is simple and intuitive and is widely accepted in the academic literature, its transposition to a real world situation is not always straightforward. There can be as much variation within policy types, as between them. It may sometimes be difficult to make a sharp distinction between supply- and demand-side innovation policies (Wintjes, 2012).

This has been apparent in the design of a number of policies. Prizes have included demand-side factors and can make the winning technology publicly available, thereby enhancing knowledge spillovers and dissemination; the IPR system may encourage both innovation and diffusion; and systemic policies such as cluster policies can bring together innovative firms and downstream users. Innovation or research vouchers are another policy tool for bridging supply and demand. They subsidise the purchase of research or technology services by SMEs either from other firms or from public research.

Governance decisions are also very much driven by political rather than economic considerations. In view of the fact that the transition to green growth will involve losers and winners, some ministries/agencies may be reluctant to upset their clientele through active co-ordination efforts in the area of green innovation.

New institutions and mechanisms for transformative change

A number of OECD countries have introduced institutions and means of improving the overall coherence of supply- and demand-side innovation policies, such as the creation of mission agencies and joint decision-making modes of governance involving green growth committees (Box 2.3), consortia and public-private partnerships.

For fragmented markets with large information asymmetries, institutions can assume specific co-ordination tasks and responsibilities for creating attractive investment environments. Recent examples include the US Clean Energy Deployment Administration Agency (CEDA), the Slovak Innovation and Energy Agency (SIEA) and the Australian Renewable Energy Agency. However, such programmes have met with mixed success. Research funding structures, the permanence of institutional settings as well as the degree of flexibility within agencies remain a problem. There is also the issue of what a larger centralised organisation sees as priorities and the priorities of different agencies' clientele (Etzkowitz and Leydesdorff, 1998).

Another possibility is for the government to give funds to a network or consortia which uses an internal decision-making process to allocate the funds among different research projects. For example, the Danish Ministry for Science, Technology and Innovation has announced plans to establish a model for a green public-private consortium, consisting of businesses, universities, technological service institutes and technological networks in green areas of research.

Given the difficulty of a systematic analysis of all of a country's programmes and initiatives, locally embedded institutions can provide relevant consultancy services or focus on information dissemination. This can provide a useful arena for mediation and negotiation to achieve policy goals. The UK Energy Technology Institute (ETI) (Box 2.4) and the Spanish Environmental Technology Platform (PLANETA) are examples of institutions that facilitate co-operation and knowledge sharing among policy makers and across the private and public

Box 2.3. **Green growth committees: A model of governance?**

Australia: In 2010, the Australian government announced the establishment of a Multi-Party Climate Change Committee to build a consensus on how to tackle the challenge of climate change and to explore options for policy measures. The Committee's membership was comprised of: Prime Minister, the Hon. Julia Gillard MP (Chair); Deputy Prime Minister and Treasurer, the Hon. Wayne Swan (co-Deputy chair); Minister for Climate Change and Energy Efficiency, the Hon. Greg Combet AM MP (co-Deputy Chair); Senator Christine Milne (Australian Greens) (co-Deputy Chair); Senator Bob Brown (Australian Greens); Mr. Tony Windsor MP (Independent); Mr. Rob Oakeshott MP (Independent). In addition, two members of Parliament were invited to assist the Multi-Party Climate Change Committee: Parliamentary Secretary for Climate Change and Energy Efficiency, the Hon. Mark Dreyfus QC MP and Mr. Adam Bandt MP (Australian Greens).

The committee met regularly and carefully considered a wide range of issues in developing the Clean Energy Future Plan. It was advised by a panel of four experts, who were selected on the basis of their eminence in the fields of climate change policy, economics, social policy and climate science, and were drawn from academia, the community and business sectors. The committee was also supported by a group comprised of the heads of the government departments who would share responsibility for the implementation of a carbon price and the associated programmes.

The government sought input from interested parties on the basis of the proposed architecture. Some 1 300 submissions were received during the consultation period, including from industry associations, non-government organisations and community groups, state and local governments, businesses and private citizens. The submissions were held in confidence and were not made public so as to allow the expression of full and frank views. Individual authors could make their submissions public if they chose. Following the work undertaken by the committee, the government announced the Clean Energy Future Plan. In addition, an independent body, the Climate Change Authority, will start work from July 2012. It will advise the government on the setting of carbon pollution caps and will conduct periodic reviews of the carbon pricing mechanism and other climate change laws.

Korea: The Korean government's National Green Growth Strategy aims to support sustainability in growth and to pursue a low-carbon green growth society. It covers various policy implementation instruments such as direct investment in R&D, enforcement of regulation, incentives for participants and enhancement of civil awareness. The government plans to invest approximately KRW 107 trillion during 2009-13 in the development of new green technologies and the building of soft and hard infrastructure, so as to generate both jobs and high value added and lead to new markets and industry.

In order to co-ordinate R&D policy, the National Science and Technology Council (NSTC, a top advisory entity to the president) is closely linked to the Green Growth Committee. Funding is both top-down and bottom-up and based on open competition. NSTC's semi-annual reviews are important for securing a budget from the government. The first review is usually made to set national R&D priorities and suggest directions for key R&D budget allocations. The second review gives detailed comments, by fields, on R&D budget requests from ministries.

NSTC's comments go directly to MOSF (Ministry of Strategy and Finance, which develops the yearly budget) following a full discussion and co-ordination at NSTC meetings. Then, the Budget Office of MOSF prepares the budget taking account of NSTC's comments on budget requests from the ministries and evaluations of major projects. Budget allocation is based on R&D investment priorities and the nature of each project. One of the top priorities is development of green technology. The Presidential Committee on Green Growth, which co-ordinates the Green Growth Strategy, works closely with NSTC in the budget process. In general, a variety of actors and factors are involved in the budget process at national level, and each ministry takes responsibility at project level.

Source: OECD case study.

Box 2.4. **UK Energy Technologies Institute**

The Energy Technologies Institute (ETI) was set up in 2007 to accelerate the development and deployment of low-carbon energy technologies in order to help meet the United Kingdom's energy and climate change goals for 2020 and 2050. It is a 50:50 public-private partnership between the UK government and its departments involved in energy, environmental and innovation policy and industry partners with strategic interest and influence in these areas.

The ETI is a member of the Low Carbon Innovation Co-ordination Group (LCICG), which co-ordinates the country's major funding and delivery bodies backed by the public sector in the area of low carbon innovation. There are six private-sector members: BP, Caterpillar, EDF Energy, E.ON, Rolls Royce and Shell, (the "industry members"). The Department for Business Innovation and Skills (BIS) leads for the government with funding from the Engineering and Physical Science Research Council (EPSRC); the Technology Strategy Board (TSB) and the Department for Energy and Climate Change (DECC) are observers on the Board. Each of the industry members contributes GBP 5 million a year to the ETI budget, a sum that is matched by the public sector. This gives the ETI access to GBP 60 million a year.

The aim is to fund a range of large-scale projects, usually in the GBP 5-25 million range. Projects are funded on the basis of a set of agreed deliverables and an agreed budget and timeframe. Payment of actual costs is based on milestones achieved and accepted by the ETI. The ETI takes a project-based approach to accelerating the development, demonstration and eventual commercial deployment of a range of energy technologies. As of June 2012, 37 projects had been commissioned for a value of GBP 152 million. By commissioning individual projects the ETI is able to make targeted commercial investments in areas in which it has determined it will have the greatest impact. The projects, undertaken within a number of technology programme areas, arise from and help inform the ETI's technology strategy.

Nine technology programme areas have been identified through strategic analysis as having the greatest impact. These are offshore wind, marine, distributed energy, buildings, energy storage and distribution, carbon capture and storage, transport, and bio energy and the latest programme area to be announced in smart systems and heat. These areas constitute the ETI's current priorities. The portfolio of projects across technology areas is chosen to ensure effective use of resources and quality of output. The portfolio has evolved over time and is continually reviewed against the aims of affordable, clean and secure energy systems.

At the outset, it was envisaged that the ETI would be evaluated according to the following criteria: *i*) the contribution that its activities collectively make to building research capacity in the relevant technical disciplines to achieve the country's domestic and international energy goals; *ii*) the extent to which the Institute demonstrates practical success in helping to accelerate key technologies towards commercial deployment; *iii*) the extent to which its activities collectively help to achieve the United Kingdom's domestic and international goals; and *iv*) the extent to which its activities collectively have wider economic benefits. ETI projects are evaluated individually upon completion against the original project value proposition.

Although most of the ETI's work focuses on the supply side of low carbon energy innovation, the ETI provides an interesting example of how, by linking key players in the low carbon energy landscape and by taking a holistic approach to technology development, demand-side barriers to the development and deployment of low carbon energy technologies can also be taken into account.

Source: OECD case study.

sector. The Flemish government established the Innovation Platform for Environmental Technologies (MIP) to develop joint measures and projects that take advantage of synergies between private and public actors, using both demand- and supply-side measures.

The United Kingdom is considering whether it would be more effective to restructure and readjust current institutional settings. The Low Carbon Innovation Delivery Review, currently under way, looks at how best to co-ordinate government support for low-carbon innovation given the specific challenges it presents. The review will consider options for enhancing the delivery of direct public support for low-carbon technologies during the spending review period and beyond.

Enabling governance through transition management

These examples show that the involvement of public and private actors in agenda and priority setting represents a vital aspect of co-ordination in otherwise fragmented markets. A more far-reaching approach for stimulating system changes is offered by the so-called "transition management", a concept borrowed from the business sector but applied to the development of sustainable technologies. Pioneered in the Netherlands, it is designed for the development and commercialisation of "niche" technologies that might be successfully scaled up or abruptly shift socio-technical regimes towards more sustainable paths.

The government of the Netherlands took a transition approach, which ended in 2010, through the Interdepartmental Project Directorate Energy Transition (IPE). This involved six energy transition platforms and the "unique chances subsidy scheme" to support transition experiments (Arundel *et al.*, 2011; Nill and Kemp, 2009). Finland's recent

Box 2.5. **Finland's TransEco programme**

TransEco is a five year (2009-13) Research Programme on Energy Efficiency and Renewable Energy in Road Transport initiated by experts on vehicle technology and biofuels of the VTT (the Technical Research Centre of Finland). The 20 projects of TransEco fall into five categories: vehicle technology; fuels; traffic systems; international co-operation and networking; co-ordination, dissemination and communication. The research partners of the programme are the VTT Technical Research Centre of Finland, Tampere University of Technology, the Aalto University School of Science and Technology, University of Oulu, Metropolia Polytechnic, Turku Polytechnic and Motiva Ltd. In addition to the research projects firms have projects attached to the programme.

The funding comes from different stakeholders and is directly allocated to the projects. There is no pre-allocated amount of funding for the programme. The biggest financers of the programme are Tekes (the Finnish Funding Agency for Technology and Innovation) and VTT's internal funds. Other financers include ministries (Transport, Economy and Employment, Finance), companies and public institutions.

The main decision-making body of TransEco is a steering group composed of some 15 members. The government is represented by the Ministry of Employment and the Economy, the Ministry of Transport and Communications, the Ministry of Finance, the Ministry of the Environment, the Finnish Transport Safety Agency (Trafi), the Finnish Transport Agency (Liikennevirasto) and Tekes. The TransEco programme has been able to support the development of several emerging technologies to facilitate the transition to more sustainable passenger transport.

Crucial to the success of the programme is broad participation and dialogue among researchers, policy makers and adopters. The main results of demonstration projects are shared even if all partners do not participate in the funding. The interaction of all four ministries and other public offices reduces administration costs and ensures that environmental policies and other sectoral policies are aligned. The administrative and economic support for experimentation (*e.g.* through tax exemptions) offers systematic protection for developing niches and provides an incentive for demand-driven innovation. However, although there is broad stakeholder participation, critical Finnish non-governmental organisations are not involved. In addition, the legitimacy of different biofuels is a challenge that may threaten the vision defined by the groups involved.

Source: OECD case study.

TransEco programme incorporates demand-side policy and transition management elements in the development, demonstration and commercialisation of nascent road transport technologies (Box 2.5).

Systemic initiatives and instruments for linking demand-side and supply-side innovation policies

Recognising the interdependence of demand and supply in the innovation process, a number of OECD countries have introduced measures that address the entire innovation chain and combine supply- and demand-side instruments for more efficient innovation policy.

In Australia, for example, the Victorian state government has introduced a combination of demand- and supply-side measures to help SMEs with high-growth potential to focus their commercialisation efforts on technology that meets market demand. The Boosting Highly Innovative SMEs (BHIS) initiative has two main components: *i)* the Technology Commercialisation programme to support the establishment and development of rapidly growing technology-oriented SMEs by reducing the time and resources needed to bring technology to global markets; and *ii)* the Market Validation programme which uses government technology demand (*i.e.* pre-commercial procurement of R&D) as a driver for technology development and commercialisation by SMEs (OECD, 2010c). Similarly, the Danish Business Innovation Fund seeks to stimulate market development and deployment by focusing on three key areas: *i*) innovation that is either user-driven or attempts to develop “system solutions” in preparation for exports in green growth and welfare; *ii*) market maturation in green growth and welfare; and *iii*) support for the exploitation of new business and growth opportunities in less favoured areas (Nordic Innovation, 2012).

At the supranational level, the European Lead Market Initiative is a co-ordinated innovation policy initiative which uses demand-side instruments in combination with supply-side measures to provide better conditions for the creation and growth of new markets for innovative products and to support the development of worldwide operations by pioneering companies operating in Europe. It is held that the fragmented nature of the internal market and the innovation system slows the creation of lead markets in the European Union. At the national level, Germany’s recently revised High-Tech Strategy identified five lead markets of special societal and global relevance for 2009-13, one of which is climate protection and energy. A key element of the strategy is the alignment of policies such as environmental and innovation policies (OECD, 2010c). Similarly, Switzerland’s newly established Cleantech Masterplan aims at co-ordinating different policy areas of the central and regional governments as well as private and academic actors.

Sources of strategic intelligence

STI strategies as sources of intelligence

Although few national strategies/plans for green technology and innovation take a whole-of-government approach, they serve to catalyse and focus efforts around common goals and visions. They also help to diffuse strategic information among stakeholders and improve policy co-operation and co-ordination (Table 2.3).

Finland has various sectoral strategies in place and has recently started to develop a more coherent approach and national strategy, including a road-map, for green growth.

Table 2.3. **STI strategies for green technologies at a glance**

	Background and policy rationale	Modes of operation and funding	Policy co-ordination
Australia ***Clean Energy Future Plan (2011)***	**Aim**: reduce carbon pollution; **Target:** cut net expected carbon pollution by at least 23% by 2020. **Consultation process**: Multi-Party Climate Change Committee to explore options to develop policy measures; composed of business, non-government organisations, government and climate experts.	**Clean Energy Future Plan:** policy mix approach; carbon price; renewable energy; energy efficiency; land use. **Series of complementary measures** including: support for renewable energy (*e.g.* Clean Technology Innovation Programme, and Clean Energy Finance Corporation); creating opportunities on the land (*e.g.* Carbon Farming Initiative); and using energy more efficiently (*e.g.* Low Carbon Communities). **Funding:** AUD 5 billion to develop and commercialise clean energy technologies.	**Department of Climate Change and Energy Efficiency:** policy advice, policy implementation and programme delivery. **Domain-specific advisory bodies:** Multi-Party Climate Change Committee (September 2010-July 2012). Climate Change Authority (July 2012 onwards).
Finland ***Green Growth Policies***	The innovation potential for welfare and green growth **well recognised by policy makers**; substantial transformative **potentia**l within the Green Growth framework **for redirecting national policies towards a sustainable path.**	**R&D energy budget** increased from 4.3% in 2001 to 11.1% in 2012. **No holistic S&T** strategy for green innovation, but green growth supported by **thematic technology and innovation programmes** (*e.g.* Trans-Eco, Sitra's Energy Programme, Tekes-funded Green Growth programme). **Complementary measures** include regulatory instruments, *e.g.* taxation, standards and financial incentives.	**S&T policies** developed from sectoral viewpoint; interministerial and cross-sectoral communication limited; **Recent trend** from sector-based towards interministerial, co-operative and horizontal direction.
Germany ***Masterplan Environmental Technologies (2008)***	**Aim**: support the development of green technologies; economic and social dimensions are also highlighted; exploitation of fast-growing markets and orientation towards lead markets. Derived from the **German High Tech Strategy.**	Strategy and policy measures organised **around technology fields rather than markets;** water technologies; resource productivity; climate protection. Scope may later be extended to other technology fields. **Complementary measures** include: innovation-friendly framework conditions; support for technology transfer; support for market introduction; internationalisation; qualification; targeted support for SMEs; **environmental regulation** considered essential.	Joint strategy of the **Federal Ministries for Education and Research (BMBF) and Environment (BMU).** Commitment to regular co-ordination between the two ministries.
Korea ***Green Growth Strategy - R&D Development Plan (2009)***	As part of **Korea's Green Growth Strategy**, the government implemented the **Comprehensive R&D Plan for Green Technologies** (January 2009), and the **Development and Commercialisation Strategy for Core Green Technologies** (May 2009).	**R&D plan:** 27 core green technologies were selected. **Funding:** For 2012, investments of KRW 2.8 trillion for all green technologies and KRW 2.3 trillion for core green technologies are foreseen. In 2011, actual investments for all green technologies reached KRW 2.7 trillion and KRW 2.0 trillion for core green technologies, respectively. **Series of complementary measures:** (supply-side) public R&D grants, tax incentives for green technology development, investments in venture capital, (demand-side) green technology standards, certifications, public procurement for green technologies, assistance for households.	**Presidential Committee on Green Growth (PCGG):** Overall strategy development, policy advice and policy evaluation. **Ministry of Finance:** special focus on budget allocation. **Ministry of Knowledge Economy:** public R&D grants, green certification system, commercialisation strategies, test-bed policies, standards. **Ministry of Education and Science and Technology:** Public R&D grants for green basic research, university human resources development for green innovations. **Small and Medium Business Agency:** Public R&D grants for green SME innovation, public procurement for SMEs green technology products.
Norway ***Energi21 (2008)***	**Aim:** value creation on the basis of national energy sources and utilisation of energy; facilitate energy restructuring; cultivate internationally competitive expertise and industrial activities. **Consultation process**: industry-led board with broad participation from industry, agencies, interest groups and the ministry; number of industry-led working groups; importance of transparent processes.	**Research Council of Norway** (NOK 1.2 billion in 2010); **Innovation Norway** (pilot and demonstration projects, NOK 140 million in 2010); **Enova (**state company); **Transnova** (transport technology projects, NOK 50 million in 2010); **Gassnova** (state company, CCS).	**Research Council, Innovation Norway, Enova, Transnova and Gassnova** although different responsibilities at the technology development stage.

Table 2.3. **STI strategies for green technologies at a glance** *(cont.)*

	Stakeholder and policy dialogues	Evaluation	Lessons learned
Australia ***Clean Energy Future Plan (2011)***	**Multi-Party Climate Change Committee** was advised by a panel of four experts and supported by heads of the government departments. A number of **roundtables and working groups** to provide information and views to ministers and departments. **Public consultation process** on the proposed architecture and implementation arrangements for the carbon pricing mechanism.	The **Climate Change Authority** established as an **independent body** to review key aspects of the carbon price mechanism and climate change mitigation initiatives. A **Clean Energy Future Programme Office** to support the implementation of the Clean Energy Future Plan as a whole. **Individual programmes** administered by the relevant government departments.	**Policy mix** implemented in line with the innovation system approach combines interconnected policy measures addressing different areas of the economy. Integrated approach to **help prevent overlaps** of individual policy instruments and reduce potential inefficiencies. Involves **supply-side and demand-side** measures.
Finland ***Green Growth Policies***	**Tekes Green Growth programme** to foster co-operation on related policies; **network analysis** of different stakeholders in Finland; **fragmented co-operation** in green growth activities; **dominated by public sector organisations**; many **co-operation linkages** focus on specific areas of activity.	Finnish green growth policies largely in preparation phase or very recently launched, **too early to make comprehensive assessments** of policy impacts.	**Need to define clearly the rationale, goals and means** for green growth policies; **little experience to judge successes or failures**; active search and development for **supply- and demand-side policy**; **need to develop horizontal co-ordination** of sectoral policies, need to address explicitly links and intersections between sector-based policies; **high expectations** for newly launched green policies a challenge between state-led regulation and market selection; **broader implementation** of public procurement and standardisation yet to be seen.
Germany ***Masterplan Environmental Technologies (2008)***	**Involvement of additional ministries** foreseen (*e.g.* Federal Ministry of Transport, Building and Urban Development) for the second version of the strategy. Revision currently in negotiation among federal ministries.	***Ex ante*** **Strengths, Weakness, Opportunities, Threats (SWOT) analysis** of technology fields.	Strategy goes **beyond energy and climate technologies. Limited to the ministries** of Research and Education (BMBF) and Environment (BMU). Both **supply-side and demand-side** measures, but their potential not exploited fully (*e.g.* no public procurement policy).
Korea ***Green Growth Strategy - R&D Development Plan (2009)***	**Inter-ministrial Policy Dialogue:** inter-governmental discussion procedures ensured. PCGG played a fundamental role of coordinating and directing overall inter-governmental strategies. Chief Green Officers, generally Director-General of each ministries, are designated as a focal point for interacting with PCGG. **Public consultation process:** The members of PCGG consisted of governmental officers, industry sectors' representatives, academia and NGOs. A series of presentations and public hearings were undertaken to introduce the green growth strategy to the Korean public.	PCGG conducted interim evaluations on various parts of Korean Green Growth Strategy including R&D parts, which was conducted in Jan. 2012. This interim evaluation report on Green Innovations identified deficiencies of policy implementations and proposed improvement plans. **Individual programmes** were also administered and evaluated by the relevant government departments.	**Comprehensive Green R&D plans along with Green Growth Strategies:** comprehensive strategies provided all possible demand and supply-sided innovation policies including financial investments, public R&D grants, tax incentives, human resource development, green technology certification system, standardisation and public procurement for new green technologies. **Difficulties:** implementation of programme-level co-ordination among ministerial departments.
Norway ***Energi21 (2008)***	**E21 board** provides thematic input: Ministry of Oil and Energy; Energy Norway (non-profit organisation); Industry (Statoil, Statkraft, Vattenfall, Aker Solution); PRIs and universities; government and funding agencies.	***Ex ante*** **analysis** of government agencies and industry.	**Political commitment**; **mobilisation** of industry and the research community; **increase in budgets.** Both **supply-side and demand-side** measures. E21 to be used for the development of strategies in other areas.

Source: OECD case studies.

Norway's Energi21 strategy was launched by the Ministry of Petroleum and Energy and designed by a range of policy stakeholders; implementation and funding have been ensured by the Research Council and Innovation Norway with the close co-operation of state companies (Enova, Transnova and Gassnova). Germany's Masterplan for Environmental Technologies, which is derived from the High-Tech Strategy, is co-ordinated and implemented by the Federal Ministry for Education and Research (BMBF) and by the

Federal Ministry for the Environment (BMU). Yet another example is Australia's Clean Energy Future Plan, which is administered and co-ordinated by the Department of Climate Change and Energy Efficiency, but was developed by the Government following the work undertaken by the Multi-Party Climate Change Committee to develop the Clean Energy Agreement.

Government R&D funding is an important means of steering and shaping green innovation systems. At first glance, much of the available public support for green technologies is still based on R&D investments. Indeed, R&D policies form the largest part of the green innovation policy mix. Apart from technology adoption policies, such as feed-in tariffs for renewable energies, policies for articulating demand for green technologies are gaining ground, from regulation and standardisation to labelling and consumer policies.

However, several policy considerations are important too. First, a policy-induced increase in R&D, which results in higher demand for S&T personnel, will not necessarily result in more innovation. If too few qualified researchers are available to undertake the necessary research it may even have negative side effects (*e.g.* an increase in research salaries) (Goolsbee, 1998). Second, the impact of a rapid increase in public R&D spending will depend on the quality of research proposed and on the ability of the innovation system to turn that spending into innovation. Third, there is some concern that increased R&D expenditure on green technology may reduce or crowd out R&D expenditures in non-environmental and non-energy areas such as health and result in an ambiguous outcome in terms of overall welfare. In Finland, for example, the share of public R&D funding is expected to decrease to 1.0% of GDP in 2012. As energy is one of the key focus areas, public R&D funding has increased from 4.3% in 2001 to 11.1% in 2012.

A major challenge for providing strategic advice on linking demand- and supply-side policies for green innovation is the lack of indicators for understanding the baseline and plotting future targets. Indeed, the lack of clear definitions of what constitutes green technologies and innovations can hamper benchmarking and policy learning. Measuring investment in green R&D on the supply side, for example, is limited to a range of research fields or technologies such as renewable energy or environmental technologies even though research in areas ranging from the physical to the social sciences contributes to the development of such technologies.

Moreover, there is little empirical evidence about the factors affecting supply of and demand for green technologies and especially about the role and importance of public policy.[6] In fact, most R&D programme evaluations in the energy area are affected by the fact that the main classical global energy systems model technology change as an exogenous variable: future technology costs are entered by the modeller and are not affected by abatement or carbon price assumptions in different control scenarios. This is equivalent to "supply-push" and contrasts with accumulating evidence of market-based technology learning (Grubb, 2005). Empirical evidence on the way in which demand dynamics can affect R&D incentives is also lacking.

Dealing with technology-specific policies

Governments are also struggling with the notion of technological neutrality (Azar and Sanden, 2011), often following unfortunate experiences with "picking winner technologies". For first-generation biofuels, for example, long-term government support, whether R&D investments or deployment policies, has not resulted in large-scale market adoption. In practice, technology neutrality for a greener system is difficult given technology convergence and the different stages of technological development. For creating new technology trajectories, technology-specific policies will be needed to complement technology-neutral policies and to address specific barriers in certain green technology fields. In the earlier stages of technology development, technology-specific supply-side measures are essential and governments cannot avoid setting priorities. However, at the later stages, progressively technology-neutral demand-side measures may be necessary (*e.g.* through performance-based procurement), in particular to move technologies closer to market readiness. The allocation of funding is not and should not be technology-neutral and governments do make choices about what type of research and applications to fund.

Appropriate targeted measures and incentives may depend on the context of the technology. The types of R&D investments or technologies may be predetermined, to some extent, by existing industrial structures, research capabilities and specialisation or other supporting framework conditions. However, it is important for the design of technology-targeted policies to ensure that they meet policy and performance objectives efficiently. The issue is when and how to provide technology-specific policies. Policy makers therefore face a complex challenge for monitoring technological and commercial developments across a wide range of technology fields.

From an operational viewpoint, this process requires mechanisms such as the use of "strategic policy intelligence" based on technology roadmapping, foresight exercises, benchmarking and *ex post* and *ex ante* evaluation of research to define and co-ordinate research priorities for funding and performance more effectively. However, to make full use of them, organisations must be able to process and make sense of the available data in a realistic and detailed manner. Considering the dynamics of technological change, this can be only understood in symbiosis with social changes and social innovation at both consumer and producer levels.

To ensure legitimacy, the priority-setting process also needs to be based on a broad political consensus, especially in terms of the concentration of resources and the prioritisation of relevant research areas. Multi-year budgeting can help develop a long-term vision for innovation and signal the stability required to secure private investment in R&D. Performance budgeting can help position policy goals and costs of innovation with respect to other policy goals.

The international dimension

Green growth and green innovation have global as well as national dimensions. The fact that innovation takes place in a globalised economy (along global value chains) on the one hand and the fact that there are global negative externalities due to climate change and environmental degradation on the other means that the generation and diffusion of green innovations is not a matter for a single country or region.

The development and diffusion of green innovations at world level requires international co-operation in a range of policy areas, not least environmental regulation. While much discussion has focused on issues such as global emissions reductions, and market and policy measures to achieve this, it should be recalled that for many emerging and developing countries the policy focus is on economic development issues, such as poverty, energy, food security and access to water. In many cases this makes them more dependent on exports of natural resources. Green technologies can help these countries achieve development goals while preserving the stocks and flows of natural resources.

Closer to the market for green technologies, international co-operation is necessary for setting global standards on environmental and energy technologies, environmental regulations on industrial production, trade policy and technology deployment mandates. Today, for example, producers of energy-efficient light bulbs face different performance standards in different markets. The result is price effects and impacts on the uptake and diffusion of such energy-saving products. On the supply side, co-operation strategies include: integrated and co-operative R&D in international networks and funding commitments; co-ordination and harmonisation of priorities and research agendas; technology transfer initiatives; and international exchange of scientific and technical information, including mobility of researchers (OECD, 2012b). Among the many perceived benefits are: cost-effectiveness through cost sharing and reduced duplication of efforts; development of absorptive capacity; and accumulation of complementary knowledge by combining the comparative strengths of different countries.

However, difficulties may also arise for international co-operation: lack of continuity of funding at times of constrained budgets; asymmetric benefits and burdens; lack of participation due to insufficient incentives for individual countries, such as unclear technology transfer mechanisms; overall lack of co-ordination and strategic vision; overlap of agreements and programmes.

Given the complexity of the challenges, additional strategies involve greater implication of the private sector, non-governmental organisations, philanthropic organisations, and other stakeholders in the prioritisation and delivery of science and innovation and the use of new financing mechanisms (*e.g.* securitisation, risk sharing) to provide incentives for global and local innovations (OECD, 2011e).

Green innovation as way to foster growth in developing countries

The deployment of green innovations to emerging and developing countries will be a strong driver for expanding markets and sustainable economic development. Various new mechanisms to accelerate the diffusion of innovation to developing countries are being explored. Knowledge markets and networks could potentially play a key role in this transfer, *e.g.* innovative collaboration mechanisms in intellectual property (patent pools are but one example) which allow for a greater flow of research, development and adoption of green technologies in the developing and developed world alike.

While much international policy discussion has focused on adjusting the IPR regime (*e.g.* weakening IP protection for critical green technologies), the limited absorptive capacity of recipient countries is often a stronger obstacle to technology adoption than the price of patented inventions. Technology transfer and adaptive R&D aimed at building local capacities may be more effective for boosting the use of environmental inventions than purely patent-centred measures. These technology transfer initiatives aim to encourage technology diffusion and adoption by providing access to knowledge, in terms of innovation skills, for example, through education and training (disembodied technology transfer) and funding to cover costs of adoption of (parts of) the technology embodied in the imported equipment (embodied technology transfer) (Popp, 2011).

Aside from foreign direct investment, licensing and international trade, aid from governments in the form of development assistance plays an important role in technology transfer as well as in capacity building for green innovation, in terms of support both for agenda and priority setting and for operations and implementation.

Conclusion

This chapter argues that the transition to green innovation will require more than supply-side, technology-push approaches. It will also require demand-side measures and careful organisational and institutional changes. More specifically, the transition to green innovation and technology requires government institutions and mechanisms to sustain it. This creates governance challenges at various levels. Co-ordination problems arise across sectors and levels of government. A key challenge 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 the appropriate policy mix for green innovation. Strategic policy intelligence can help to enhance policy learning and to avoid government failures.

On the supply side, many of the enabling conditions are the same for green innovation or for innovation more generally. The fundamental drivers and barriers are largely identical. Green innovation thrives in a sound environment for overall innovation (OECD, 2011e; OECD, 2011f). In order to address the diversity of environmental risks, the growth environment needs in addition to focus on areas explicitly geared towards the creation and use (commercial and non-commercial) of knowledge for green purposes. In short, this means accelerating not only the rate, but also the direction of innovation towards producing knowledge solutions that address environmental problems.

Innovation policy also has a role to play in accelerating the rate of diffusion and adoption. While supply-side policies help facilitate the creation of new green technologies, they provide few incentives for adoption and diffusion. Only when green technology is used and spreads can it generate benefits for the economy and the society overall. To unlock and to create the necessary scale, supply-side policies need to be complemented and linked to specific diffusion and demand-side policies. The governance capabilities required for commercialisation differ significantly from those required to develop new knowledge.

Notes

1. This chapter is largely based on the ongoing OECD Working Party on Innovation and Technology Policy (TIP) project, "Transitioning to Green Innovation and Technology: The Role of Supply and Demand-side Policies", and builds on the recent OECD report *Fostering Innovation for Green Growth, 2011*.
2. Although this chapter distinguishes supply-side and demand-side policies, it is also concerned with their complex interrelationships in generating innovation for greener pathways.
3. In fact, studies evaluating the effectiveness of such policies find that environmental and technology policies work best in combination (Newell, 2010).
4. A disciplinary research field can be defined as a group of researchers working on specific research questions, using the same methods and a shared approach (*e.g.* Kuhn, 1962). In multidisciplinary research, the subject is approached from different angles, using different disciplinary perspectives but without integrating them. An interdisciplinary approach, on the other hand, creates its own theoretical, conceptual and methodological identity.
5. See Di Stefano *et al.* (2012) for a recent discussion.
6. Notable exceptions are Peters *et al.* (2012) and Nemet (2009).

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PART II

Chapter 3

Science and technology perspectives on an ageing society

This chapter explores the health and disability challenges of ageing societies and the potential contribution of science, technology and innovation in the near- to medium-term to meeting those challenges. In the coming years, science and technology, and particularly information and communication technology applications, will play an important role in achieving that the elderly remain as healthy, as autonomous and as active as possible.

The chapter begins with an overview of worldwide demographic developments to 2050, before turning to the impending difficulties of matching the rising demand for elderly care with an adequate supply of carers. It presents examples of scientific and technological innovations which are on the horizon or already in the pipeline. The chapter looks at spending on national and international age-related research programmes and projects, and suggests policy areas on which efforts might focus in order to facilitate the introduction and diffusion of technological advances that promise to strengthen older people's health, independence and active involvement in society.

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.

Introduction

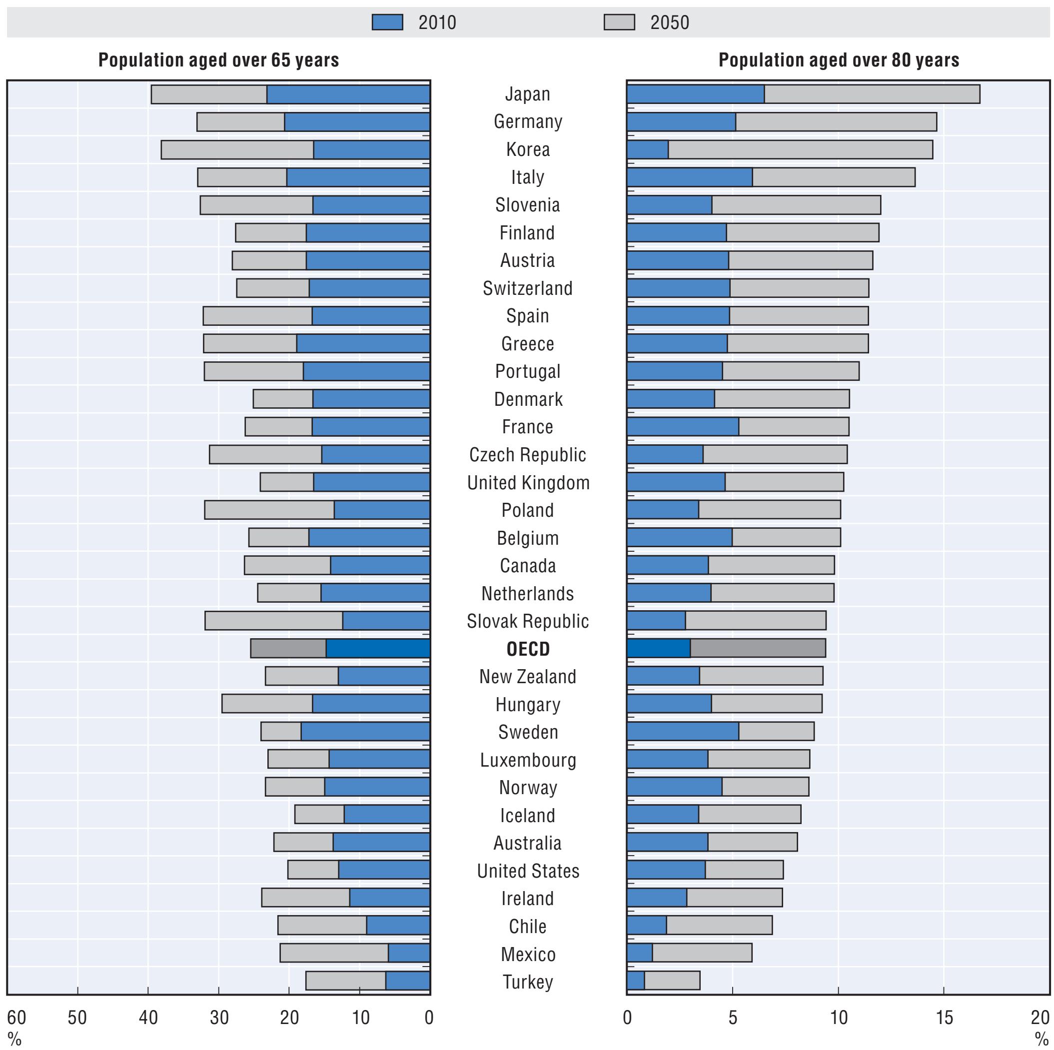
This chapter takes a long-term view of the potential of science and technology, particularly information and communication technology (ICT) applications, to help address some of the challenges and leverage some of the opportunities associated with the health and disability aspects of ageing populations. To do so, it draws on diverse reports conducted in recent years in various departments of the OECD. The aim of this synthesis is to bring the science and technology (S&T) dimension of ageing, health and disability into sharper focus and stimulate interest in further thinking and, possibly, further work. The chapter begins with an overview of the demographic issues many countries will need to address as their populations age, in some cases, at quite alarming rates. Not only will ageing place a growing burden on health services, long-term care systems and public finances, it will also take its toll on economic performance, as workforces age and, in some countries, shrink. In light of such long-term prospects, it is essential that the elderly remain as healthy, as independent and as active as possible, so that they can play their part in family life, in society and in the economy.

Science and technology can contribute to these objectives in important ways, for example by opening new avenues to improving the health and autonomy of the elderly, by facilitating the tasks of care providers, by enhancing the efficiency of health and long-term care delivery systems, and by shaping the home environment in a more elderly-friendly fashion. It follows that the ageing of populations should not be seen only as a burden; it is also a very real opportunity. Innovation for an ageing society offers the prospect of new market opportunities and new growth industries. This chapter looks at some of the technologies and applications that are in the pipeline, and discusses the outlook for further innovations in the future. However, those opportunities are unlikely to be fully exploited unless a significant effort is made to step up investment in R&D, encourage innovation, and tackle a range of obstacles, including barriers to market-driven creativity and a lack of innovation-stimulating public policies. Equally, however, it would be a mistake to assume that tomorrow's elderly will, collectively, have the same characteristics as today's. Systemic changes such as higher education levels, rates of elderly labour force participation, and later onset of disability may significantly alter older people's requirements in terms of technology-based and personal care. Such systemic changes need to be factored into all efforts aimed at enhancing the future contribution of science and technology to improving the health and mobility of the elderly.

Demographic trends – profiling ageing societies

The world population is expected to exceed 9 billion by 2050, up from 7 billion today. The increase will take place almost entirely in developing countries, lifting their numbers from 5.6 billion in 2009 to 7.9 billion in 2050. In the developed world, the size of the population is likely to remain largely unchanged, but its age profile is set to shift significantly (United Nations, 2011).

Figure 3.1. **The shares of the population aged over 65 and 80 years, selected OECD countries, 2010 and 2050**



Source: OECD Labour Force and Demographic Database, 2010; OECD (2011), *Help Wanted? Providing and Paying for Long-term Care*, OECD, Paris.

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The share of the population over 65 years of age has been increasing in OECD countries over the past few decades. In 1960, 9% of the OECD population was over 65 years old, but the proportion rose to around 15% in 2010 (OECD, 2011a). This trend is expected to continue into the future as life expectancy keeps rising, so that by 2050 the share of the population aged 65 or more is expected to reach 26% of the total OECD population. Also, the share of the group over 80 years of age is expected to reach unprecedented levels. This group accounted for only 1% of the OECD population in 1950, but its share rose to 4% in 2010 and is projected to be 9.4% by 2050 (OECD, 2011b). The countries with the highest proportions of this group are expected to be Germany, Italy, Japan and Korea (around 15% by 2050). Korea stands out as the country with the largest change in its share of the very old, moving from 2% in 2010 to around 15% in 2050. A number of other countries will experience more gradual changes. These include Australia, Iceland, Ireland, Luxembourg, Norway and Sweden, where increases of less than 5% are expected by 2050, and where shares are likely to remain below 9% (OECD, 2011c).

Fertility rates are likely to remain low in most of the world's more developed countries, and the size of the working age population (15-64), currently at an historical peak, will very soon begin to diminish. As a result, the size of the "dependent" population (*i.e.* children under 15 and persons over 65 years of age) relative to the "working age" population that theoretically provides social and economic support will increase. The United Nations sees the old-age dependency ratio in the more developed regions of the world rising from 24 per hundred working-age population in 2010 to 45 per hundred in 2050. By 2050 in some OECD countries old-age dependency ratios are expected to reach very high levels indeed – 70 per hundred in Japan and over 60 in Italy, Korea, Portugal and Spain (United Nations, 2011).

Outside of the OECD area, the picture is mixed. On the whole, the less developed regions of the world still have young populations, a situation that is unlikely to change much before 2020 when ageing will become a more significant factor. Some of the larger emerging economies, however, are likely to be converging with OECD population-ageing profiles by mid-century. Projections for 2050 indicate that the share of those over 65 is heading for around 25% in China and 23% in Brazil and the Russian Federation, closely followed by Argentina, Colombia and Indonesia with 18-19% (United Nations, 2011). By contrast, countries such as Egypt, India and South Africa will continue to benefit from considerably younger population profiles.

Trends in old-age dependency are correspondingly diverse. In the least developed countries the ratio is projected to rise from just 6 elderly per 100 working-age population in 2010 to around 11 by 2050. By contrast, some emerging economies are likely to see ratios attain significant levels by 2050. These include China (42), the Russian Federation (39), Brazil (36), Argentina and Indonesia (both around 30). Egypt, India and South Africa will benefit from old-age dependency ratios below 20. Hence, most of these future dependency rates will remain below those of most OECD countries. In some of the larger emerging economies, such ratios nonetheless signify huge elderly populations, an issue that their governments will need to address with increasing urgency in the years ahead. By mid-century China will have about 330 million citizens aged 65 or more, India about 230 million, Brazil and Indonesia over 50 million (United Nations, 2011).

Over the short to medium term for OECD countries and over the medium to long term for many emerging economies, ageing will generate a range of serious challenges linked to growing pressures on economic performance, social and health care, and public finances. Whether these challenges are addressed successfully will depend to a critical extent on how governments mobilise innovation, including organisational and social innovation, for their ageing populations.

Major challenges ahead

A crucial issue is whether ageing is healthy or unhealthy, whether it means more years of healthy life or more years of frailty and infirmity. The elderly are a heterogeneous group in terms of levels of activity and health. While ageing is a universal biological process, it is not a uniform one. Many old people experience good health until death while others may suffer from prolonged disabling conditions. In general, older people, particularly the very old, use more health care and are responsible for a large share of health and long-term care spending.

The young elderly (65-75 years) tend to be physically independent and enjoy good health, whereas the older elderly (75-85 years) face a higher risk of loss of autonomy. Per capita expenditure for those aged 65 and over is, on average, two and a half to five times higher than for younger people, with even higher ratios for those aged 75 and over. Both groups can however potentially take on paid work, household tasks and/or provide care. It is the group of those over 85 years old which tends to be most demanding in terms of care and resources.

Health status of the elderly

Three general theories on possible trends in old-age disability in a context of rising life expectancy have been proposed:

1. an expansion of morbidity/disability, with increasing longevity linked to a prolonged period of morbidity and disability at the end of life, owing to improved survival rates among the sick and a greater prevalence of ageing-related diseases such as dementia (Gruenberg, 1977);
2. a compression of morbidity/disability, in which increasing longevity is linked to a shorter period of illness and disability at the end of life, owing to disease prevention efforts by individuals, organisations and governments (Fries, 1980);
3. a dynamic equilibrium, with increasing longevity linked to an expansion of light morbidity and disability and a reduction of severe morbidity and disability, owing to improvements in health care and increased use of assistive devices (Manton, 1982).

The question is to determine which of the above theories is appropriate, in a given country and for a given population group (LaFortuna and Balestat, 2007).

Recent OECD projections of public spending on long-term care highlight the importance of future developments in disability rates among elderly people, from the point of view of the increasing prevalence and persistence of some chronic disorders which may reverse generally positive trends and ultimately result in higher levels of incapacity. If mortality falls faster than morbidity (owing, for example, to diabetes or ischemic heart disease), the number of disabled elderly people may rise.

Based on recent trends in chronic diseases (and particularly in obesity) among those aged 50 to 69, projections by the OECD and others suggest that in Belgium, Japan and Sweden disability rates will continue to rise. Even if the age-specific prevalence of severe disability remains unchanged, in some countries the projected strong increase in the number of the elderly – especially the very old – would trigger a strong rise in the numbers of severely disabled elderly people. Australia, Canada and Finland, for example, could see such numbers more than double by 2030 (LaFortuna and Balestat, 2007).

Data on disability rates among the elderly in developing countries and emerging economies are rare, but a few recent studies indicate a growing problem. In China for example, the population of the disabled elderly is estimated to have risen from 20 million in 1987 to around 40 million in 2006 (Liu, 2007). In India around a quarter of all elderly persons are thought to be disabled (Pandey, 2011), and an increasing prevalence of functional disability has also been observed in Brazil (Alves *et al.*, 2010).

Mental health and well-being

Future trends in neurological and cognitive diseases (such as dementia) are uncertain. Dementia, for example, occurs in every country of the world; it affects 1 in 20 people over the age of 65 and 1 in 5 over the age of 80. The prevalence of dementia among the elderly population has been reported to range from 3.6% to 11.9% in the West (Ott, *et al.*, 1995; O'Connor, *et al.*, 1989) and from 4.8% to 7.2% in Japan (Ueda, *et al.*, 1992; Hasegawa, 1990; Yamada, *et al.*, 1999; Shibayama, *et al.*, 1986). For China, Dong, *et al.* (2007) report a prevalence of 3.1%.

According to Statistics Korea (2010), the prevalence of dementia among the elderly aged 65 or more in Korea is 8.6%. Approximately 460 000 older people are diagnosed with dementia, a number expected to rise to 690 000 by 2020. Cases of Alzheimer's disease range from 4.2% to 9.0%. In 2010, up to a million elderly people were also reported to suffer from significant depressive symptoms. With an expected tripling of the elderly population in the next 40 years, the number of Korea's elderly diagnosed with major depression could exceed a million, and of those with depressive symptoms four million.

In Finland, dementia is also becoming more prevalent among the very old (80 years or more) and is an increasingly widespread cause of death alongside ischemic heart diseases. In 2009, almost one in two of those who died over the age of 80 died either of ischemic heart disease or memory disorders. The number of deaths caused by dementia more than doubled in two decades (Statistics Finland, 2009; Forma, *et al.*, 2011).

In 2001, people with dementia in Denmark numbered about 4 800. In 2007, there were around 5 700 registered institutionalised individuals, an increase of 19% in less than six years (Ministry of Social Welfare and Statistics Denmark).

The Italian Institute for Health estimates that Italy currently has around a million people with dementia and 3 million family caregivers involved in caring for their relatives (Ruggeri and Vanacore, 2008). By 2020, Italy may expect to see 213 000 new cases a year, 113 000 of them involving Alzheimer's disease. An extensive qualitative analysis conducted in Italy in 2007 by the Censis Research Foundation (Censis, 2007) found that people with dementia have an average age of 77.8.

Such trends point not only to the risks of a rising burden for health and long-term care and a need for greater cost efficiency, but also to a considerable uphill task for ensuring that the growing number of older people maintain the best possible health and mental capital, and so preserve their independence and well-being.

Maintaining and enhancing social care for the elderly

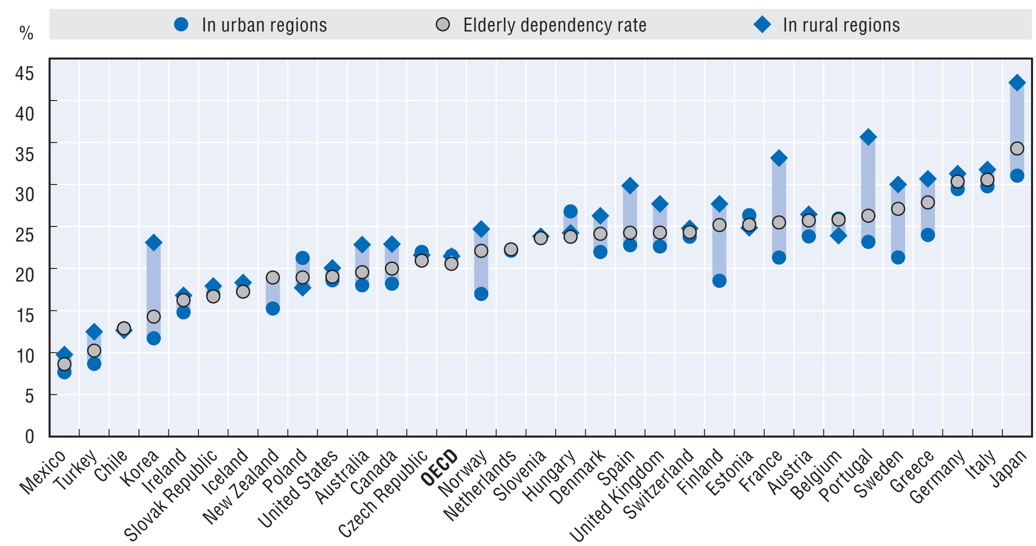
Given these perspectives, ageing societies face critical policy challenges for maintaining and enhancing the supply of health and social services for the elderly. The rising numbers of the elderly will increase demand for care, including in nursing and residential homes and for home care services. Demand is likely to be reinforced by other societal changes such as rising rates of female participation in the labour market, declining family size, childlessness, divorce and the continuing rise in the "step-kin" or "patchwork" family (OECD, 2012; OECD, 2011c).

The health workforce has, however, diminished dramatically in recent times (OECD, 2011c), a trend that will further affect the pool of care providers (Figure 3.2). There are documented and forecasted shortages across the OECD area of public health physicians, nurses, epidemiologists, health-care educators, and administrators. Public health workforce shortages are even more critical in rural areas.

Since the 1990s, the age gap between urban, intermediate and rural areas has increased in most OECD countries. The elderly dependency rate across OECD regions is

Figure 3.2. **Elderly dependency rate in urban and rural regions, small regions, 2008**

Percentage population aged 65 and over



Source: OECD (2011), *OECD Factbook 2011-12: Economic, Environmental and Social Statistics*, OECD, Paris.

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higher in rural than in urban regions except in Belgium, Chile, the Czech Republic, Estonia, Hungary, Netherlands, New Zealand and Poland (Figure 3.2). Among OECD countries, Japan has the highest share of population aged 65 or more living in rural areas, followed by Portugal, France, Italy and Germany.

Rural areas are generally less well served, and when it is difficult to access readily needed health and social care services, health needs may not be adequately met and there may be insufficient continuity of care. This can mean worse health outcomes.

There are several ways to tackle shortages in the social care sector, particularly for long-term care (LTC) (Fujisawa and Colombo, 2009). First, the LTC workforce can be increased by recruiting workers from inactive or foreign populations and by developing better working conditions, trainee programmes and career structures for carers.

In the United States, between 1990 and 2000, the number of migrant registered nurses and licensed practical nurses in LTC facilities increased by 164% and 27%, respectively, while native-born nurses increased by only 23% and 84%, respectively (Redfoot and Houser, 2008). This trend is also seen in European countries such as Austria (Österle and Hammer, 2007), Ireland (Walsh and O'Shea, 2009) and Italy (Bettio, *et al.*, 2006), and in North America more generally (Bourgeault *et al.*, 2010). Productivity in the social care sector can also be increased, *e.g.* through better co-ordination of care, new smart care models and the development of new technologies to increase the autonomy and independence of the elderly.

Unlocking the social and economic potential of the elderly

There is also a strong case for unlocking the social and economic potential of the elderly by expanding their engagement in economic and social activities (Box 3.1).

However, OECD countries differ markedly with respect to participation rates of the over-65s (Box 3.1). They also differ markedly in terms of job market participation rates for this age group. While in most European countries job market participation rates for this age group are quite low, they are quite high in Japan, Korea and the United States. Canada also has quite low participation rates among the elderly, although the last 15 years have seen a significant and continuous trend increase.

Box 3.1. **Income and wealth among the elderly**

In several OECD countries household surveys can be used to relate the levels of household consumption to age groups. Based on results from these and other surveys, Deloitte reported in 2009 that US consumers aged 65+ are the most affluent of any age segment and many have multiple income sources. Consumers over 50 account for almost half of the total consumer spending in the United States. Americans aged 50+ also account for nearly half of the market share in personal insurance and pensions; transport; health; housing; and food. With 80 million baby boomers and 75 million so-called "traditionalist" consumers (those born between 1900 and 1945) in America, the changing needs and priorities for these ageing consumers are already driving major shifts in product and service consumption across industries.

Similarly, Statistics Canada reports that the vast majority of Canadian retirees give a positive report when asked about their economic well-being. Almost eight in ten believe that their financial situation is as expected or better than before they retired. Retirees aged 75 and over are significantly more likely to report positively on their economic situation than those aged 55 to 64, even controlling for variables such as level of income and debt. For example, 83% of the older cohort felt they were financially as well off as or better than expected before retirement compared with 76% of the younger group.

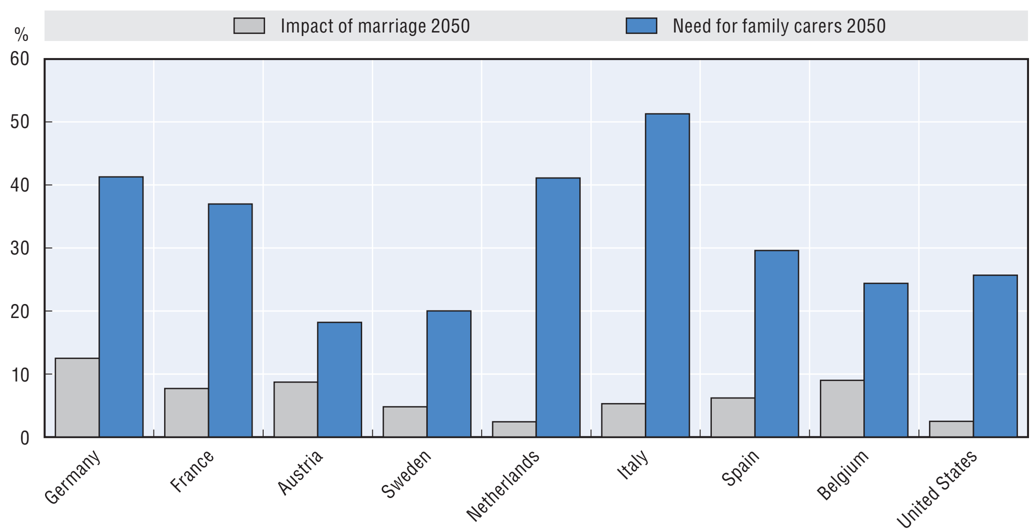
Japan's statistics shows similar trends. There are approximately 49 million households in Japan, of which about 70% are two-or-more-person households and about 30% are one-person households. Family budgets vary significantly depending on the employment situation and ages of their members. According to the Family Income and Expenditure Survey, average monthly disposable income of workers' households in 2009 was the highest in households in their 50s (USD 4 174, JPY 480 804), followed by those in their 40s (USD 4 032, JPY 467 293) and their 30s (USD 3 387, JPY 392 592).

In the short to medium term, it will be important to help employers recognise the importance of investing in the training and re-skilling of older workers and better understand their training needs. This could contribute substantially to making lifelong learning a reality. It will also be important to harness the potential of information and communications technologies (ICTs) for the development of new smart products and services to enhance elderly people's autonomy and independence and maintain and improve their active participation in social, economic and cultural life. As the share of the elderly in OECD populations grows, so will the pressure for more elderly-friendly arrangements for housing, transport, communications, access to public services and so on.

Maintaining or increasing female labour market participation is a further means of mitigating the effects of an ageing workforce. Here too the elderly can play an important role. Especially in countries with less well-developed childcare facilities, working mothers rely heavily on the informal care provided by grandparents. For example, more than half of all grandparents in France look after their grandchildren regularly and around a quarter of grandparents in Spain look after their grandchildren daily (OECD, 2011d). If grandparents are to be involved in regular childcare, they must be sufficiently healthy, active and mobile.

Figure 3.3. **The projected growth in frail elderly greatly outweighs that of potential caregivers by 2050**

Percentages



Note: "Need for family carers" indicates the change in family carers necessary by 2050 in order to maintain the existing carer/care recipient ratio. This depends on demographic trends, the existing proportions of individuals with restrictions in daily living activities (ADL) and of those providing unpaid care. A relatively high need for family carers can reflect a low proportion of family carers among the oldest old (*e.g.* Germany, the Netherlands) or a high proportion of the oldest old having ADL restrictions (*e.g.* Italy). "Impact of marriage" indicates the expected change in the availability of potential carers (spouses) by 2050. The difference between the two indicates the size of the potential care gap.

Source: OECD calculations based on population projections, the Survey of Health, Ageing and Retirement in Europe (SHARE) and the US Health and Retirement Study (HRS).

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Scientific advances and new technologies – what's in the pipeline?

Scientific advances and new technologies will help to meet the needs of ageing societies. They can help elderly individuals improve their quality of life, stay healthier, live independently for longer, and counteract the lessening of physical capabilities that become more prevalent with age. They can enable the elderly to remain active at work and/or in their community, manage their lives in their preferred environment, maintain a high degree of independence and autonomy, enhance their mobility and quality of life, and improve their access to technology and personalised integrated social and health services. In addition, new technologies can help improve conditions for people working in the care sector and therefore help to make care work more attractive in the future (European Commission, 2010).

The elderly face increased likelihood of disability or functional limitation as ageing takes place. Science and technology can help by changing the course of this "disablement process" (Verbrugge and Jette, 1994). They can: prevent pathologies through drugs, vaccines, genetic interventions, etc.; restore physiological status or organ functioning after a health shock with prostheses, implants and other devices, and treatments; and prevent disability, when a limb or organ has been lost and cannot be repaired or restored, through the use of assistive technology (AT).

Technology already contributes significantly in all three domains. Technologies now being deployed already allow better and more cost-effective care for many conditions, and more will follow. For example, cataract excision is now provided as routine ambulatory care in many countries and significantly reduces the proportion of blind or near-blind elderly (the main cause now is age-related macular degeneration); hip and knee replacement surgery, now also routine in most OECD countries, helps maintain mobility; cochlear implants address a major source of deafness among the elderly; and many assistive devices are available for the disabled, from vision-enlarging video systems and devices for translating on-screen text into Braille, to corrective communication devices for speech impairment and use of computers with the help of verbal instructions or eye movements (Emaliani, *et al.*, 2011).

Looking further ahead, as our understanding of the molecular basis of disease progresses, so will our understanding of the fundamental biological processes of ageing. Most diseases have multiple causes and genetics plays a part in almost all. Today, the genetic basis of common conditions such as cardiovascular disease, Alzheimer's disease, cancer and arthritis is the subject of active research.

Alzheimer's disease implies a high level of dependency and leads to much institutionalisation. Presently, there are no effective means of dealing with this condition. However, developments in biotechnology and the elaboration of new model systems for basic and applied research with the use of biomarkers (OECD, 2011e) offer some promise of improvements during the next decades.

In the pursuit of healthy ageing, research goes well beyond genes and recombinant DNA technology to include biomaterials and bioengineering. In the field of visual impairment (Grignon and Dunn, 2011), major advances in developing artificial retina devices and implants in the brain (the visual cortex) appear likely. In the field of bio-engineering, experiments to implant an artificial pancreas for diabetes, an artificial heart for patients with end-stage heart failure and an artificial bladder grown from stem cells have been conducted successfully. For osteoarthritis it appears increasingly feasible to regenerate joints with stem cells. To prevent hearing loss, antioxydants hold the promise of hindering cochlea degeneration. Future developments in assistive technology (optical imaging, hearing devices, voice recognition and speech disorder re-processing, etc.) are expected to be driven largely by marginal changes to adapt mainstream products to disabled individuals.

The growing promise of ICTs for healthy ageing

Many OECD countries seek to draw on the strengths of ICTs to help elderly individuals improve their quality of life, stay healthier, live independently longer, and counteract the lowering of physical capabilities that comes with age. For daily life, ICTs can facilitate social communication via phone and broadband, travel, uptake of public services, and daily shopping via the Internet. They can improve safety and make the home environment easier to manage through user-friendly interfaces. For care, they can open up new opportunities for telecare and telemedicine and improve workflows in care by integrating health and social care through information sharing, monitoring and co-ordinated follow-up.

Emerging technologies – robotics, new materials and biosensors – are expected to offer solutions in many of these areas. The emerging concept of ambient intelligence also offers great potential for giving the whole environment – at home, on the move, in the street, in transport – the means to help solve some everyday needs. ICT-enhanced equipment, processes and delivery mechanisms can help to increase the quantity, value and quality of services provided to older persons at equal or lower cost, especially for short- and medium-term health and social care. They can facilitate the tasks of informal care givers and personal assistance services.

Robotics is a difficult and challenging area of research that is making rapid progress, and a range of service robot prototypes now exist. Home security and surveillance robots monitor elderly people at home or in hospitals and nursing homes, alerting caregivers when necessary. General purpose humanoid robots can act as home companions and assistants to the elderly. Rehabilitation robots such as intelligent wheelchairs, walkers and motor-skill enhancement armatures assist elderly people who can no longer manoeuvre on their own because of cognitive, sensory or mobility impairments (Pollack, 2005). Rehabilitation robots that assist with tasks such as lifting and washing patients can reduce the physical work of institutional caregivers.

Social assistive robots are personal use robots designed to offer companionship to the elderly. The Japanese National Institute of Advanced Industrial Science and Technology (AIST) has developed PARO, a baby seal robot, for therapeutic purposes. It can talk to and entertain the user through mimic and movement (Broadbent, *et al.*, 2009; Wada and Shibata, 2007). A number of mobile assistive robots have been launched, including Wakamuru, a communications robot developed by Mitsubishi Heavy Industries; KASPAR (Kinesics and Synchronisation in Personal Assistance Robotics) designed by a UK research group (*http://kaspar.herts.ac.uk*); and Nursebot, developed by Carnegie Mellon University, which helps the elderly in their homes, a prototype of which is now ready and working (*http://hospiceandnursinghomes.blogspot.com/2011/07/meet-nursebot-pearl-robotic-assistant.html*).

The prospects for innovation in and diffusion of assistive robots are as yet uncertain. Robotic technologies have not entered the mainstream in most OECD member countries, mainly for reasons of cost and performance. Acceptance will also play a key role, and there may be significant cross-cultural differences in the acceptability of social robots, for example for providing nursing services. At first blush, Japan and Korea appear to be making faster progress in introducing social robots, but other studies (*e.g.* Bartneck, *et al.*, 2005, who surveyed respondents in China, Japan and the Netherlands) have not been able to establish a higher rate of acceptability in Asian countries. Moreover, many researchers consider that assistive robots cannot replace human interaction (Pols and Moser, 2009; Sparrow and Sparrow, 2006). Indeed, the potential of social robots is thought to reside more in a complementary role, by assisting care workers and relieving them of repetitive, arduous and often exhausting tasks (OECD, 2012; TNO, 2008).

Tracking age-related research and development activities

Owing to the multidisciplinary nature of age-related research, there are very different views of what is covered by the term "ageing research". Consequently, there are no established and reliable systems for tracking age-related research funding and projects, and information is often anecdotal at best.

The UK Wellcome Trust reported in 2005 at a hearing of the House of Lords (House of Lords, 2005), that between 1994 and 2004, it had spent 16% of its research budget (USD 855 million or GBP 547 million) on ageing-related areas. However, it had also made substantial investments in medical imaging technology and infrastructure support. If these are included, the total came to USD 1 370 million (GBP 877 million), or 26% of its budget. On a broad definition of ageing-related research this was research directly or indirectly related to ageing.

Under the European Union's Fifth Framework Programme (FP5) from 1998 to 2002, of the USD 17 billion (EUR 14.96 billion) spent on research, USD 215 million (EUR 190 million) was spent on Key Action 1 (Quality of Life) and Key Action 6 (Ageing and Disability). Framework Programme 6 (FP6), which ran from 2002 to 2006, did not have a specific heading for research on ageing and disability. Out of a total of USD 20 billion (EUR 17.5 billion), USD 1.3 billion (EUR 1.2 billion) was spent on combating major diseases, but the proportion related to ageing research is not clear.

The Seventh Framework Programme (FP7) runs from 2007 to 2013. Out of a total of USD 40 billion (EUR 32.4 billion), USD 7.5 billion (EUR 6.1 billion) are being spent over seven years on health research, including research on the health of ageing populations. An additional USD 864 million (EUR 700 million) is being spent on assisted ambient living (AAL) projects for the elderly (Zilgalvis, 2010). The funding includes contributions from the participating national programmes of the AAL partners and a maximum contribution of USD 185 million (EUR 150 million) from the European Commission.

In the United States, the National Institute on Aging (NIA) is one of the 27 institutes of the National Institutes of Health (NIH). The NIA has an enviable reputation for effective organisation and co-ordination of ageing research which is internationally acknowledged.

For the financial year 2011 the NIA had an appropriation of USD 1.14 billion, an increase of USD 32 million over the 2010 appropriation of USD 1.1 billion. One-tenth is generally spent on the NIA's intramural programme, and the rest finances extramural research in the United States and, to a very limited extent, elsewhere in the world.

Industry support for research on ageing is also difficult to measure because there is no central repository of information. Indirect evidence from a review of the literature by the Institute of Medicine in 1991 showed that 5% of research papers on ageing cited corporate support. In 1989, US pharmaceutical companies spent more than USD 3.6 billion on research and development (R&D) of drugs primarily used to treat diseases that afflict older patients (IOM, 1991). This represented 50% of the pharmaceutical industry's total R&D budget of USD 7.3 billion for that year. Cardiovascular disorders (stroke, heart disease, hypertension) consumed 39% of the reported age-related research budget; the remainder supported investigation of drugs for the treatment of cancer, arthritis and other conditions that afflict the elderly. Because most of these disorders also affect younger persons and because a significant portion of the funds went for development purposes, the proportion that specifically supported age-related research is unclear.

Better information on age-related research funding and activities is needed to allow for better planning and decision making at government level, within universities, research organisations, funding agencies and laboratories.

Harnessing the opportunities: Addressing the obstacles

The introduction and diffusion of technological advances that can strengthen older people's health, autonomy and independence will require a strong effort at several levels. It will require more investment in R&D and more encouragement of innovation. Obstacles to be overcome include: barriers to market-driven innovation; insufficient awareness of market opportunities; lack of innovation-stimulating public policies; unclear industry business models; and the high cost of technology development and validation. More widespread use of ICTs and new technologies offers huge possibilities, but the vast majority of older people are not yet reaping the benefits of the digital age. Policy has a crucial role to play in determining the future development of and demand for new technologies for healthy, active older lives.

Take a more proactive perspective

To extend the quality of life of future cohorts of older people, efforts must focus on the whole of the life course and leverage science and technology to prevent morbidity. As the World Health Organization (WHO) has noted, years have been added to life, but it is also necessary to add life to years in order to affect the demand for health and social services and make sustainable improvements in quality. This would entail, first, a refocusing of health research and services from sickness to promotion of health at all ages and from curative to preventive medicine. In most countries this would also require closer collaboration between health and social services.

Increase investments in research on ageing

There is a biomedical and social need to understand the connection between ageing and ageing-related disease, because the major burden of ill health falls on the elderly. Yet the full value and potential of ageing research has still to be harnessed because it is often believed that money for such research is better spent on other age groups. According to Alzheimer's Research UK, government and charitable organisations spend 12 times less on dementia research than on cancer research. OECD countries are well placed to address the immense scientific and health challenge that Alzheimer's presents, but their investments are not commensurate with the scale of the challenge. While USD 908 million (GBP 590 million) are spent annually on cancer research, just USD 77 million (GBP 50 million) are spent on dementia research (Luengo-Fernandez, *et al.*, 2010). Yet a recent report on R&D in the United Kingdom shows that dementia affects 820 000 people in that country, as well as their families and carers, and costs the country USD 38.5 billion (GBP 23 billion) a year in care costs and lost productivity. This is twice as much as the cost of cancer, three times as much as heart disease and four times as much as stroke. Investment in prevention and treatment of disease in old age can reap rewards by lowering morbidity, decreasing disability rates, reducing the burden of care both for formal and informal (family) care, and it can promote the active participation of the elderly in the market and workforce.

Encourage strategic alliances

Strategic alliances among industry, academia and government are needed to promote the development of interventions that target the ageing process and associated age-related diseases. Urgent action is also needed to develop collaborative international relationships that can enhance knowledge development and the diffusion of new products and ensure that differences in national regulations on clinical and population research and the clinical testing of new medicines do not hinder these efforts.

Make advanced medical technologies for the elderly available

Clinical technology is changing rapidly and investments in this area are significant. Many forces promote the acceptance of new clinical technologies and can lead to their early acceptance. Technologies that specifically support the elderly and the disabled are not developed nearly so rapidly. Governments have not been much involved in this field, and industry has generally shown little interest. In recent years, a number of countries have tried to stimulate such developments. Such efforts need to be expanded.

Understand that technology is both technical and social

With regard to research and development opportunities, it must be kept in mind that innovation in any field requires recognising that technology is both technical and social in nature. This means that research programmes should be designed and operated according to some basic principles: user involvement in research and technology development, integration of social research and trans-generational design principles, and interdisciplinary programme structures (European Technology Assessment Network, 1998). What is needed is a new awareness of the social character of technology. All technology is social, and the social dimension of technology is very powerful (Felt and Nowotny, 1992). Technology needs people and people need technology, but its application requires training and the development of the necessary skills.

To conclude, recent years have witnessed a shift in perspectives on ageing towards a more systemic, indeed holistic, view of its implications for society more generally. A strong case can be made for considering the issues surrounding the future role played by science and technology in ageing societies in a far broader context than that of health and disability. Education and learning, housing and urban/rural development, mobility, welfare systems and the world of work are just some of the additional dimensions that deserve more attention. At the same time, the collective ageing process itself is certain to influence the science, technology and innovation landscape of the future, opening up further interesting avenues for research and for policy consideration. It is expected that at least some of these future issues will be examined in new OECD work proposed for the period 2013-14. Eventually, however, there are likely to be further calls for a broader-based, systematic effort to explore the rapidly changing world of ageing societies and their interface with science, technology and innovation.

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PART II

Chapter 4

Innovation for development: The challenges ahead

This chapter addresses three related aspects of innovation for development in developing and emerging economies. Why is it important for emerging and developing countries to encourage innovation? How can innovation affect social inequalities ("inclusive development")? How can emerging and developing countries seize the opportunities offered by globalisation to harness innovation?

In discussing the role of innovation for development it shows that innovation plays a fundamental role as a driver of growth and as a means of addressing social challenges. Notably, building up innovation capacity, promoting niche competences and gaining competitiveness in frontier industries are objectives that support growth. It looks at inclusive innovation and the implications for different groups in the society, with attention to innovative products for and by middle- and low-income households and the effects of innovation on productivity differences and inequality.

The implications of the global context for these countries' innovation objectives are also considered. While openness offers opportunities to tap into global knowledge stocks, the development of innovation capacity in national industries requires supportive policy measures. The discussion also addresses trade-induced specialisation patterns and the question of industrial policies.

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.

Introduction

The recent economic crises have drawn increased attention to a change in the world economy: emerging countries are playing a much more prominent role (Chapter 1). While the BRICs (Brazil, the Russian Federation, India and the People's Republic of China) have received the most attention, other Asian countries and regions of Latin America and Africa also enter the picture. However, it is not always easy for these countries to maintain their dynamism, as they face substantial unresolved socioeconomic challenges and many barriers to industrial development.

The OECD's Innovation Strategy identified three areas that will be significant for developing and emerging countries: *i)* the importance of innovation for growth and for addressing socioeconomic challenges; *ii)* the need for innovation to contribute to well-being across the whole of society ("inclusiveness"); and *iii)* the need for openness to foreign sources of knowledge (OECD, 2010).

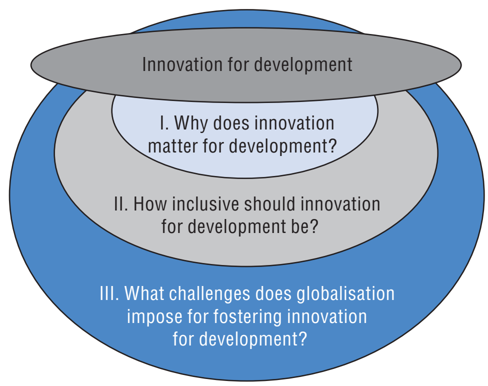
One of the important lessons of the past two decades has been the pivotal role of innovation in economic development (Bernanke, 2011). The build-up of innovation capacities has played a central role in the growth dynamics of successful developing countries, and a few emerging countries have demonstrated their capacity to be internationally competitive innovators. They have recognised that innovation is not just about high-technology products and that innovation capacity has to be built early in the development process in order to possess the learning capacities that will allow "catch-up" to happen. Moreover, they need innovation capacity and local innovations to address challenges specific to their local contexts (*e.g.* tropical diseases). Ultimately a successful development strategy has to build extensive innovation capacities to foster growth.

Public promotion of innovation in emerging and developing economies will require strong justification as public resources are scarce and poverty is widespread. Substantial inequalities also shape the opportunities of different groups in society. Innovative products targeted at and produced by low- and middle-income households can help address inequalities in opportunities. Moreover, many developing countries possess a small group of innovators while the vast majority of firms and individuals lack even basic innovation capabilities.

In developing their innovation strategies countries have to take account of today's globalised world. The disappointing innovation performance of certain countries that have substantially opened their economies to foreign competition has demonstrated that globalisation alone does not stimulate innovation. It has indeed been argued that trade-induced specialisation patterns can restrain opportunities for innovation if they lead countries to specialise in low-technology sectors or to compete on costs alone. A number of conditions, notably on the institutional side, have to be met for countries to climb up the value chain.

The following pages first examine the role of innovation for development. The discussion then turns to inclusive innovation and the implications for different groups in the society. Next, the implications of the global context for countries' innovation objectives are considered. Hence, a number of important aspects of the connection between innovation and development are not covered as such (*e.g.* the role of human capital, of information and communication technologies [ICTs], of the institutional context). What the chapter does is to bring together the main issues and pieces of evidence regarding central questions in the field: what the role of innovation is in development processes; what its impact is across different groups in society; how its main source (foreign knowledge) can be efficiently mobilised (Figure 4.1).

Figure 4.1. **Overview of core themes discussed**



The relevance of innovation for development

Innovation matters for developing and emerging economies

As part of the broader policy agenda, innovation helps to drive economic growth and address socioeconomic challenges (*e.g.* poverty and health). Many growth-enhancing innovations also address social challenges. For example, poverty-related effects can substantially influence opportunities for engaging in entrepreneurial activities (*e.g.* ill health reduces the potential productivity of workers), so that addressing social challenges can also encourage growth processes. In India's Green Revolution of the 1960s, innovation led to the introduction of high-yield varieties and seeds and increased use of fertilisers and irrigation and this resulted in a substantial increase in grain production. This not only raised agricultural productivity but also directly addressed food scarcity among the country's poor.[1]

Innovation is important at all stages of development; specifically the creation and diffusion of technologies matter for economic growth across all economies. However, it is also true that different types of innovation play different roles at various stages. In earlier stages, incremental innovation is often associated with the adoption of foreign technology, and social innovation can improve the effectiveness of business and public services. High-technology R&D-based innovation matters at later stages of development, when it is both a factor of competitiveness and of learning (which allows for completing the "catch-up" process). Table 4.1 provides a schematic overview of various aspects of innovation for various categories of countries. Depending on the support mechanisms used, the types of innovation and the main agents involved differ somewhat.

In spite of its demonstrated benefits for meeting the immediate and long-term developmental goals of emerging and developing countries, the relevance of innovation for these countries is sometimes questioned. Such thinking is often based on a fairly restricted understanding of innovation as high technology. It is true that an exclusive focus on high-technology industries ("high-tech myopia") can be costly if the potential for innovation in other sectors is ignored (OECD, 2011a). Countries can incur high costs without reaping any benefits if they choose sectors that require expertise they lack and are internationally highly competitive. Yet, innovation takes place in different sectors including services, agriculture and mining (OECD, 2010). Many opportunities for innovation have arisen in lower-technology sectors with high export opportunities, *e.g.* the production of palm oil and derivative products in Malaysia. Also, innovation in agriculture is particularly relevant for addressing socioeconomic challenges and fostering growth at the same time. There is evidence that agricultural R&D has a greater impact on poverty reduction than most other public investments (Thirtle *et al.*, 2003).

Table 4.1. **Why innovating is important for developing and emerging countries**

Country category	Mechanism/objective of innovation	Type/source of innovation	Main agents involved	Evidence/example
Developing/ low-income countries and emerging and middle-income countries	**Adoption requires adaptation:** Innovation needs to respond to specific "local" conditions for outcomes.	Incremental innovation based on foreign innovations and technologies.	Universities and research institutes, leading private businesses, esp. those with exposure to foreign markets and businesses.	New plant varieties for agriculture. Efforts at developing new methods for mineral extraction in the Chilean copper industry to satisfy local needs (Box 4.5).
	Inclusive innovation: for/by low- and middle-income households to improve welfare and access to business opportunities.	Incremental innovation based on foreign technology and/or local, traditional knowledge generated "out of necessity". Social innovation helping to introduce technical innovations in communities.	NGOs, small firms, public and private associations engaged in disseminating knowledge via networks, private, often large businesses.	India (nano cars; grassroots innovation). Mobile banking services. See also examples of Box 4.2.
Mainly middle-income countries but also some opportunities for developing / low-income countries	**Build up innovation capacities** that will be key for reaching the world technological frontier in many industries, esp. relevant to avoid "middle-income traps".	Incremental and radical innovation capacity to compete with leading world innovators.	Requires full development of innovation systems involving diasporas as a connector.	Korea increased R&D in the 1990s.
	Address environmental, health and social challenges through global innovation efforts and local efforts to address them.	Major innovations and scientific research conducted in global partnerships but also marginal innovations to address welfare of poor people.	Public and private universities and research institutions connected to global networks. Major private businesses operating in these sectors.	Innovations concerning soil.
	Build-up niche competencies *i.e.* growth/ exports in sectors of comparative advantage.	Incremental innovations based on applying foreign innovations and technologies strategically to support industrial development.	Public institutions to address co-ordination challenges, private sector initiative including foreign companies.	Colombian and Ecuadorian flower industry. Malaysia's palm oil sector.
Mainly emerging/ middle-income countries after initial progress on dimensions above	**Climb the value ladder in global value chains**	Incremental and radical innovation capacity to differentiate contributions.	Involves private sectors with support from public agents, intermediaries, diasporas can play a central role, large firms can be important.	Automotive industries in Malaysia and Thailand. India's software industry.
	Keep competitiveness in frontier industries when the country is already at the frontier.	Innovation is identical to developed countries exposed to developments in the global market.	Involves mainly private sector in interaction with public research institutions and universities, global partnerships often equally of relevance, role of large firms.	Brazilian company Embraer as well as leading R&D firms from emerging economies (see Table 4.2).

Some emerging and developing countries do emphasise their support for a number of high-technology sectors, in part owing to national security concerns. Yet in very large countries such as China or India, certain areas can be very advanced despite the average backwardness of the economy. In fact, a number of corporations from emerging countries feature among the largest global and most competitive R&D spenders. In addition, such countries need to innovate in order to "catch up" with the global knowledge frontier.

Innovation is needed for adoption and for learning

Innovation matters even in least developed countries with backward industrial conditions. Their adoption of foreign technologies will have high payoffs, because technology adoption requires adaptation to local economic, technological or environmental conditions. This requires innovation capabilities. There is evidence that domestic innovation played a bigger role than imports of knowledge for the take-off of emerging Asian economies (Ang and Madsen, 2011).

The value of starting from imported novelties in order to advance has long been known. The notion was popularised by Gerschenkron (1962), who believed that differences in nations' ability to develop technology and adapt it to their particular circumstances were the primary cause of countries' differences in per capita income and that the ability to appropriate the innovations of others was the essence of the latecomer's advantage.

Incremental innovations in activities beyond "knowledge-intensive" sectors can offer substantial opportunities for success. Examples include the successful exports of fish from Uganda, wine from Argentina and Chile, and medicinal plants from India. In the initial stages technology adoption with minor innovations can be profitable and successful (Acemoglu *et al.*, 2006). Korea, Chinese Taipei, Singapore and Hong Kong, China, started from an initial stage of development based on technology learning and maintained a strong emphasis on building innovation capacity as they moved gradually towards higher and leading technologies.

The situation for middle-income economies is different. They often have an industrial base and a set of core framework conditions for innovative firms. They have often already addressed the initial challenges for adopting novel technologies but they often face what has been called the "middle-income trap". In order to make further progress these countries need to raise their innovation capabilities. This "second stage" of the process will require developing innovation-related strategies to reach convergence with developed countries. To achieve full catch-up these countries must innovate.

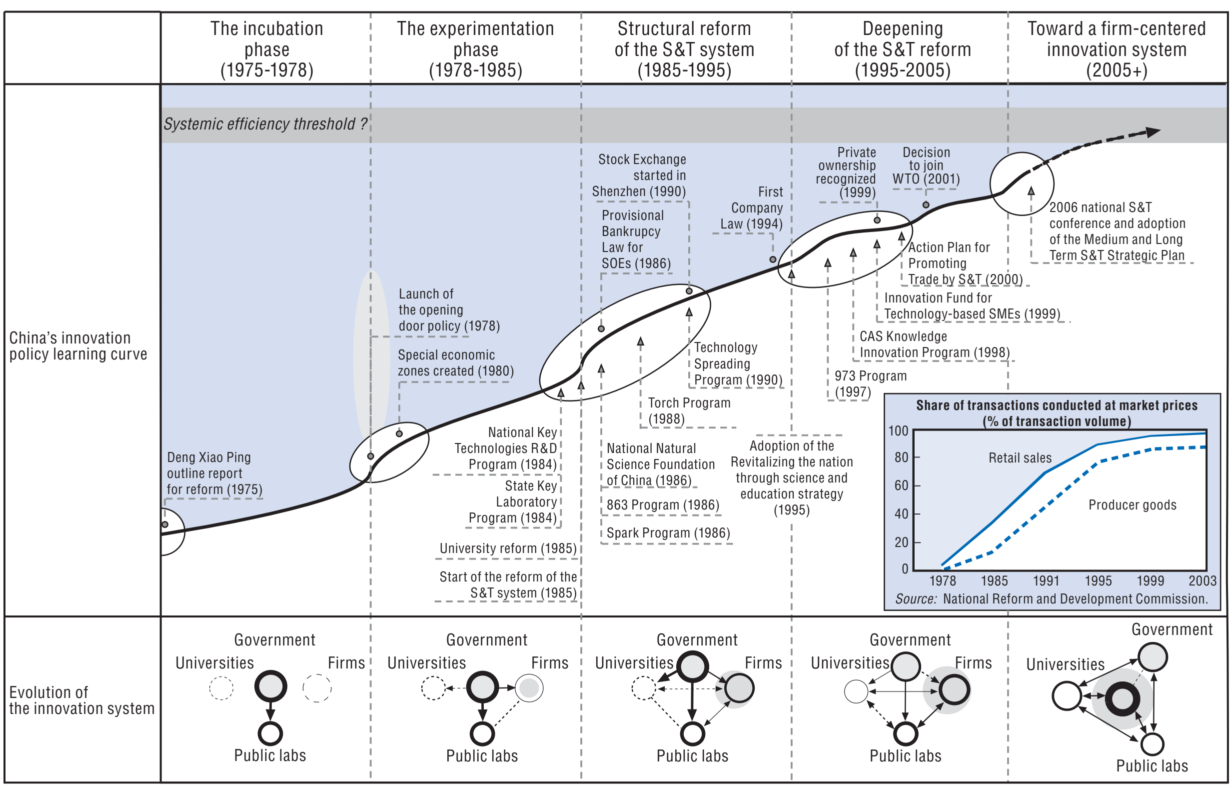
An emphasis on innovation policies at all stages of development matters since governments must also engage in a learning process in order to build the institutions and competences needed to play their role at the core of the emerging national innovation system. Box 4.1 and Figure 4.2 give the example of China's development over the past four decades.

The first policy implications that can be drawn from these observations is that innovation matters in all contexts, including in low-income countries, and should not be off the agendas of developing and emerging countries and donors.[2] It is also important to adopt a more "pluralistic" view of innovation: in terms of objectives, of content or of processes, innovation is extremely varied (*e.g.* in connection with the level and orientation of socioeconomic development) and policies must be adapted accordingly.

Box 4.1. **Changes in innovation systems in the development process: The case of China**

In the initial phase, much of the innovation activity in China tended to be concentrated in public laboratories financed by the government. The private sector played a marginal role and had limited innovation capabilities in terms of R&D-type technological investment. Private businesses often lacked the scale and human capital base to innovate and suffered from unfavourable market conditions. This type of context characterises developing countries. The private sector plays a more prominent but still not a central role as is the case in middle-income economies that have done some catching up and have evolved towards more private firm-centred systems of innovation as in the most advanced economies. In the case of China this went hand in hand with an innovation policy learning curve – an issue to be discussed further below. Figure 4.2 describes these developments.

Figure 4.2. **China's innovation policy: institutional reform and learning curve**



Source: OECD (2008), *OECD Innovation Policy Reviews: China*, OECD, Paris.

Successful innovation performance is not restricted to developed countries

Several emerging economies, and China in particular, have become significant actors in the global innovation system. There is evidence that R&D played a key role in the take-off of Asian economies such as China, India and Korea (Ang and Madsen, 2011). What is more, many emerging economies have industries or firms that are at the technology frontier and need to innovate to compete. In the EU R&D Scoreboard, which lists the world's top 1 400 R&D-investing companies, more than 100 were from emerging and developing economies in 2011, including Chinese Taipei (50), China (19), India (18) and Brazil (9). Others were from Malaysia, the Russian Federation, Singapore, South Africa and Thailand (EC, 2011). Table 4.2 lists the top 15 firms from emerging economies based on their R&D investment.

Table 4.2. **Top 15 firms from emerging economies in terms of R&D investment, 2011**

No.	Firm	Sector of activity	Economy	R&D investment (in million USD)	Employment (in 1 000)
1	Huawei Technologies	Telecommunications equipment (9578)	China	2 392	110
2	PetroChina	Oil and gas producers (53)	China	1 774	553
3	China Railway Construction	Construction and materials (235)	China	1 407	229
4	Hon Hai Precision Industry	Electronic equipment (2737)	Chinese Taipei	1 314	n.a.
5	ZTE	Telecommunications equipment (9578)	China	1 188	85
6	Taiwan Semiconductor Manufacturing	Semiconductors (9576)	Chinese Taipei	1 006	33
7	Petroleo Brasiliero	Oil and gas producers (53)	Brazil	980	80
8	Vale	Mining (177)	Brazil	867	71
9	MediaTek	Semiconductors (9576)	Chinese Taipei	789	5
10	Gazprom	Oil and gas producers (53)	Russian Federation	781	393
11	China Petroleum and Chemicals	Oil and gas producers (53)	China	724	373
12	HTC	Telecommunications equipment (9578)	Chinese Taipei	438	13
13	Tata Motors	Automobiles and parts (335)	India	413	n.a.
14	CSR China	Commercial vehicles and trucks (2753)	China	366	80
15	Wistron	Computer hardware (9572)	Chinese Taipei	335	n.a.

Source: EC (2011), "Monitoring industrial research: the 2011 EU Industrial R&D investment Scoreboard", European Commission, Luxembourg.

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Similarly, businesses from emerging economies have increased their patenting activities (see Figure 1.17 of *OECD STI Outlook 2012* Chapter 1 and the discussion on global innovation leadership trends) and their researchers contribute more to scientific publications.[3] Increased participation in global innovation networks is evident in China's (but also, to a lesser extent, India's, Brazil's and Russia's) increased share of co-authorships with leading OECD economies, in particular the United States (Figure 4.3). On the input side China's substantial R&D budget is noteworthy (Figure 4.4).

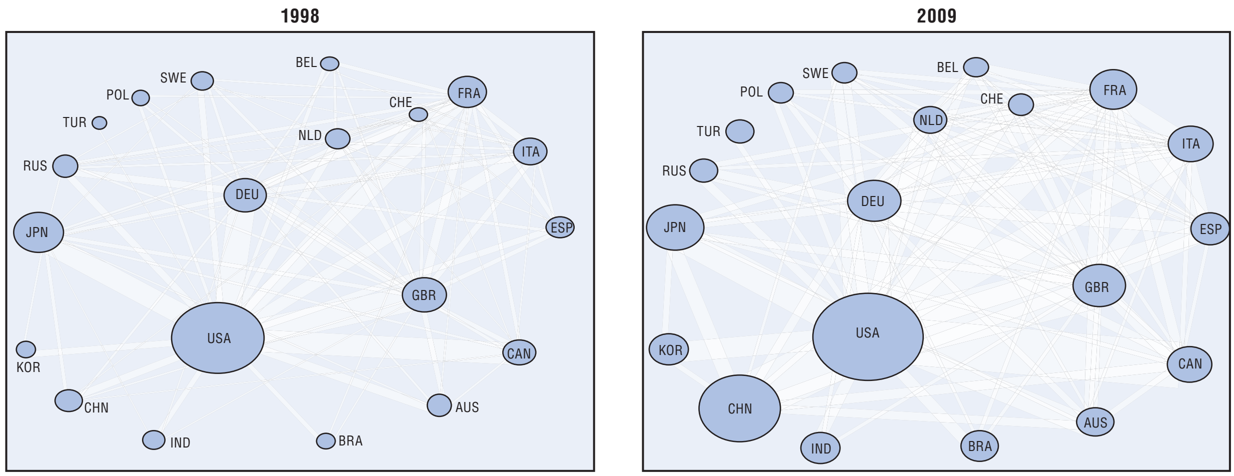
The present offers opportunities for successful innovation experiments

Several developments may offer opportunities for developing and emerging economies to engage in innovation:

- As some emerging countries become more innovative, opportunities for new entrants are created. The vertical fragmentation of value chains and the consequent division of labour in East Asia seems to have increased as other countries (Cambodia, the Philippines, Vietnam) take over lower value activities from China (the "flying geese" development model). Chinese firms' investments in Africa have also altered local business opportunities. The increase in South-South co-operation activities is another factor (*e.g.* the International Science, Technology and Innovation Centre for South-South Cooperation).[4] There are also potential challenges (*e.g.* the potential impact on innovation systems of China's manufacturing sector's growing demand for primary inputs).

Figure 4.3. **Scientific articles and co-authorship, 1998 and 2009**

Numbers based on whole counts



Notes: The area of the bubbles reflects the number of scientific publications and the thickness of the link indicates the intensity of the collaboration *i.e.* co-authorship.

Source: OECD (2011), *OECD Science, Technology and Industry Scoreboard 2011*, OECD, Paris; OECD, calculations based on Scopus Custom Data, Elsevier, December 2010.

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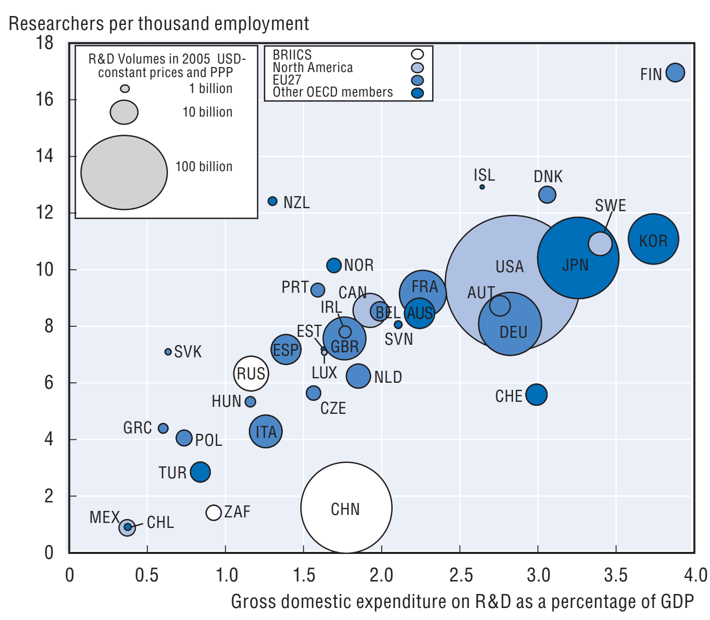
Figure 4.4. **R&D in OECD and non-OECD economies, 2010 or latest available year**



Source: OECD, Main Science and Technology Indicators (MSTI) Database, June 2012 based on OECD (2011), *OECD Science, Technology and Industry Scoreboard 2011*, OECD, Paris.

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- Information and communication technologies (ICTs) offer many new opportunities for connecting to global innovation networks and also as sources of innovation (Trajtenberg, 2005).
- Global value chains offer a potentially different framework for development. Countries such as Korea industrialised early through the development of vertically integrated industries (which produced both intermediates and final products). Countries that start to industrialise today may choose a different development path and specialise in specific activities. Sequentially upgrading value chains will likely require rethinking industry policy and the role of government.[5] To date, however, most discussions of innovation have not dealt with such trajectories.
- Increasingly, service-based economies call into question manufacturing-based development strategies. "Dematerialised" innovation (*e.g.* product design) is more relevant today for countries' positioning in global value chains. However, it is also argued that a manufacturing basis is still necessary for development. To date no country has developed without one. The differential growth paths of China, which focuses strongly on its manufacturing base, and India, which has focused on information technology (IT) services, among others, might offer insights on the question.
- Greater openness to trade and foreign direct investment (FDI) in the context of international treaties necessarily creates a very different context from that of the past. Many developing and emerging countries are members of the World Trade Organization (WTO) and must comply with the rules imposed on trade policy.

Inclusive development and innovation

The previous section identified the importance of innovation in very different development contexts and the need for innovation policies to support the development of developing and emerging countries. Their policy design requires setting specific priorities and objectives. An important question in this respect is the extent to which innovation policy should contribute to inclusive development. It is an important question for developing countries because social and economic exclusion results in potential sources of conflict as well as extreme poverty. Moreover, the informal economy, a direct consequence of economic exclusion, often plays a non-negligible role. Considering these activities within the reach of innovation policies could magnify the latter's impact. This section therefore focuses on the question of inclusive development and innovation.

While countries' priorities differ, a source of rising concern for many has been the recognition that the growth process is insufficiently inclusive. Beyond well-known differences across countries, within-country inequalities in living conditions, income and capabilities exist across regions, economic activities and social groups but also within each of these groups. Inequalities are often much greater in developing and emerging economies as the gap between the most advantaged and the most disadvantaged is wider and as those at the bottom of the distribution face more extreme living conditions than those in developed economies.

The concept of inclusive growth often figures prominently in political debate: for instance, the government of India's 11th Five-Year-Plan (2007-12) focuses not only on sustainable growth but also specifies the reduction of economic disparities as its key objective. South Africa is another example of a country in which reconciling efficiency and equity is a fundamental priority in every sphere of policy and therefore affects any potential trade-offs in terms of excellence *vs.* efficiency. In China the regional dimension is very present in discussions of inequalities. "Innovation" is related to "inclusion" in the following ways:

- First, "inclusive innovation" can provide solutions for reducing gaps in living standards between the richest and poorest groups in society. Such innovations typically consist in obtaining cheaper (often simplified) versions of existing devices for purchase by lower-income groups ("frugal innovation" or "innovation for low and middle-income groups").
- Second, some innovations facilitate grassroots entrepreneurship and could help integrate previously marginalised groups into circuits of economic activities ("innovation by low- and middle-income groups").
- Third, firms do not engage in innovation to the same extent. Differences among firms' innovation activities and use of new technologies translate into substantial productivity gaps. The resulting inequalities in wages have an impact on the distribution of income ("innovation and its impacts on low- and middle-income groups").

The first two concepts describe inclusive innovation activities. Inclusive innovation differs in nature (*i.e.* products and processes targeting lower-income groups) and in its source (*i.e.* produced by lower-income groups). The third is more concerned with the socioeconomic impacts of all types of innovation that affect welfare across different groups in society. Income inequality is one proxy for such differences.

The priority to be accorded to inclusiveness needs to be discussed, particularly if policy approaches require a trade-off between pursuing economic growth and inclusive development. In a cross-country study, Kraay (2004) found that a rise in average incomes explains 70% of the variation in poverty reduction in the short run and as much as 97% in the long run. Hence, economic growth can be a powerful tool for combating poverty, but this is not necessarily the case in all countries and at all time periods. Moreover, inequalities might only arise temporarily as economies develop (although the evidence on increased inequalities in developed countries does not fully corroborate this hypothesis). Even if inequalities occur temporarily they can be countered by targeted policies. Also, it might be argued that endemic poverty should have higher policy priority owing to its serious impact on well-being, including starvation and human rights abuses, among others.

Innovation for and by middle- and low-income groups

Innovations for the "bottom of the pyramid"

Inclusive innovation is about harnessing science, technology and innovation know-how to address the needs of those at the "bottom of the pyramid", especially in rural areas, improve their quality of life and reduce social disparities. Many innovations, especially those that address the health and nutritional needs of the poorest, can improve their living conditions substantially, although price remains an issue. Inclusive innovation can boost the welfare of the poorest by providing products of lower quality – often cheaper, simplified versions of more sophisticated goods – that are accessible to a wider share of the population. Innovation can in that way help provide opportunities in addition to the two well-known traditional approaches for doing so: redistributive policies and international aid. Box 4.2 provides examples of such innovations. An attractive element of this approach is the idea that this may create a market for private businesses and thus be self-sustaining.

It is unclear, however, how sustainable such business models would be. There is the question of scale and whether investing in the lower-priced good for sale to consumers with low incomes and to the emerging middle class would be worthwhile. Businesses might hesitate to produce lower-priced versions of existing products if it meant loss of sales of the higher quality product (even more affluent consumers might switch to the cheaper product and market discrimination might be difficult). Finally, low incomes probably restrict opportunities for such innovations to a few key sectors such as health and food. So far, inclusive innovation has consisted in the adaptation of technologies mainly from developed countries. Many products have also been invented in developed countries, often by non-profit endeavours aimed at addressing social challenges.

Box 4.2. **Examples of inclusive innovation**

Eyecare Hospital. India's Aravind Eyecare Hospital has done unique "workflow innovation" to avoid needless blindness for over 2 million patients so far. Cataract surgery, which costs around USD 3 000 in advanced countries, is done for around USD 30-300, with the exact price determined by the capacity to pay. The quality compares with international benchmarks. Aravind Eyecare performs around 200 000 to 300 000 operations annually.

Nano Car – physical mobility with safety and comfort. India's Tata Motors created a people's car, the Nano. It is the cheapest car in the world that meets high standards of fuel efficiency (25 km/litre), environment (Euro IV standards), safety and comfort. It is priced at only USD 2 000.

Computer-based functional literacy. People are poor because they are illiterate, and they are illiterate because they are poor. An Indian company has developed a technique called computer-based functional literacy (CBFL) for teaching an illiterate individual to read a newspaper with only 40 hours of training at a cost per individual of only USD 2. There are 800 million illiterates in the world; this technique could make them all literate for less than USD 2 billion.

Bici-Lavadora. The Bici-Lavadora (a MIT D-Lab USA project), is a portable, pedal-powered washing machine. With an estimated prototype price of USD 127, this innovation stands to increase greatly the productivity of washerwomen and bring some of the benefits of an appliance often taken for granted elsewhere in the world at low cost and without reliance on electricity.

MoneyMaker Irrigation Pump. The MoneyMaker Irrigation Pump designed by KickStart International (NGO) in Kenya helps poor families become self-sustaining through small-scale farming. These low-cost (USD 100) pumps are sold in local shops and enable poor farmers to move from rain-fed agriculture to irrigated commercial farming. On average farmers increase their annual incomes by over USD 1 000, an increase which raises families out of poverty. The pumps are foot-powered and have a maximum pumping height of 46 ft. and a daily irrigation capability of 1.25-2 acres. They can significantly increase the yield and crop diversity available to small farmers. With over 153 000 pumps sold (by January 2010), and 97 500 business created, KickStart estimates that the pump has lifted 488 000 people out of poverty.

Source: R. Mashelkar and V. Goel (2010), "Inclusive Innovation: More from Less for More", draft.

Grassroots innovations

The second meaning of inclusive innovation, "grassroots innovation", is innovation by low- and middle-income groups. It often involves either traditional knowledge (agriculture, craftsmanship) or an adapted use of modern technology that most people can afford (mobile phones are the archetype). There is often value in local innovations that are born out of necessity and can help improve living standards more than some technical innovations. Gupta (2006) emphasises such processes in the context of the Honey Bee Network, developed in India. The network aims at collecting such innovations and connecting them to scientists, researchers as well as other farmers who might directly benefit from them.

A different aspect of the grassroots or frugal innovation debate is whether this can enable the entrepreneurship that would allow the poor to improve their living standards and incomes. On this issue the role of mobile communications has been widely noted and a couple of business models have been identified. Mobile banking opportunities and other mobile applications have generated activities that were previously difficult to carry out. While there are many interesting case studies it is not clear how substantial the potential aggregate impact could be (Aker and Mbiti, 2010). Many groups at the bottom of the pyramid are excluded from the formal economy and operate on rural markets that are poorly serviced, dominated by the informal economy and relatively inefficient. If new tools can enable these groups to integrate the formal economy they would do more than marginally improve their well-being: they would stand a higher chance of sharing in future growth dynamics.

A central goal for an inclusive innovation agenda, then, is to see whether it is possible to scale up innovations done in "laboratories of life". So far such achievements have been isolated in terms of their scope and impact. It needs to be seen whether public funding, public support policies and/or an effective innovation chain can help support such innovation. Grassroots innovation can also play a potentially much more substantial role for developing and emerging countries by serving as a bridge between the informal and formal sectors of economies. Moreover, grassroots innovation can significantly facilitate the adoption of innovations: local adjustments and social acceptance are often needed for technologies to be used and thus to improve well-being.

Producers: productivity and income dispersion

Higher dispersion of productivity in developing countries on the producer side

Substantial inequalities are prevalent in development processes of "modern" sectors, as well. For example, Lach *et al.* (2008) describe how Israel's ICT sector failed in the 1990s to support economic growth beyond its own contributions (*i.e.* there were no spillovers to the rest of the economy) and remained an "island of excellence". Substantial differences also exist within industries in developed countries (Syverson, 2004). For the United States, the evidence shows that in the same industry the plant in the top 10% of the productivity distribution makes almost twice as much output with the same measured inputs as the plant in the bottom 10% (Syverson, 2004). That is, firms operating less efficiently owing to outdated technologies co-exist with highly efficient frontier firms with up-to-date leading technologies. The aggregate cost to the economy is substantial.

Such inequalities are even more marked in developing and emerging economies. Hsieh and Klenow (2009) show that if the dispersion of total factor productivity (TFP) across Indian and Chinese manufacturing plants could be reduced to the level of dispersion in US manufacturing plants, between a third and a half of the gap in aggregate TFP between the United States and these economies would be reduced. Latin American economies similarly have very large dispersion of TFP within sectors (IADB, 2010).

The lack of "inclusiveness" (*i.e.* wide dispersion of productivity and income) is a fundamental reason for the lack of convergence between developing and developed countries. A McKinsey Global Institute (2001) report on India examined the main sources of inefficiency in a range of industries in India. In some of these industries (dairy processing, steel, software) better firms were using more or less global best-practice technologies wherever they were economically viable. The latest (or if not the latest, relatively recent) technologies were thus available in India. Banerjee and Duflo (2005) argue that it is not the case that developing economies suffer from overall technological backwardness but rather that in the same country some use the latest technologies while others use more obsolete modes of production. The question that arises is that of within-country rather than cross-country dispersion. In fact, now a majority of the world's poor actually live in middle income countries.

Such differences are probably even more pronounced for innovation performance, at least when the focus is on traditional indicators such as R&D investments and/or patenting. An increasing number of developing and emerging country firms are responsible for major R&D investments and tend to account for the bulk of national investments. Such "islands of excellence", however, do not represent the majority of firms and fail to produce the overall transfer and dissemination that would boost overall performance.

Innovation as a driver of inequalities

Technological change is one of the factors behind increases in wage inequalities. Wage inequalities for workers with different skill levels have occurred not only in several OECD countries (notably the United Kingdom and the United States) but also in developing and emerging countries (OECD, 2011b). They are substantial among firms even within industries.

Scale is also an important factor of productivity in innovation-intensive activities, and in fact innovation is often driven by large firms in both developed and developing economies. As a result, certain economies will have a small number of large, high-productivity, innovative firms surrounded by many small, low-productivity firms, often in the informal sector. Inequality sometimes seems effectively to be the price to pay for competitiveness due to scale advantages, but it is by no means inevitable (Box 4.3). However, market power, which is often associated with scale, can also reduce incentives to innovate. Moreover, scale may not matter equally for different types of industries and innovation projects. Certain small firms have much larger innovation potential than larger businesses, which may face greater internal resistance to change. With insufficient market competition they may rely on rents and hamper innovation.

Box 4.3. **Scale constraints and inclusive development**

There are examples of inclusive and exclusive industrial development. Bangladesh's food processing sector is increasingly based on large-scale processing industries at the cost of home-based businesses (World Bank, 2006). It is the lack of scale which makes the adoption of technologies less useful to small businesses and constrains their efficiency. Since big firms have not absorbed large numbers of workers the industry is not inclusive.

By contrast, Malaysia's efforts to develop successful palm exports were part of an economic restructuring effort aimed at alleviating poverty and inequality. It took place following a land scheme which allocated land to small-scale producers. To ensure efficiency (which in this case also required substantial scale) centralised management of the production processes of the various small-scale producers was implemented. The process has therefore been much more inclusive than in Bangladesh's food-processing sector, as joint operations are the response to the scale constraints of smallholders.

A similar type of distribution characterises the cultivation of medicinal plants, which became at the end of the 1990s, with the rise in international demand for herbal products, an increasingly attractive export sector for Indian producers. The structure of the sector is a pyramid: tribal communities in forest areas do most of the planting and count on a few alternative livelihood opportunities; at the bottom, small, family-owned businesses manufacture and sell the products locally. Only a small number of large pharmaceutical companies in India operate in international markets. In this case ensuring that all groups share in the industry's growth is a challenge.

Source: World Bank (2006).

The impact of inequalities on innovation-based growth

Redistribution might be an alternative way to reduce inequalities if these are instrumental for growth.[6] The argument here is that inequalities are supportive of growth because growth-enhancing investments need savings. The rich have a higher marginal propensity to save than the poor so that transferring income from the poor to the rich can foster capital accumulation and bring about a higher steady-state level of capital and output per workers. Consequently, more inequality fosters growth.

However, there are opposing arguments: in the presence of credit market imperfections the lack of access to capital can reduce investments in human capital. Talented individuals who would benefit from further education are excluded and only those with financial resources have access to it. Also, if talented but low-income entrepreneurs have limited access to financing, potentially successful projects cannot be realised. Moreover, inequalities can lead to conflict, corruption and policy making that is much less focused on fostering growth.[7] Since capital market imperfections are greater in emerging and developing countries, the downsides to inequality described here are likely much larger than in developed countries. Finally, inequalities produce greater scope for discrimination across gender, ethnicity or other criteria and can produce costs to the economy when resources are not allocated in line with talent.

An interesting case study that would suggest the advantages of lower inequality for growth compares Korea and the Philippines. They had similar macroeconomic indicators in the early 1960s – GDP per capita as well as investment and savings – but substantial differences in inequality. Korea was a much less unequal society in terms of income and grew much faster than the Philippines (Benabou, 1996). Policies aimed at creating a "level playing field" should therefore contribute to growth by enabling a better allocation of talent.

Explanations for inequalities among producers

A lack of competition can be a leading source of productivity dispersion. Competition can foster more efficient allocation of resources because it leads to the contraction or exit of inefficient businesses and the entry or expansion of new or more efficient firms. However, while competition alone may bring about the exit of inefficient producers it will not necessarily generate entry. In fact, if there is a substantial informal economy and underemployment labour will not necessarily be put to more efficient use as inefficient businesses exit. If capabilities are not widely spread, such reallocations might not lead to overall upgrading and less dispersed performance by different producers. Income inequality may even worsen if more resources are put to less efficient uses.

Other factors that help to explain inequalities and that can provide a basis for policy include:

- First, knowledge spillovers can reduce performance gaps. Policies to increase such spillovers must be careful not to destroy firms' incentives to innovate. If innovative firms are poorly integrated with local industries knowledge spillovers to other sectors might be reduced. Lach *et al.* (2008) argue that the failure of Israel's ICT sector to generate further benefits for other national firms was its strong export orientation which restricted domestic linkages. This meant that few national consumers and/or firms were direct clients of the ICT firms and benefited from their technology and knowledge.
- Second, firms have to enjoy the right framework conditions in order to respond to changes, in particular access to finance (Banerjee and Duflo, 2005). If firms cannot engage in necessary investments their only option is to delay or fail to adopt leading technologies. Various institutional factors can also affect whether firms choose to engage in high-risk activities (*e.g.* Bartelsman *et al.*, 2011).
- Third, differences in capabilities, including managerial abilities (*e.g.* Bloom and Van Reenen, 2010), and a lack of qualified workers able to deal with changing technologies and new innovations can mean that some firms adopt new technologies while others do not (Faggio *et al.*, 2010). Moreover, general purpose technologies, notably those based on ICTs, may introduce greater inequalities in the initial phase and affect the distribution of earnings until educational systems have adjusted (Galor and Tsiddon, 1997).
- Fourth, the changing nature of technology, which forces firms constantly to engage in learning processes, plays a potentially important role. Chun *et al.* (2011) posit that a general purpose technology may spread unevenly across firms and industries, with successful early adopters accumulating quasi-rents and outpacing unsuccessful adopters and non-adopters.

The discussion of inclusive innovation raises some interesting questions for policy, including issues concerning innovation in the informal sector, the role of grassroots innovation for economic development and the role traditional knowledge can play for economic growth. Some questions will need answering before policy implications can be fully drawn: Are inequalities and resulting types of innovation transitory phenomena or are they permanent? Is there a market for innovations for middle- and lower-income groups? Is public financing justified because of the positive externalities generated by such innovations? Finally, with regard to productivity differentials: what policy complementarities can support different types of firms in their innovation activities?

Globalisation

The previous sections established the importance of innovation for development and discussed the extent to which innovation can matter for inclusive development strategies. There is another "external" parameter that will shape innovation policies of developing and emerging economies: given the worldwide liberalisation of trade and FDI over the past decades, national innovation performance will necessarily depend on the global context. Moreover, global value chains and the fragmentation of production across different stages and countries have deepened globalisation by involving more countries (including emerging countries), by increasingly affecting service activities and by fostering R&D and innovation. The implications of globalisation for innovation policies are covered here.

Openness benefits innovation in various ways

There are demonstrated benefits from trade openness and FDI for developing and emerging economies' innovation performance. Briefly, five distinct sources of benefits can be identified:

First, opening national markets to foreign competitors' products is a powerful means of strengthening competition and decreasing the market power of domestic producers. Firms defend against competition by improving total factor productivity and innovation performance. Moreover, processes of "creative destruction" reshuffle productive resources from less productive to more dynamic firms and lead to aggregate improvements in productivity performance.

Second, openness facilitates access to foreign know-how and technologies. It is impossible today for any country to rely exclusively on domestic knowledge for sustainable technological upgrading and productivity growth. Accessing more advanced technologies, for instance in the form of intermediate production inputs from abroad, is all the more valuable for producers in developing and emerging economies who face a substantial technology gap (Amiti and Konings, 2007) but also for their innovation performance (Box 4.4; Almeida and Fernandes, 2008).[8] Success stories of industrial development in the Kenyan floriculture sector, the Taiwanese electronics industry and the Indian software sector point to the importance of acquiring foreign know-how, whether via foreign multinationals, consultation of foreign experts, the acquisition of foreign licences and/or imports at different stages of industrial upgrading (Chandra and Kolavalli, 2006).

Emerging economies seem well integrated in global innovation networks (Figure 4.5): joint patents with foreign co-inventors are above the world average and particularly high for Argentina, Chinese Taipei and Indonesia. Of course, size conditions these ratios, as inventors in smaller economies have a greater need to co-operate with foreign partners on patenting than those in larger economies. This partly explains the relatively modest rate for China.

Third, trade integration allows for economies of scale and specialisation. The additional income opportunity of supplying foreign markets can make efforts at technology upgrading and innovation even more worthwhile (Bustos, 2011).

Fourth, trade liberalisation can strengthen governments' commitment to reform programmes as international competition exerts pressure, for instance, on the performance of national producers (Sachs and Warner, 1995).

Fifth, trade openness leads economies to specialise in sectors with a comparative advantage and can therefore foster the welfare-enhancing restructuring of countries'

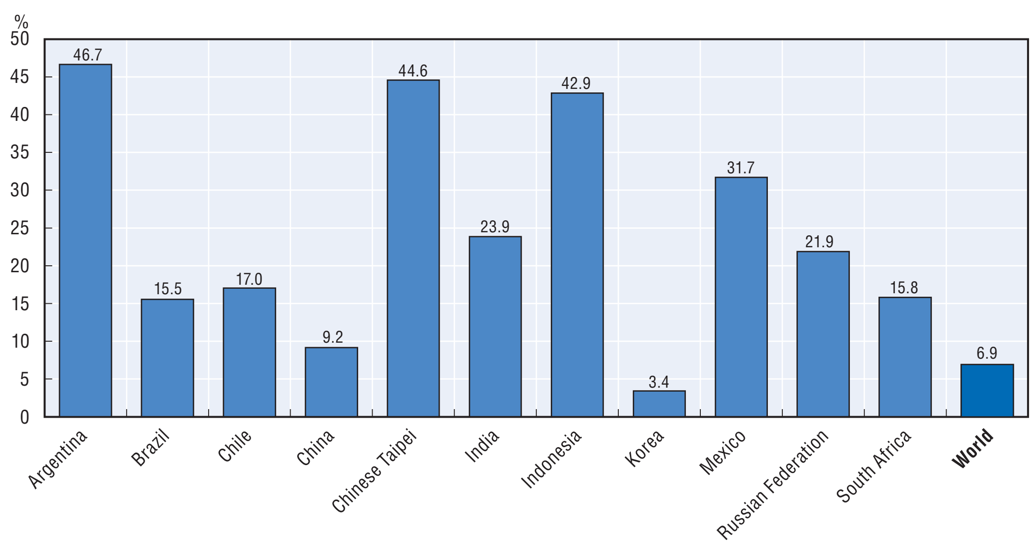
Box 4.4. **Import competition, innovation and employment: Evidence for Ecuador**

Access to imported intermediate inputs can be essential to stimulate innovation in developing countries. Innovations in products, increments in product scope and product cost reductions facilitated by imports of intermediate inputs may also stimulate employment. An econometric analysis of detailed data on firms in Ecuador finds this to be the case. Imports led to product innovation, increased firms' product scope, reduced production costs and created new employment, including for the less skilled. Increased import competition in firms' main product markets, by contrast, had negative employment effects. These impacts were apparent not only among producers in high-technology industries but also for firms in more traditional sectors. Moreover, employment effects were much stronger several years after the country's major economic crisis of 1999. Sluggish employment adjustments, in spite of a recovery of innovation performance, may also be a likely outcome in the aftermath of the current global crisis as uncertainties over the recovery persist.

Source: Paunov (2011).

Figure 4.5. **Share of patents with foreign co-inventors in selected economies, 2009**

Patents filed under the PCT by priority date in percentage



Source: OECD, Patent Database, June 2012.

StatLink http://dx.doi.org/10.1787/888932689788

production structures. The achievement of optimal specialisation patterns can, in turn, encourage innovation performance.

Global value chains and their impact on development strategies

Increasing segmentation of production processes across countries creates new challenges for traditional trade and innovation policies. First, it may offer a novel approach to development if it is no longer necessary to build full industrial production capacities to produce leading products and if specialisation in certain sub-activities would provide conditions for success. The increasingly prevalent fragmentation of production processes, as firms exploit new technological opportunities, could increase exposure to foreign knowledge and know-how. However, as it becomes easier to shift production across countries, specialisation needs to be innovative to be at the world frontier.

Second, the issue of sectoral specialisation becomes less relevant than the segment of production within sectors. For instance, countries involved in the production of sophisticated technical products such as iPods will need to move towards securing activities with higher value added (*e.g.* from product assembly to production of intermediate inputs to design). However, countries may also be locked into "modularity traps", *i.e.* activities with limited opportunities for capability upgrading (Song, 2007).

Third, multinationals and large firms are often the dominant actors. Engaging in global value chains will therefore require linking with them. Market power along the value chain and payoffs to smaller producers become important issues for the dynamics of inclusive development.

Openness alone may not suffice

Openness to trade and FDI can stimulate the build-up of innovation capacities. The impressive growth of several Asian economies is often cited in this regard. And, in spite of substantial trade reforms in the 1980s and 1990s, growth in Latin American countries has not met expectations (Easterly, 2001). At the same time, the use of diverse types of protectionism by emerging Asian economies to shield emerging industries judged to be of strategic importance from foreign competition has also been widely noted (Rodrik, 2011).

There is no statistical evidence to suggest that the trade-growth relationship is a negative one; neither has a robust positive relationship been identified.[9] Moreover, existing research suggests that more may be needed to achieve innovation-based development: *i)* firms' "learning from exporting" has been fairly limited; *ii)* firms in developing and emerging economies have benefited little from knowledge spillovers from FDI in their own industries; and *iii)* gains from trade benefit the most efficient firms but others suffer. This last aspect is particularly relevant for achieving "inclusive" growth.

Such shortcomings not only challenge the potentially powerful role of trade, they point to the need for complementary economic and institutional reforms (Chang *et al.*, 2009). Many factors can be relevant for building innovation capacity; they include providing access to finance for businesses, easing conditions for entrepreneurship, and improving access to skilled human capital. Complementary policies are critical for generating the desired benefits (Figueiredo, 2008).

Trade and "undesired" structural change: Is it bad for innovation?

Trade and "undesired" structural change

A fundamental question is whether globalisation can impede innovation-based development by resulting in specialisation patterns that offer only limited opportunities for innovation. Classical trade theory says that the payoffs from specialisation do not depend on whether a country specialises in "apples" or "computers". However, if certain sectors have dynamic disadvantages for growth (Grossman and Helpman, 1991) and/or limited opportunities for innovation and learning by doing, then innovation-based development paths might be at risk.

China's manufacturing sector's growing demand for primary inputs has renewed attention to this issue. While developing and emerging economies with primary resources obtain revenue, there is the question of whether their long-term growth prospects will not suffer if they rely mainly on production while processing industries are abroad.[10] This makes a case for industrial policies that are not "neutral" across different economic activities.

Are some industries less "innovation-prone" than others?

It is worth reflecting on whether certain industries are inherently more "innovation-prone" and offer more "learning by doing" opportunities and opportunities for technological and institutional upgrading than others. This is a central element of the "wrong" specialisation hypothesis. There is evidence of differences across sectors, such as the fact that the growth effects of openness are related to the composition of trade and, in particular, whether it is manufacturing or skill-intensive goods rather than primary products that are exported (Xu and Wang, 1999). It is also known that richer countries consume and export higher-quality products than developing countries (Hummels and Klenow, 2005), and the relationship between export quality and growth has been widely noted (Grossman and Helpman, 1991; Hausmann and Rodrik, 2003).

Industry classifications also point to differences in products' innovation potential. The OECD categorises industries as high-technology, medium-technology or low-technology, while Rauch (1999) categorises industries by degrees of possible product differentiation (and, hence, potential for product innovation). While the former classification is based on industries' R&D spending, the latter approach is based on whether products have a set price and/or are traded in organised exchanges. Cement is a classic example of a product with traditionally fewer upgrading possibilities, whereas computers arguably offer many opportunities for product innovation. However, even in the cement industry forms of innovations exist, as the Mexican multinational CEMEX has demonstrated.

Determining which sectors will be most successful and offer the most opportunities for dynamic specialisation in the future is fraught with uncertainties. An advantage for developing and emerging economies is that they can base their choices on developed economies' experience, at least if catching up rather than industry leadership is the objective. However, even if the focus is simply on the present, it is difficult to know what metrics should be used to identify the potential for "learning by doing" and for innovation. With the recognition that innovation is about more than R&D and patenting activities, questions arise as to how best to evaluate the innovation intensity of sectors. Challenges are also substantial for the services sector, which cannot be disregarded if policy is to take account of global specialisation patterns. The OECD is currently working to provide definitions of innovation intensity based on a broader set of innovation inputs, activities and outcome-related measures, such as R&D expenditures, human capital skills, organisational and marketing innovations, patents and IPR.

An industry's outputs are not only final consumption products but also intermediate inputs. Therefore, a sector's achievement will also depend on the performance of downstream industries.[11] While imports can be a useful alternative for several production inputs, they cannot fully substitute for missing or inefficient local goods and services. Local presence counts and can create complementarities across sectors. Moreover, some production inputs are not tradable, and substantial adjustments to local contexts are often needed. Imports also involve additional costs (transport, customs). Therefore, even if differences in a sector's innovation potential could be easily identified, the existence of interrelationships means that simplified categorisations are not possible.

Extractive industries figure prominently among the sectors viewed as offering few opportunities for improving local innovation capabilities. One reason is the fact that the final products are classified as low value-added activities. There is also the potential lack of a link with the other national production structures; this would likely reduce potential knowledge spillovers, for instance from foreign firms. The reason is the few employment opportunities in such industries, which are capital-intensive and tend to import specialised products and services. For innovation purposes, natural resources only benefit from the royalties generated.

However, this view has been contested on several grounds. There is the experience of countries such as Australia, Finland and Sweden which have built strong innovation capabilities from a primary resource base (which is itself now "knowledge-based"). In addition, these sectors offer opportunities for the provision of knowledge-intensive services following changes in their operations since the 1980s which have given more opportunities for outsourcing of services and equipment, *i.e.* a move away from the "enclave" prototype (Bloch and Owusu, 2011, on gold mining in Ghana).

Such positive developments have not always materialised, however. Latin American economies such as Peru and Chile so far seem to have had limited success in developing domestic innovation from resource-based growth (OECD, 2011c). Yet, even if they are still catching up, local producers in natural resource-based industries often need to adapt equipment to local circumstances, and thus to innovate, to optimise extraction and processing. For example, conditions for extracting copper differ; northern Chilean mines have to find ways to optimise the use of water, a scarce resource in that part of the country. The recognition that such opportunities can build innovation capacities has led to the creation of the Chilean BhP Billiton Cluster Programme (Box 4.5). Brazil is also actively engaged in stimulating innovations needed to exploit off-shore oil reserves.

Box 4.5. **Chile's BhP Billiton cluster programme**

This is a new initiative for developing more innovation-intensive links between the company's core mining operations and local suppliers. It originated as a way of addressing corporate and industrial challenges in Chile, but it is also a component of BhP Billiton's corporate social responsibility strategy. It involves reshaping conventional modes of procurement from local suppliers in ways that are specifically designed to offer them opportunities to develop innovative solutions. Parallel activities are designed to strengthen their ability to produce such innovations. The longer-term aim is to enable these local firms to capture a larger share of the industry's rising demand for complex and increasingly innovative goods and services in Chile and in wider international markets. The initiative has been emulated by another mining company in Chile, Codelco, a state-owned company which is the country's largest copper producer. The two companies have recently launched a major joint programme. Although it is too early to assess the outcome, the signs are very positive. Preliminary internal estimates suggest innovation-centred projects with suppliers yield high internal rates of return. Feedback from suppliers that have participated in the programme suggest that they too have achieved significant benefits, both short-term and strategic.

Are industrial policies needed to channel trade into innovation-based development?

What are the main arguments of the debate on industrial policies?

Leaving aside the question of identifying "innovation-prone" sectors, a long debate that has received renewed focus revolves around the question of industrial policies (Table 4.3).

Table 4.3. **The main ideas towards the debate on industrial policies (IP)**

Phase	Key Ideas
1940s to late 1960s	• Industrialization is necessary for development. • Market failures would prevent this from happening automatically. • Market failures are pervasive in developing countries. • Industrial policy is needed, particularly infant industry protection, state-ownership and state coordination.
1970s to 1990s	• Practical obstacles to industrial policy are considered significant. • Government failure is worse than market failure. IP is invitation to waste and rent-seeking. • Trade liberalization (exports), privatization and attracting FDI together with macroeconomic stability and minimum government interference are the basic requirement for growth and industrialisation. • The era of the Washington consensus, especially after the debt crisis of the early 1980s and the ubiquity of structural adjustment programmes (SAPs).
2000s to present	• Market and government failures are present. • The 'how' rather than the 'why' of industrial policy is important. • Institutional setting matters but design difficult. Need to understand political context. • Flexibility in the practice of industrial policy is important. • Differences exist with respect to the extent to which comparative advantage needs to be defied, not the principle. • Innovation and technological upgrading should be a central objective of industrial policy. • Promoting national innovation systems should be an important objective of industrial policy.

Source: Naudé (2010).

The case for industrial policy is based on the argument that market failures in developing and emerging economies hamper growth-enhancing industrial development. Suboptimal investment in new activities and low rates of business creation can occur if capital market imperfections impede growth-enhancing resource reallocations (Aghion *et al.*, 2011). This argument would not in itself necessarily justify targeted industrial development policies since one could argue that capital market reforms across all sectors would be an equally feasible approach. This is no longer the case if any of the following circumstances apply:

1. If industries need an initial learning period before they will be profitable. Short-termism and risk aversion on the part of investors, especially if the learning period is long, might not lead to sufficient investment to enable the build-up of potential. Openness to foreign competition might kill emerging industries.
2. If these industries offered larger positive externalities (*e.g.* by addressing environmental challenges), private interests might not take up such opportunities and more targeted sector support policies would be justified.[12] Hausmann and Rodrik (2003) point to the important role of venturing into new sectors of activity to discover what an economy is good at producing. The uncertainties involved in such discovery processes and the small payoffs for entrepreneurs compared to the large social value of uncovering potentially new successful activities lead to less than optimal investments.
3. If the success of a potentially highly innovative sector depends on developing a multitude of complementary activities simultaneously, creating viable business opportunities might require targeted interventions since an individual entrepreneur entering a specific industry will not ensure success. The situation can be particularly

challenging for developing and emerging countries with infrastructure facilities that do not meet innovative businesses' needs (Box 4.6).

4. Another argument for targeting certain sectors is that keeping labour assigned to activities that do not reflect comparative advantage can in some circumstances be preferable to allowing full adjustments to comparative advantage. If there are differences in the capacity of certain sectors to absorb labour (primary resources are often mentioned in this respect), displacement from low-productivity activities might result in allocations to even less productive activities (*e.g.* informal occupations or low-productivity services) (McMillan and Rodrik, 2011).[13]
5. A more pragmatic argument is that limited public financing, substantial institutional weaknesses and the multitude of market failures in developing and emerging economies make it impossible to address all sectors' difficulties. In such cases supporting certain industries may be the best option.

Box 4.6. **Co-ordination failures and their impact on development**

This argument relates to the literature that has emphasised co-ordination failures as a reason for lack of development, a factor associated with a lack of industrialisation (Murphy *et al.*, 1989). Successful cases of product development, such as Brazilian genetically modified soy and aircraft, Uruguayan animal vaccines and Argentinean and Chilean wine have benefited from public support to overcome co-ordination failures (Sabel, 2010).

The Ecuadorian flower industry offers a concrete example of how co-ordination failures mattered for the industry's development. This sector failed in spite of many attempts to develop exports in the 1960s and 1970s but took off successfully in the 1980s. Successful lobbying by the producers' association led to setting up cargo flights, the provision of refrigerated facilities at airports and assistance with regulatory services needed for exporting (Hernández *et al.*, 2007). The simultaneous infrastructure investments provided sufficient returns for individual entrepreneurs to engage in such activities. Since costs were substantial private investors would not have made these investments.

A particular issue for sectoral support based on dynamic comparative advantage is the difficulty of determining when industries should be able to operate without public support. Arguments against industrial policy also point to the direct and indirect costs of subsidising unsuccessful producers. Since removal of support in such cases shows that public support was not warranted, there is a tendency to prolong it. Another question is whether governments are in fact well positioned to detect sectors with latent comparative advantage. However, the past provides little help for deciding whether or not industrial policies are needed (Box 4.7).

Conditions for successful industrial policies

While many dimensions of potential industrial policies in emerging and developing countries will be similar to those in developed economies, there are some differences: state-owned enterprises are often important players in these economies, including for innovation. For instance, PetroChina, China Railway Construction and Petroleo Brasileiro are leading R&D and state-owned firms. This provides rather different conditions for industrial policy design. A further factor worth emphasising is that "catching up" with

Box 4.7. **Why past experience provides little support**

Industrial policies of diverse types have been implemented by both developed and developing countries at different stages of development and at different times. Proponents of industrial policy often point out that many of today's developed economies, including Japan, the United Kingdom and the United States, employed industrial support policies during their industrialisation process (Chang, 2003). Such policies have also been associated by some with the success of East Asian newly industrialised economies (*e.g.* Chang, 2003). However, opponents point to many examples in which government-directed industrialisation efforts failed to unleash growth, as in the case of India in the early 1960s. This is equally the case for Latin American import substitution policies. Yet, as these experiences are not controlled experiments, they give little guidance as to whether or not industrial policies ultimately fostered development. Many other factors also intervened, *e.g.* major macroeconomic shocks and imbalances could either have been the driver of growth performance or have affected the odds on the success of the industrial policy. Moreover, industrial policy implies in practice a multitude of interventions and the type of intervention chosen may also play a role in success or failure. For instance, in Latin America import substitution was widely practised with limited monitoring and little penalty for failure. This could ultimately have been the main reason for its limited success.

These shortcomings might suggest focusing more closely on specific cases and examples. Evidence suggests that protection of the semiconductor industry in Japan was necessary in the beginning so that it could reach sufficient scale and become competitive internationally through learning. However, protectionism ultimately seems to have been costlier than the benefits derived. Similar conclusions hold for the infant-industry protection provided for the US tinplate industry in the 1890s: ultimately the costs outweighed the benefits (Irwin, 2000). By contrast, the Brazilian microcomputer industry failed to develop in spite of substantial support (Luzio and Greenstein, 1995). There are, however, limitations on using case study evidence to assess industrial policies. It is far from clear whether the conditions under which they were implemented could be expected to result in success. In the past in fact support appears often to have been provided to declining industries and/or based on political rather than economic criteria (*e.g.* Beason and Weinstein, 1996).

developed countries can allow following in their steps. This can reduce uncertainties related to adoption of industrial policy. In any case for such policies to have a chance of success a set of conditions must be met:

1. A country's institutional context has to provide sufficient checks on spending and on the influence of political factors to ensure that such policies are not abused or provide rents to failing industries. The emphasis needs to be on competition and focus on entrepreneurship and should move away from an exclusive concentration on support for large firms. Transparency is also a key element.
2. The public sector needs to be able to experiment, learn from past mistakes and adjust as well as be flexible and react quickly to new developments. This will make it possible to phase out failed industrial support policies before too many resources have been deployed. Rolling out projects sequentially with regular evaluations to learn from mistakes and adjust is therefore a good approach. The emphasis is, in other words, very much on "discovery" (Hausmann and Rodrik, 2003).

3. Well-designed support systems have to rely on information that the public sector alone cannot have. An active and ongoing dialogue and co-operation with the private sector and other stakeholders is necessary.[14] The combination of bottom-up and top-down approaches will matter greatly for success.
4. The choice of policy instruments matters; import substitution policies are not the best solution. Comparisons of East Asia and Latin America usually point out that the export subsidies used for the former were probably preferable to the import tariffs used for the latter (Harrison and Rodriguez-Clare, 2009). The lack of foreign competition is regarded as a downside to these types of industrial policies as they could weaken firms' performance. Exploiting the variety of policy options ranging from direct industry support measures, to production subsidies, to trade and foreign investment policies, and active support of public infrastructure of various types would be important.
5. Substantial institutional differences can affect the success and/or failure of industrial policies. It has been argued that the difference between East Asia and Latin America in the efficiency of their national innovation systems led to the different outcomes. If certain framework conditions are not in place simultaneously, such policy interventions might still fail.

These diverse requirements have led some to conclude that "the conditions necessary to generate positive net welfare gains from infant industry protection are difficult to satisfy in developing countries" (Harrison and Rodriguez-Clare, 2009). While public interventions necessarily play an important role in industrial policies, the private sector also needs to be actively involved. Such policies may also be more difficult to operate at present owing to the greater complexity of industries, their changing interdependencies, stronger competition, the rapid pace of new developments and the changing needs of industries, and the more constrained international legal environment regarding trade (*e.g.* WTO).

This discussion raises a more general question about the role of governments in economic development, including, among others, the targeting of sectoral specialisation (industrial policies). Institutional and political capacities are important for the success of such policies, which require an effective governance system.

Globalisation offers plenty of opportunities and even when it comes to specialisation patterns, a debate that is far from settled. Import substitution policies are generally not the most effective means for conducting specialisation policies. A fundamental issue is the need for complementary framework conditions that will facilitate benefits from trade and/ or FDI. This includes well-known but hard to achieve policies such as ensuring that firms have skilled workers capable of innovating on the basis of foreign knowledge and receive credit for implementing innovative ideas in their production processes. Donors can possibly also play an important role in support.

Conclusion

Different types of innovation, notably social and incremental innovations, are essential to the development process in developing and emerging economies. Building up innovation capacity, promoting niche competences and, in the case of emerging and middle-income countries, gaining competitiveness in frontier industries are objectives that support growth. Beyond growth, innovation can address many social, environmental and health challenges which require local capacities for adaptation.

Moreover, while countries' priorities differ, a source of rising concern in many has been the realisation that the growth process has been insufficiently inclusive. Innovative products targeted at low-and middle-income households can help reduce the impact of income inequalities on living conditions. If these can be the basis of sustainable business models, their potential aggregate impact can be substantial. Moreover, grassroots innovations, *e.g.* those enabled by mobile applications, can improve the welfare of the less well-off. At the same time, substantial differences in productivity among firms within industries, which are linked to unequal access to innovation, enhances income inequalities.

Finally, globalisation requires developing and emerging countries to adopt global innovation strategies. While openness offers opportunities to tap into global knowledge stocks, the development of innovation capacity in national industries requires supportive policy measures (*e.g.* access to finance, provision of suitable skills). There is an open debate on how specialisation patterns induced exclusively by market forces might affect the build-up of innovation capabilities, and consequently, whether industrial policies that seek to target specific sectors would enhance the development of domestic innovation.

Many factors not covered here are important for developing and emerging countries' innovation strategies. The institutions responsible for implementing innovation policies are particularly important since they play a key role in setting the stage for private actors to engage in innovation. However, a major challenge for development dynamics is the institutional weaknesses that often arise with development. An informal sector, a narrow tax base, corruption and co-ordination failures in governance are some of the main challenges. Such constraints have to be taken into account when policy tools are selected; the impact of policies might not be the same as in countries with fewer constraints.

Notes

1. However, there were also downsides to the Green Revolution: the overuse of chemicals led to substantial land degradation (World Bank, 2006).
2. USAID's Development Innovation Venture initiative, which invests in innovations that address development challenges such as those of Haiti, are one example of development policies aimed at taking advantage of innovation that is clearly tied to payoffs for development.
3. A factor that fosters such dynamics is the fact that many multinationals have chosen to conduct R&D activities in these countries.
4. South-South triangular co-operation, new forms of public-private partnerships, and other modalities and vehicles for development have become more prominent, complementing North-South forms of co-operation. This new emphasis was very evident at the 4th High Level Forum on Aid Effectiveness in Busan, Korea in 2011.
5. OECD work on global value chains (GVCs) is concerned with the increasing importance of GVCs and their impact on national economies. This research focuses on issues such as the role of emerging economies in GVCs, national competitiveness, the importance of intangible assets for GVC upgrading, GVCs and trade policy, and GVCs and global systemic risk. An OECD report (expected at the end of 2012) will bring the different results together and focus on the policy implications.
6. It is important to note that while innovation can have an impact on inequalities (the focus adopted in this discussion), political and social policy choices are very important for the level of inequalities in society, notably but not only via redistribution.
7. Aghion *et al.* (1999) discuss the inequality-growth relationship in further detail.
8. FDI in downstream and upstream industries has similarly benefited producers in developing countries (*e.g.* Fernandes and Paunov, 2012).

9. While Sachs and Warner (1995) among others find trade enhances economic performance, Rodrik *et al.* (2004) show that in many cases such positive evidence no longer holds when existing institutions and geography are taken into account.
10. Openness may lead such countries to make addressing global markets a priority. They may therefore spend fewer resources on addressing local demand, *e.g.* treatment for tropical diseases (Trajtenberg, 2005).
11. Closely related to the work on trade in value added, a joint OECD-WTO initiative on Trade in Value Added develops new measures of trade in order to have a better picture of the global trade landscape. Owing to the increasing importance of GVCs traditional trade statistics suffer from multiple counting of intermediates. The project aims to develop (bilateral) trade statistics in value added (*i.e.* how much value each country adds to imported intermediates) instead of gross production terms. First results are expected at the end of 2012.
12. If these sectors' economy-wide externalities are substantial they can justify industrial policy in the absence of a latent comparative advantage.
13. The differential growth performance of Latin America and Africa compared to Asia over the past decades has been attributed to the fact that their specialisation led to labour allocations to less efficient employment than previously (McMillan and Rodrik, 2011).
14. Chandra and Kolavelli (2006) conclude, on the basis of several case studies such as Malaysia's palm industry, India's IT services and Chinese Taipei's electronics, that "getting it right" depended on the appropriate synchronisation of various elements of industry-specific policies and the institutions necessary to motivate learning. This means support for all potentially constraining elements, from relevant public R&D institutes to developing skills, finance, infrastructure, export promotion, regulations, etc.

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PART III

Main trends in science, technology and innovation (STI) policy

PART III

Chapter 5

STI policy profiles: Innovation policy governance

This part presents, in a series of policy profiles, the main trends in national science, technology and innovation (STI) policies, with a particular focus on policies and programmes introduced between 2010 and 2012. It discusses the rationale for public policy intervention, major aspects of STI policies and STI policy instruments, and recent policy developments across countries, in a large variety of STI policy areas. This chapter focuss on innovation policy governance, including STI policy evaluation and coordination.

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.

National strategies for science, technology and innovation

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.* university research funding and evaluation systems). Third, the development of these strategies can engage stakeholders ranging from the research community, funding agencies, business, and civil society to regional and local governments in policy making and implementation. In some cases, national strategies outline the specific policy instruments to be used to meet a set of goals or objectives. In others, they serve as visionary guideposts for various stakeholders.

Today OECD countries are no longer alone in developing national strategies for science, technology and innovation. Brazil, the People's Republic of China and India have developed national innovation strategies as part of their longer-term economic development strategies. More recently, middle-income and developing countries such as Argentina, Colombia and Vietnam are developing strategies to diversify their economies and mobilise innovation to improve their competitiveness. Several policy trends emphasised since 2010 are discussed below.

Finding new sources of growth and competitiveness. France, Italy, Japan and the United States are mobilising STI to re-start economic growth, which slowed in the wake of the financial and economic crisis. The French Investments for the Future Programme (Programme des investissements d'avenir, PIA) seeks to restore industrial competitiveness through investment in innovative and industrial projects and financial support for institutional reform of the French national innovation system. Germany and Korea are fostering investment in new growth areas such as green innovation. Countries that are innovation followers still focus largely on improving the quality of the business environment and moving up the value chain to gain competitive advantage. An example is Chile's new National Innovation Strategy for Competitiveness.

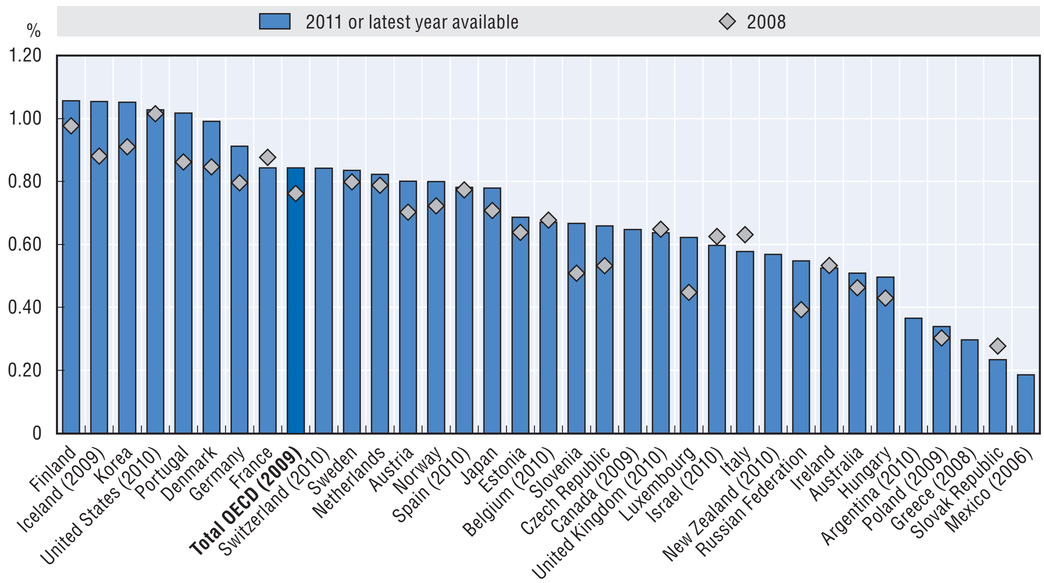
New industrial policy and targeting of strategic technologies/sectors. Besides their support for general purpose technologies such as nanotechnology, biotechnology and information and communication technologies (ICTs), many OECD countries are emphasising support for innovation in strategic technologies or sectors, including traditional ones (*e.g.* agriculture) and services. A number of STI strategies include industrial policy in wider innovation policies. Among others, the new Dutch industrial policy, Top Sectors, Brazil's *Plano Brasil Major*, China's 12th Five-Year-Plan for S&T development and Turkey's Industrial Strategy Document and Action Plan define strategic sectors that can strengthen national and industrial competitiveness.

Grand challenges. Complementing the rise of a "new industrial policy", many OECD countries have used the so-called grand or global challenges (*e.g.* climate change, energy security, etc.) as a means of orienting public investments in STI. Denmark, Korea and Germany are "greening" their national research and innovation strategies, and most countries continue to place environmental issues, climate change and energy high on the agenda. Health and demographic changes also remain important challenges, in particular for Italy, Japan and Germany.

Stable R&D expenditures. In spite of the economic slowdown and fiscal austerity policies, data on government budget appropriations or outlays for R&D (GBAORD) (Figure 5.1) show that government R&D budgets have remained stable in about half of OECD countries. As a share of GDP, total R&D budgets in the OECD area rose from 0.78% in 2005 to 0.82% in 2009.

Figure 5.1. **Government budget appropriations and outlays for R&D, 2008 and 2011**

As a % of GDP



Source: OECD, *Research and Development Statistics (RDS) Database*, March 2012.

StatLink http://dx.doi.org/10.1787/888932689807

Emphasis on demand-side innovation policies. While supply-side innovation policies such as public R&D investments are necessary to preserve long-term innovation capacity, they are not enough. Some countries have broadened their STI strategies to include demand-side innovation and diffusion policies. For example, the Research and Innovation Policy Guidelines of the Finnish Research Council include specifications on demand-side approaches. However, aligning demand- and supply-side innovation polices remains a challenge, as does the evaluation of such measures.

Social cohesion. Income disparities and levels of inequality increased in several OECD and non-OECD countries in the past decades. National STI strategies are being used to enhance social cohesion while boosting economic growth. Poland's National Cohesion Strategy, Ireland's Strategy for Science, Technology and Innovation, and Portugal's National Strategic Reference Framework include policies that aim to create, sustain and rebuild social cohesion.

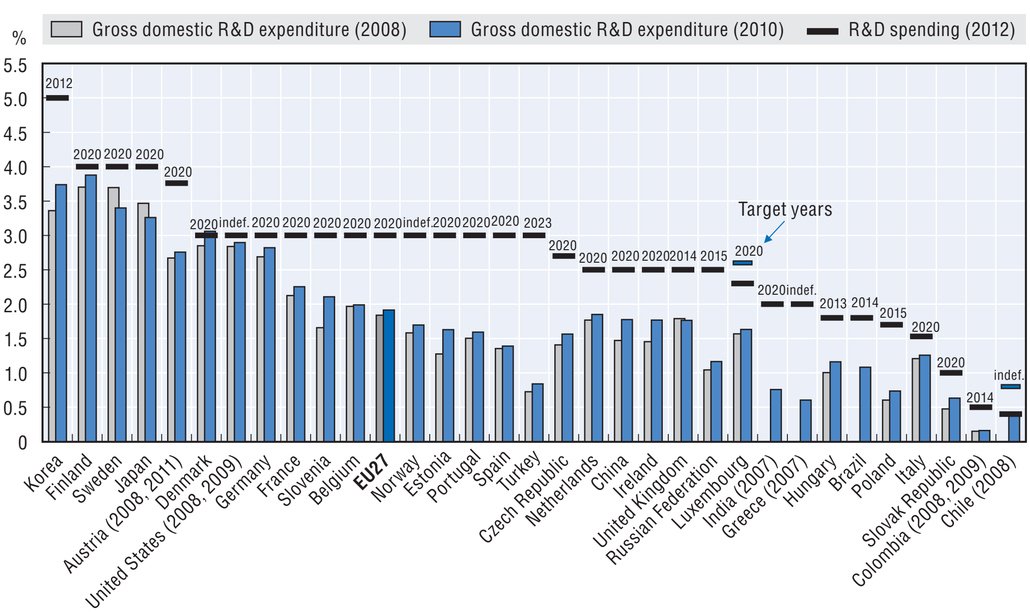
Public support for basic research. The science base has always been a cornerstone of national competitiveness and an essential source of knowledge for coping with grand challenges. Scientific leaders such as France, Switzerland and the United Kingdom preserve their lead in basic research. Countries that have lost ground or transition economies such as the Czech Republic and Poland continue to deepen the reform of their research systems by granting universities more autonomy to allocate their public funds. In the Netherlands, Japan, the United Kingdom and the United States there is a strong focus on improving the impact and output of public research through assessment and evaluation and improved priority setting. There is also a strong push to accelerate the transfer, exploitation and commercialisation of public research results, for example by improving the management of intellectual property rights at universities and public research institutions and increasing access to publicly funded research data.

Human resources. Improvements in skills and in education in science, technology, engineering and mathematics play a role in innovation that is as large or larger than improvements in other tangible or intangible assets. Policies to improve human resources in science and technology, to encourage international mobility, to reduce gender gaps and to attract foreign talent remain high priorities in the national STI strategies of OECD countries.

Business support. Support to business innovation focuses on improving framework conditions, streamlining business innovation programmes, and expanding indirect funding instruments such as R&D tax credits. At the same time, given the critical role of the business sector in addressing challenges such as energy and the environment, much public support to business innovation is being directed towards public-private partnerships and towards improving links between public and private research through instruments such as innovation vouchers and via cluster policies. Improving conditions for entrepreneurship and the supply of risk capital, especially for small and medium-sized enterprises, remains an important focus of business innovation support policies. Finally, evaluation not only of public research but also of business support schemes is becoming more important in light of fiscal consolidation and the need to adapt policies to the rapidly changing nature of innovation.

Figure 5.2. **National R&D spending targets and gap with current levels of GERD intensity, 2012**

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 2010 (or latest available year). For countries that adopted a range of target values, the minimum threshold is used in the ranking.

Source: Country responses to the *OECD Science, Technology and Industry Outlook* policy questionnaires 2010 and 2012; OECD, MSTI Database, June 2012; UNESCO Institute for Statistics, June 2012.

StatLink http://dx.doi.org/10.1787/888932689826

STI GOVERNANCE STRUCTURES AND ARRANGEMENTS

Rationale and objectives

The term "governance" is generally ill-defined and has gained a range of meanings. For the purposes of this profile, the definition of STI governance is limited to the set of publicly defined institutional arrangements, including incentive structures and norms, that shape the ways in which various public and private actors involved in socioeconomic development interact when allocating and managing resources for innovation. The emphasis on interaction naturally raises issues of co-ordination, and "failures" in governance are, more often than not, related to failures of co-ordination.

Co-ordination is a difficult challenge and governments often encounter a mix of imperatives when seeking to co-ordinate innovation-related policies across different ministries and agencies. Furthermore, recent years have seen a significant expansion in the number and range of interested ministries and agencies, owing in part to new public management (NPM) reforms and emerging multi-scalar governance arrangements, but also to changing perceptions of innovation processes and their determinants. In particular, policy makers and analysts have widely adopted an innovation systems perspective that has resulted in increased attention to a wide range of actors and their interactions.

Major aspects

Co-ordination relies upon a mix of hierarchical, market and network-based interactions. As such, it has both vertical and horizontal aspects, the former referring, for example, to co-ordination between a ministry and its delivery agencies and the latter covering inter-ministry relations. Instruments of co-ordination can be based on regulation, incentives, norms and information. They can be top-down and rely upon the authority of a lead actor or bottom-up and emergent.

Co-ordination can be fostered at different points in the policy cycle. For example, in agenda-setting processes, high-level policy councils often support shared problem and solution definition. The formulation of strategic, long-term policies and visions that set the direction for priority setting also plays an influential role. Co-ordination can also be achieved in implementation processes, for example through joint programming. Recent trends in such co-ordination mechanisms are outlined below.

In many countries co-ordination efforts have been affected by a growing regionalism, in which more control over policy and resources is devolved to sub-national authorities. This movement has seen the emergence of innovation, and increasingly science, agendas in sub-national regions. Matters have been further complicated by the growth of international governmental organisations and international regulations that increasingly shape governance regimes. This is especially true in Europe, where the European Commission plays a prominent role in supporting research and innovation agendas, mostly at the European level, but also at the sub-national level. Several countries report specific arrangements to improve co-ordination between these different levels. For example, institutionalised forums – in the form of roundtables or policy councils – are reported by Argentina, Australia, Brazil and Denmark, while Spain relies on the articulation of STI collaboration agreements between state and regional governments.

Recent policy trends

While efforts at improving STI policy co-ordination are often part of wider initiatives to improve policy coherence across government, domain-specific measures are also common. The *OECD Science Technology and Industry Outlook 2012* policy questionnaire invited countries to rate the importance of eight common arrangements directed at STI policy co-ordination. The results are shown in Figure 5.3 and discussed below.

Figure 5.3. **Arrangements contributing to the co-ordination of innovation policy, 2012**

Based on own country ratings, where 7 = high importance, 1 = low importance and 0 = non-existent

Source: Country responses to the *OECD Science Technology and Industry Outlook 2012* policy questionnaire.

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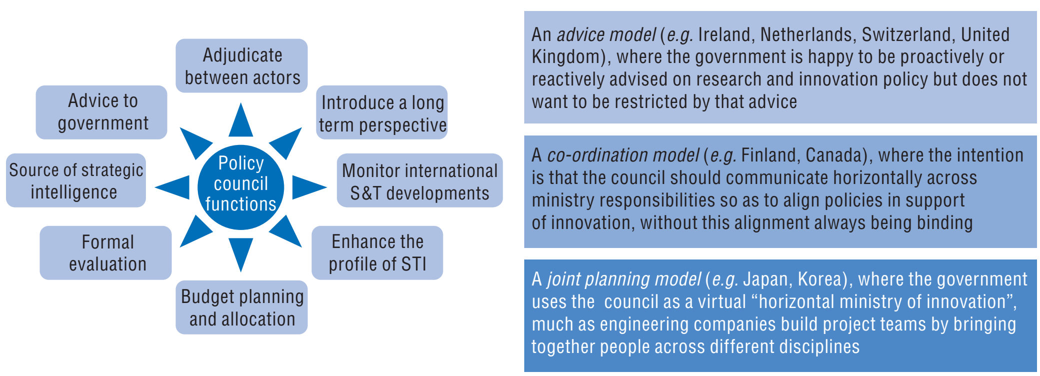
National strategies and visions are considered to contribute the most to innovation policy co-ordination. While such strategies often highlight the need to improve co-ordination and accountability, they are themselves instruments to these ends. They typically involve wide consultation and deliberation and provide diagnostic overviews of innovation system strengths and weaknesses and the opportunities and threats that are likely to arise in the near future. Belgium rates this factor at zero, a reflection of its strong devolution to regions, while the United Kingdom rates it as the factor contributing the least to co-ordination.

Dedicated innovation agencies or ministries come next in the ranking of arrangements that contribute to policy co-ordination. There is evidence of a growing movement to establish lead organisations for innovation policy. Italy and South Africa have recently established new agencies dedicated to innovation, while Australia, Denmark, the Netherlands and Turkey have sought to bring several innovation system functions together in newly consolidated ministries. Consolidation may present risks, however, particularly if science policy ministries assume leadership of the national innovation agenda. This may lead to "high-tech myopia" and insufficient attention to the innovation support needs of low-tech sectors. South Africa and Spain drew attention to this concern. Consolidation efforts have taken an interesting turn in New Zealand and the Russian Federation, where previous NPM reforms have been reversed and agencies have been reintegrated back into ministries. Canada, Germany, the Russian Federation, Switzerland and the United States do not have dedicated innovation agencies or ministries and therefore rate this factor at zero.

Policy evaluations and reviews are a source of strategic intelligence, which also rates highly in terms of its contribution to innovation policy co-ordination. Only in Poland, the Russian Federation and Sweden did this receive a low rating. System reviews can make more explicit the links and interdependencies between actors and institutions in innovation systems. Colombia and South Africa also mentioned the potential role of better measurement, particularly of the systemic aspects of innovation, as a means of promoting greater co-ordination.

High-level policy councils are rated similarly to policy evaluations and reviews. Most countries have a range of councils, commissions and committees dealing with aspects of STI policy co-ordination. The role of policy councils is variable, as Figure 5.4 shows. In a few countries, notably Japan and Korea, they adopt a joint planning model, but most are confined to less ambitious co-ordination or advisory roles. Some councils are independent, others are composed of government representatives, and many are somewhere in between. Some are chaired by the head of state or a senior minister, many are not. Recent years have seen a growing number of councils dedicated to innovation policy. These sometimes extend the remit of existing S&T councils (*e.g.* Finland) but more often they are new structures (*e.g.* Australia). New Zealand, Poland, the Slovak Republic, Spain and Sweden rate them zero, indicating that such arrangements do not exist. Israel and the United Kingdom rate them as making relatively little contribution to co-ordination.

Figure 5.4. **Functions and types of high-level STI policy councils**



Source: Adapted from OECD (2009), *Chile's National Innovation Council for Competitiveness*, OECD, Paris.

The contribution of informal channels of communication between officials is also highly rated, particularly in Canada, Finland, New Zealand, Sweden and the United Kingdom. Such arrangements tend to work best where there already exists a relatively well-developed culture of inter-agency trust and communication.

While not among the highest-rated contributors to policy co-ordination, *inter-agency joint programming* can draw together a number of interested agencies around a shared programmatic agenda. Some countries have moved further in this direction. For example, a single funding stream for STI was introduced in Ireland in 2010 to maximise the efficiency and focus of STI investment. Canada, Denmark and Luxembourg report efforts to better standardise procedures across agencies – *e.g.* for funding applications and impact assessments – to facilitate co-ordination and further other aspects of governance.

High-level leadership, for example, through the *intervention of the President's or Prime Minister's office*, is important for furthering co-ordination of innovation policy agendas and programmes in some countries. Argentina, Australia, the People's Republic of China, Ireland, the Russian Federation and Turkey all rated this as important. High-level leaders are in a good position to further co-ordination and are well placed to bridge traditional interest and bureaucratic boundaries.

By far the lowest-rated contributing factor is *job circulation of civil servants, experts and stakeholders*. This may be because typical career paths tend to keep civil servants within the same ministries and discourage inter-sectoral mobility between academia, the civil service and business sectors.

Evaluation of STI policies

Rationale and objectives

The role of evaluation is to generate information about the appropriateness and effectiveness of public policy interventions. This information can be used to assess and "enlighten" processes of learning around policy practices and performance, stimulate discussions among actors (*e.g.* about appropriate evaluation criteria), signal quality and reinforce reputations (*e.g.* in public research), and allow policy makers to account for public spending choices. Evaluation results may prompt a re-positioning of policies and programmes, shape the allocation or re-allocation of public funding (*e.g.* more generous block grants to top-performing universities) and inform the development of national STI strategy.

Major aspects

There is agreement in principle that all policy interventions should be evaluated, but there is no clear consensus on the right time to do so, the level of aggregation or the assessment criteria.

Evaluation takes place at different stages of the policy cycle (*ex ante*, mid-term, *ex post*). It may be implemented as part of a contract (*e.g.* R&D programme funding) or enforced by law (*e.g.* the US *Government Performance and Results Act*).

Individuals, projects, organisations (*e.g.* universities, funding agencies), programmes, policies and even the overall STI system can be evaluated. The evaluation can examine management processes (process-oriented) or outcomes *vis-à-vis* pre-defined objectives (impact-oriented) (Figure 5.5). It can be carried out by external experts or by those evaluated (*e.g.* self-evaluation of public research institutions in the Netherlands).

Evaluation of individuals, organisations or national STI systems focuses on their performance of defined missions or functions. Evaluation of policies and programmes typically sets out to demonstrate input, output or behavioural additionality of public intervention, *i.e.* the extent to which intervention supplements rather than substitutes for private inputs (*e.g.* R&D tax incentives), contributes to create more output (*e.g.* reform of higher education), and changes sustainably the behaviour of a target population (*e.g.* green subsidies).

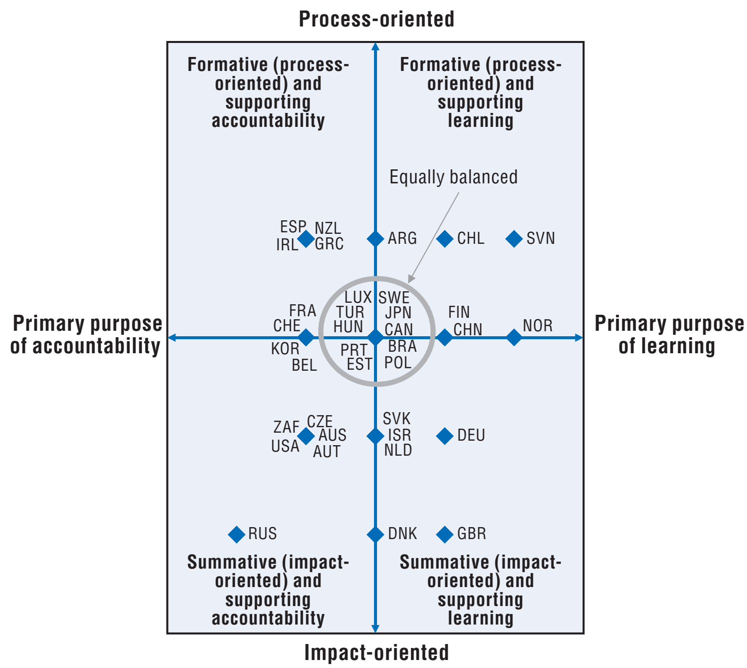
Assessment methods and criteria vary, depending on the kind of information sought. They matter because those who are evaluated typically learn to perform better over time. This is desirable if evaluation criteria steer actors to perform beneficial activities they otherwise might not perform, such as strengthening academic linkages with industry. However, they can also have perverse effects: for instance, peer review tends to favour conservative research and well-established research groups; a focus on publication and citation counts can discourage activities other than academic publishing, often to the detriment of teaching; and too strong a focus on patent and spin-off counts and on research income from private sources can promote short-termism.

Recent policy trends

STI policy evaluation has recently gained more policy attention because governments devote significant resources to R&D and innovation during fiscal crises. Fiscal constraints have raised the need to demonstrate value for public money but limit the resources available for evaluation.

Figure 5.5. **Primary purposes and orientation of STI policy evaluation, 2012**

Based on own country rating



Note: Country rating to the question: What are the purposes and orientations of STI policy evaluation in your country? A summative evaluation measures the impact a policy programme may have upon the problems to which it was addressed. A formative evaluation monitors the way in which a programme is being administered or managed so as to improve the implementation process.

Source: Country responses to the *OECD Science Technology and Industry Outlook 2012* policy questionnaire.

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STI policy evaluation faces the same complex challenges as STI policies themselves. Policy interventions typically seek to affect complex phenomena that involve a number of actors and institutional settings. Their evaluation must also deal with this complexity. A system-level assessment (meta-evaluation) must draw on various evaluation exercises, typically distributed across the policy landscape. Addressing social challenges requires adapting evaluation methods and criteria often based on investment models to capture non-economic outcomes and the social impact of STI policy. Adjusting to globalisation means expanding the scope of STI policy evaluation and further increases its complexity.

Governments have consolidated the legal framework of evaluation, streamlined evaluation procedures, sometimes through the establishment of a single dedicated agency, or reinforced the co-ordination of evaluation units. Besides general efforts to build an evidence-based STI policy knowledge base (through the development of impact assessment studies and the systematisation of evaluation), some countries have implemented a whole-of-government approach to evaluation, many have sought to harmonise practices by defining common methodologies and consolidating indicators, and a few are building data infrastructures and expert communities (Table 5.1). The United States and Japan have been particularly active in setting up science of science and innovation policy (SciSIP) initiatives to develop, improve and expand models, analytical tools, data and metrics that can be applied in STI policy decision-making processes. Norway also has set up a SciSIP research programme over 2010-14 called “FORFI”.

Table 5.1. **Major shifts in STI policy evaluation over the past five years**

Consolidating framework conditions for evaluation	Promoting a culture of evaluation	Belgium (Wallonia and Capital), Brazil, Poland, Portugal, Russian Federation, Turkey
	Enforcing evaluation by law	Belgium (Wallonia and Capital), Canada, Hungary (higher education institutions)
	Establishing performance agreements and/or contracts with central government	Finland (higher education institutions), France, Luxembourg
	Increasing budget allocated to evaluation policy	the People's Republic of China
Agencification and co-ordination	Establishing new evaluation units	Poland, South Africa
	Streamlining evaluation exercises (*e.g.* through a single agency)	Argentina, France, Korea, Finland, Israel, Italy, Portugal, Slovenia, Turkey, Netherlands
	Increasing co-ordination of evaluation units	Poland
Evaluation capacity building	Implementing a Whole-of-Government approach/ framework for policy evaluation and impact assessment (IA)	Australia, Canada, Finland, Ireland, Japan, Russian Federation, South Africa, United Kingdom
	Defining standards, guidelines and methodological framework for evaluation	Argentina, Austria, China, Colombia, Estonia, Japan, Netherlands, Spain, Switzerland, United Kingdom
	Developing and consolidating STI and key performance indicators (KPIs)	Australia, Belgium (Capital), Colombia, Denmark, Finland, Norway, Slovenia, Spain, Switzerland, Turkey
	Building STI policy data infrastructure, *e.g.* science of science and innovation policy (SciSIP) initiatives	United States, Japan, Korea
	Building evaluation and IA experts community	United States

Source: Country responses to the *OECD Science Technology and Industry Outlook 2012* policy questionnaire.

OECD Science, Technology and Industry Outlook 2012

PART III

Chapter 6

STI policy profiles: Building competences and capacity to innovate

This part presents, in a series of policy profiles, the main trends in national science, technology and innovation (STI) policies, with a particular focus on policies and programmes introduced between 2010 and 2012. It discusses the rationale for public policy intervention, major aspects of STI policies and STI policy instruments, and recent policy developments across countries, in a large variety of STI policy areas. This chapter focuss on public support to STI actors (including the business sector, public research and public services.

INNOVATION POLICY MIX FOR BUSINESS R&D AND INNOVATION

Rationale and objectives

Recent years have seen increased interest in the “policy mix” to support business R&D and innovation. 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 the adoption of more holistic perspectives.

Questions regarding the policy mix are not confined to assessing existing policy arrangements. They also extend to the design of new ones. Thus, a policy mix concept can be used *ex ante* to assess the fit or lack thereof of new policy measures as well as *ex post* to evaluate the performance and fit of an existing array of policies.

Major aspects

New policy instruments are typically introduced into settings that already contain an array of instruments, often with the same or overlapping targets. The effectiveness of a policy instrument almost always depends upon its interaction with other instruments. These are often designed at different times and for somewhat different purposes. In principle, the selection and design of policy instruments should take account of such interactions, as these may conflict with as well as reinforce each other.

Accounting for such interactions is far from straightforward, however, for a number of reasons. To begin with, an expansion of the range of objectives of innovation policy and of the bundles of instruments deployed has made for an increasingly complex policy landscape. This widening of the “frame” of innovation policy has led to new rationales for policy intervention and has opened up a larger toolbox of policy instruments. Beyond core innovation policies, such as S&T and education, there are other policies whose impacts must be taken into account, *e.g.* taxation policy, competition laws and regulations, etc., as they constitute the framework conditions for innovation.

Achieving coherence and balance in the innovation policy mix is an important goal. This can be hindered by the compartmentalisation of relevant policies in different departments and agencies. The primary objectives of such policies may not be support of business R&D and innovation.

It is important as well to avoid inefficiencies arising from operating too many schemes at too small a scale. The incremental accretion of policy instruments, if widespread and long-standing, can result in complex and dense policy mixes. As the instruments built up over time normally have differing conceptions of the causes of specific problems and variations in how problems are framed, this also makes achieving policy coherence difficult. Using the policy mix concept in policy assessment and design work helps draw attention to inconsistencies and redundancies.

In a more dynamic perspective, 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.

Recent policy trends

Policies and associated instruments can be characterised in several ways: their target groups, their desired outcomes, the funding mechanism employed. Many of the most popular characterisations are binary in nature, *e.g.* supply-side *versus* demand-side instruments, but should be interpreted not as alternatives but as complements. 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. The *OECD Science Technology and Industry Outlook 2012* policy questionnaire therefore 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 policy categories. The results are shown in Figure 6.1 and are discussed below.

Population-targeted versus *generic (non-population-targeted) instruments:* Figure 6.1(a) suggests that many countries have moved towards more population-targeted instruments over the last decade and that this development will continue in the next five years. Such instruments target small and medium-sized enterprises (SMEs) and young firms, as well as particular sectors.

Technology-targeted versus *generic (non-technology-targeted) instruments:* Figure 6.1(b) shows that countries vary markedly in the balance of technology-oriented and non-technology-oriented instruments. While the aggregate changes little over time, there is considerable movement in individual countries; around 80% of those answering this question indicated past and/or future changes in the policy mix, with almost as many countries moving towards more technology-oriented instruments (*e.g.* Brazil, Greece, Slovenia and the United Kingdom) as moving towards more generic instruments (*e.g.* the People's Republic of China, Finland, Germany and Switzerland).

Financial versus *non-financial instruments:* Figure 6.1(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.

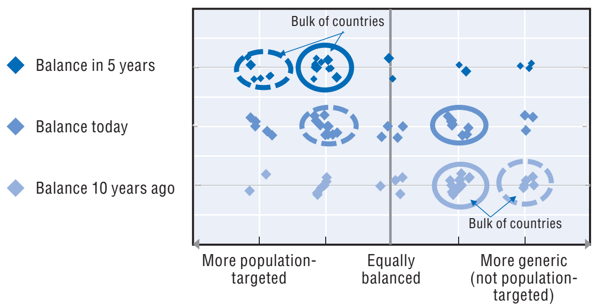
Direct versus *indirect financing instruments:* Direct financing instruments include credit loans and guarantees, repayable advances, competitive grants, technology consulting services and extension programmes, innovation vouchers, equity financing and venture capital investments etc. Indirect financing instruments include tax incentives on R&D and innovation, which may be both expenditure-based (R&D tax credits, R&D tax allowances and payroll withholding tax credit for R&D wages) or income-based (preferential rates on royalty income and other income from knowledge capital). The general trend across countries has been to increase the availability and generosity of R&D tax incentives, making the policy mix more indirect over time (see policy profile on Tax incentives for R&D).

Competitive versus *non-competitive instruments:* Figure 6.1(d) shows a strong preference for competitive instruments, *i.e.* those using performance rather than eligibility criteria in selection processes. Around 40% of countries answering this question indicated a shift towards more competitive instruments.

Figure 6.1. **Changing balance in the policy mix for business R&D and innovation, 2012**

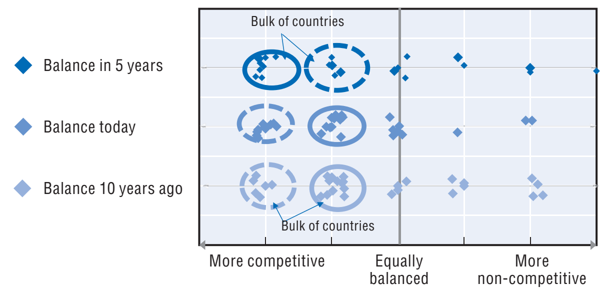
Based on country self-assessments

A. Population-targeted versus generic instruments



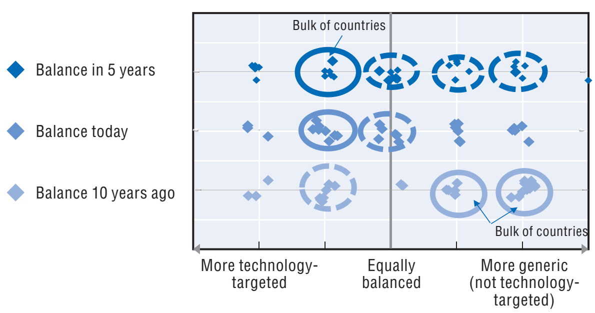
Population-targeted refers to instruments targeted towards specific populations, e.g. types of firms, SMEs or new-technology-based firms, specific sectors, etc.

D. Competitive versus non-competitive instruments



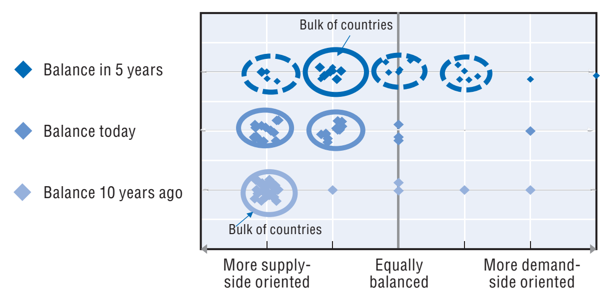
Competitive policy instruments are granted after a selection process based on established criteria of performance. Non-competitive policy instruments may be granted universally or after a selection process based on eligibility criteria.

B. Technology-targeted versus generic instruments



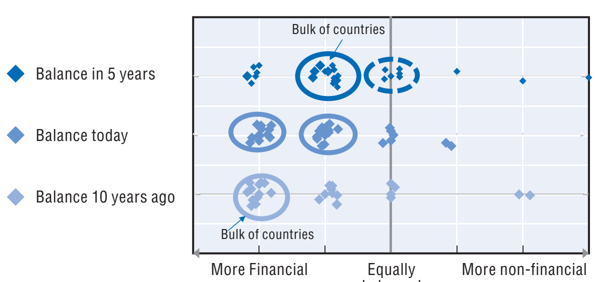
Technology-targeted refers to instruments targeted at specific technological fields of R&D and innovation, e.g. biotechnology, nanotechnology, ICT, etc.

E. Supply-side versus demand-side instruments



Supply-side policy instruments aim to boost knowledge production and supply in order to accelerate knowledge spillovers and externalities. Demand-side policy instruments focus on boosting market opportunities and demand for innovation as well as encouraging suppliers to meet expressed user needs.

C. Financial versus non-financial instruments



Financial instruments include both direct (credit loans and guarantees, repayable advances, competitive grants, innovation vouchers) and indirect funding (R&D tax incentives), while non-financial instruments include the provision of services, organisation of events, information campaigns, etc.

Source: Country responses to the *OECD Science Technology and Industry Outlook 2012* policy questionnaire.

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Supply-side versus *demand-side instruments:* Figure 6.1[(e)] confirms the traditional 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.

In summary, based on countries' self-assessment of their policy mixes, it is evident that the balance of their policy mixes differs and that these balances change over time. 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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Financing business R&D and innovation

Rationale and objectives

Financing is extremely important for innovation and growth, in particular at the seed and early stages of business development. Access to finance is a central issue for both innovative entrepreneurs and policy makers. Entrepreneurial start-ups and small and medium-sized enterprises (SMEs) face financial constraints largely because of their inherent riskiness and weaknesses. Evidence shows that innovative SMEs in the euro area considered access to finance one of their most pressing problems following the sovereign debt crisis in 2011 (EC, 2011a).

In spite of the growing importance of entrepreneurial activities in creating new ventures and implementing frontier research, innovative SMEs face several barriers for accessing finance, such as asymmetric information and financing gaps between investors and entrepreneurs. They also suffer from resource constraints, insufficient collateral, and lack of a track record. The quality of a business plan, in terms of due diligence, can be a very influential factor in funding decisions.

These potential market imperfections justify public intervention in entrepreneurial financing. In addition to establishing framework conditions that foster investment in R&D and innovation, governments use a variety of instruments such as subsidised loans, tax incentives and public support to venture capital (Table 6.1). Grants and subsidies are considered especially effective for mitigating financing constraints in young and small R&D-intensive, technology-based SMEs in the early stages of development. Seed funding can help entrepreneurs not only to gain access to finance but also to overcome the "valley of death", as they have great difficulty obtaining project or debt financing or venture capital for projects that imply higher risks.

Major aspects

R&D investment in OECD economies has risen steadily over the decades despite fluctuations in the business cycle (OECD, 2011a). This strongly suggests that public R&D, which tends to be counter-cyclical, serves as a buffer by complementing funding gaps due to a decline in private R&D investment during economic downturns. Global R&D spending surged from USD 1 252 billion in 2010 to USD 1 333 billion in 2011, and is expected to reach USD 1 403 billion in 2012, with continued strong growth in emerging economies and stable growth in established economies (Battelle, 2011). Global business R&D increased by 4% in 2010, a robust upturn after a 1.9% drop in 2009 in the wake of the financial crisis (EC, 2011b).

Venture capital investment, which has become an important source of financing for technology-based ventures, has tended to increase, except for the moderate drop in the United States and the EU in 2009 in the aftermath of the 2008 financial crisis (OECD, 2011b). Investments by US business angel groups fell significantly in 2009, again owing to the 2008 crisis, but in Europe these investments rose steadily. As experienced, wealthy and informal investors, business angels tend to invest in the early and riskier stages and play a crucial role in filling the financing gap between the early- and the later-growth stage.

Table 6.1. **Major financing instruments for promoting innovation**

Financing instrument	Key features in financing	Remarks
Bank loan	Used as one of the most common tools for access to finance, It needs collateral or guarantees in exchange for loans.	Obligation to repay as debt
Grant, subsidy	Used as seed funding for innovative start-ups and SMEs at the seed and early stage: small business innovation research in the United States, the United Kingdom and the Netherlands; feed-in-tariffs in Denmark and Germany: OSEO funding in France; Innovation Investment Fund in the United Kingdom.	Complements market failures, financing at seed and initial stage
Business angel	Financing source at early riskier stage and provides financing, advice and mentoring on business management. Tends to invest in the form of groups and networks, *e.g.* Tech Coast Angels and Common ANGELS in the United States, Seraphim Fund in the United Kingdom.	Financing at start-up and early stage
Venture capital	Tends increasingly to invest at later, less risky growth stage. Referred to as patient capital owing to the lengthy time span (10-12 years) for investing, maturing and finally exiting, *e.g.* Pre-seed Fund and Innovation Investment Fund in Australia, Yozma Fund in Israel, Seed Fund Vera in Finland, Scottish Co-investment Fund in the United Kingdom.	Financing at later expansion stage
Corporate venturing	Used by large firms to invest in innovative start-ups with a view to improving corporate competitiveness with either strategic or financial objectives.	Strategic motive
Crowd funding	A collective funding tool via the Internet which makes it easier for small businesses to raise capital at the seed and early stages.	Potential for fraud
Tax incentive	A broad range of tax incentives for R&D and entrepreneurial investments in most countries, *e.g.* Enterprise Investment Scheme in the United Kingdom, tax relief on the wealth tax (ISF) in France, Business Expansion Scheme in Ireland.	Indirect, non-discriminatory

Source: OECD (2011), *OECD Science, Technology and Industry Scoreboard*; OECD (2011), *Financing High-Growth Firms*; NIST (2008), *Corporate Venture Capital*, and other sources.

Recent policy trends

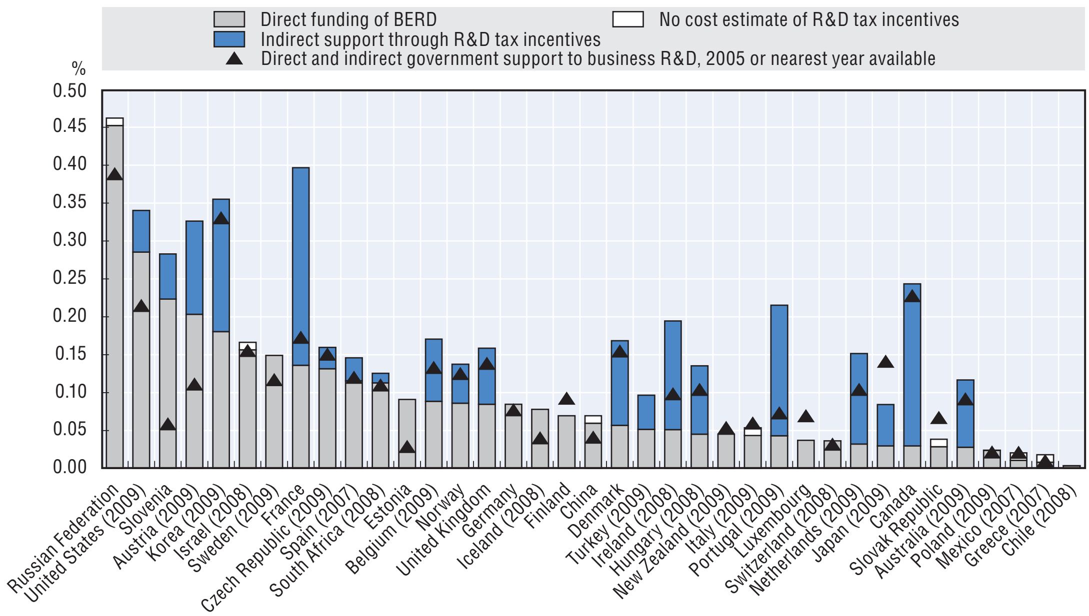
Promoting investment in innovation through greater access to finance remains an issue across the OECD. The problem is how to increase and broaden the sources of public and private financing for innovation, given the increasingly short-term focus of investors in OECD countries following the recent financial and sovereign debt crisis. Reforms to the banking and financing system following the financial crisis, such as banks' increased capital requirements, may reduce the appetite for risk among traditional investors. Governments are therefore promoting new ways to stimulate access to finance for R&D and innovation, including public-private partnerships.

The rise of new institutional investors and sovereign wealth funds may provide sources of innovation financing. The Internet is also providing new channels for financing small ventures. In the United States new legislation on crowd funding has gained attention there and in other economies. Corporate venturing in which large firms invest in smaller and innovative firms, is another potential source of R&D financing. On the institutional level, new legislation was passed in the United Kingdom for angel investment, and there is a new tax benefit law in Portugal, a new angel law in Israel, tax relief on the wealth tax (ISF) in France, etc.

Tax incentives for R&D have also been introduced in 26 out of 34 OECD countries and in a number of non-OECD economies (OECD, 2011a). This form of indirect financing is increasingly used to complement direct government funding through R&D contracts, subsidies or grants. In Canada, Denmark, Korea and Portugal, it is the main channel of government financial support to business R&D. Most recent estimates, although still experimental, suggest that the intensity of combined direct and indirect public support to business R&D has increased significantly in most countries since 2005 (Figure 6.2). While France and Portugal have extended their R&D tax system, either permanently or as a temporary response to the crisis, the Russian Federation and the United States have substantially increased direct funding. Slovenia and Austria, which have recorded the largest increases in government support, have done both. These reforms have led to significant shifts in national R&D policy mixes in some countries.

Figure 6.2. **Direct government funding of business R&D and tax incentives for R&D, 2010**

As a percentage of GDP



Note:

The estimates of R&D tax incentives do not cover sub-national R&D tax incentives.

Estonia, Finland, Germany, Luxembourg, Sweden and Switzerland do not provide R&D tax incentives.

China, Greece, Israel, Italy, the Slovak Republic and the Russian Federation provide R&D tax incentives but cost estimates are not available.

Iceland introduced a tax reduction scheme for R&D in 2009 with effect from 2011.

Mexico and New Zealand repealed tax schemes in 2009. No cost estimates are available for Mexico before this date. In 2008, the cost for newly-introduced R&D tax incentives for New Zealand was NZD 103 million (0.056% of GDP).

Data refer to 2004 instead of 2005 for Austria and Switzerland, 2006 for Poland, Portugal and South Africa, 2007 for Slovenia, 2008 for Belgium, Korea and New Zealand.

Estimates for Australia, Hungary and Korea are based on their responses to the 2010 OECD R&D tax incentives questionnaire.

The estimate for Austria covers the refundable research premium but excludes other R&D allowances. The value of research premium has been taken out of direct government funding of business R&D to avoid double counting.

France implemented in 2008 a major upgrade of its R&D tax scheme which is now volume based and has very high credit rates (up to 30%). In addition, as from 2009 immediate repayment of unused credits are permanent for SMEs (before 2009, unused credits could not be refunded before three years). Foregone revenues for 2010 is estimated based on national sources.

Cost estimate of R&D tax incentives for Belgium are drawn from its responses to the *OECD Science, Technology and Industry Outlook 2012* policy questionnaire.

The United States estimate covers the research tax credit but excludes the expensing of R&D.

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: OECD, Main Science and Technology Indicators (MSTI) Database, June 2012; OECD R&D tax incentives questionnaires, January 2010 and July 2011; and national sources, based on OECD (2011), *OECD Science, Technology and Industry Scoreboard 2011*, OECD, Paris.

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Tax incentives for R&D and innovation

Rationale and objectives

Tax incentives for R&D are often considered to have certain advantages over direct support for R&D, such as procurement of R&D or grants. As a market-based tool aimed at reducing the marginal cost of R&D activities, they allow firms to decide which R&D projects to fund. They are expected to lead to an increase in private investment in R&D and in turn to a rise in innovation outcomes and ultimately to higher long-run growth. They can also boost R&D start-up decisions. Potential downsides include 1) higher wage levels for researchers because more R&D increases demand for their skills (hence part of the government foregone revenue dilutes in rising cost instead of a volume increase) and 2) (re)location of R&D activities (tax competition between countries or between regions).

Major aspects

Existing R&D tax incentive schemes differ significantly in terms of their generosity, their design and the categories of firms or R&D areas they target (Table 6.2).

They include expenditure-based tax incentives – most importantly R&D tax credits, R&D tax allowances and payroll withholding tax credit for R&D wages – and income-based tax incentives – most importantly preferential rates on royalty income and other income from knowledge capital.

Most OECD and emerging economies provide R&D tax credits on the volume of R&D expenditure undertaken (*e.g.* Brazil, Canada, the People's Republic of China, France, India, Japan, Norway and the United Kingdom). Some provide R&D tax credits for R&D expenditure in excess of some baseline amount.

Table 6.2. **Differences in R&D tax incentives schemes in selected OECD countries, 2009**

Design of the R&D tax incentive scheme	*Volume-based R&D tax credit*	Australia, Brazil, Canada, China, France, India, Norway
	Incremental R&D tax credit	United States
	Hybrid volume and incremental credit	Japan, Korea, Portugal, Spain
	R&D tax allowance	Austria, Czech Republic, Denmark, Hungary, Turkey, United Kingdom
Payroll withholding tax credit for R&D wages		Belgium, Hungary, Netherlands, Spain, Turkey
More generous R&D tax incentives for SMEs		Australia, Canada, France, Hungary, Japan, Korea, Norway, United Kingdom
Targeting	*Energy*	United States
	Collaboration	Hungary, Italy, Japan, Norway, Turkey
	New claimants	France
	Young firms and start-ups	France, Korea, Netherlands
Ceilings on amounts that can be claimed		Austria, Italy, Japan, Netherlands, Norway, United States
Income-based R&D tax incentives		Belgium, Netherlands, Spain
No R&D tax incentives		Estonia, Finland, Germany, Luxembourg, Mexico, New Zealand, Sweden, Switzerland

Note: R&D tax allowances are tax concessions up to a certain percentage of the R&D expenditure and can be used to offset taxable income; R&D tax credits reduce the actual amount of tax that must be paid.
Source: OECD (2011) OECD testimony to the US Congress on R&D tax incentives, September and country responses to the *OECD Science, Technology and Industry Outlook* 2012 policy questionnaire.

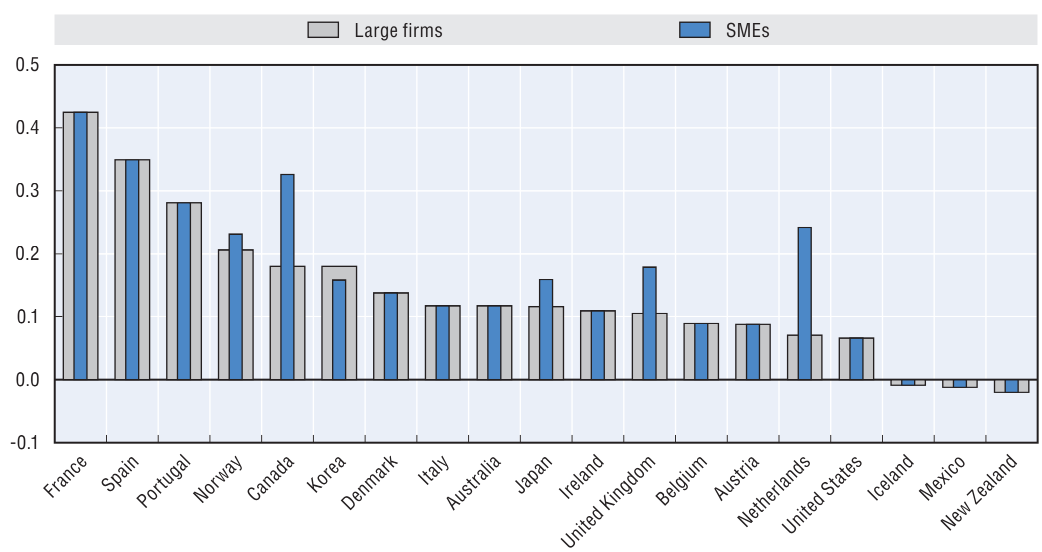
R&D tax allowances are available in Austria, the Czech Republic, Denmark, Hungary, and the United Kingdom. Payroll withholding tax credit for R&D wages (deductions from payroll taxes and social security contributions), are used in Belgium, Hungary, the Netherlands, Spain and Turkey.

In addition, R&D tax incentives may provide for special treatment of certain types of firms or of R&D. Certain countries allow carry-forward or carry-back for firms whose tax bill is lower than their allowable R&D credit. It can even be refunded in certain cases (*e.g.* for start-up firms, which often do not show a profit).

Recent policy trends

The general trend has been to increase the availability, simplicity of use and generosity of R&D tax incentives. France (in 2008) and Australia (in 2010) replaced relatively complex hybrid volume- and increment-based schemes with simpler and more generous volume-based schemes. Belgium, Ireland, Korea, Norway, Portugal and the United Kingdom have increased their tax credit rates or the ceilings for eligible R&D in recent years. China extended its R&D tax credit to all firms working in key areas of technology (biotechnology, information and communication technologies, and other high-technology fields) even if the firms are located outside the specially designated "new technology zones".

Figure 6.3. **Tax treatment of R&D: Tax subsidy rate for USD 1 of R&D, large firms and SMEs, 2008**



Note: The tax subsidy rate is calculated as 1 minus the B-index. The B-index measures the before-tax income needed to break even on one dollar of R&D outlays and is calculated for representative small and large corporations. The tax subsidy rate is reported for a profitable firm able to claim tax credits/allowances. The subsidy rate calculations only include expenditure-based tax incentives and do not account for income-based tax incentives.

Source: OECD (2009), *OECD Science, Technology and Industry Scoreboard 2009*, OECD, Paris; Warda, J. (2009), "An Update of R&D Tax Treatment in OECD Countries and Selected Emerging Economies, 2008-2009", *mimeo*.

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In contrast, Mexico and New Zealand have recently repealed their R&D tax incentives. Mexico converted its R&D tax credit to direct assistance in 2009. New Zealand introduced an R&D tax credit in 2008 but then repealed it, with effect from the 2009-10 fiscal year. Canada has also decided to streamline its R&D tax credit and to move its policy mix towards more direct support.

Recently, R&D tax incentives have also been used to help firms cope with the financial crisis, usually on a temporary basis. Japan and the Netherlands, for example, temporarily increased the ceiling for eligible R&D. Recognising that several firms would not be in position to claim all of their R&D tax credit because of a likely fall in profits following the economic downturn, Japan also allowed a longer carry-forward of unused R&D credits. In 2009, France offered to refund all pending claims from previous years. Before 2009, firms had to wait for up to three years for the refund of their unused credit. This measure is expected to have increased foregone tax revenue to USD 5.5 billion in 2009 (0.26% of GDP).

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Service innovation and non-technological innovation

Rationale and objectives

With lagging productivity and slow job growth, many OECD governments are looking for new sources of growth and have also recognised the importance of services in this regard. Services already account for around 70% of gross domestic product (GDP) in OECD countries. The expansion of services has largely been fuelled by globalisation and widespread use of information and communication technologies (ICTs) to provide more standardised services (health, education, government services). New market opportunities for services are also created by deregulation and privatisation of the public sector (financial, telecommunications and energy services) as well as by outsourcing of activities by manufacturing firms.

In spite of the growth in services, productivity in services has risen slowly in many OECD countries. Policy makers are therefore giving greater attention to promoting innovation in services through the design of appropriate framework conditions, such as regulation and competition policy and more targeted innovation policies.

Innovation in service activities extends beyond the services sector *per se*, as it can also be carried out by manufacturing firms. Examples include new channels for customer interaction, new business models or new service applications embedded in manufactured products (*e.g.* service and maintenance contracts, applications on smartphones). Service innovation often has technological (mainly information technology) and non-technological aspects and does not necessarily rely on R&D. Service innovation is also characterised by proximity to users and customers who often participate in the joint development (or co-creation) of such services.

Major aspects

In OECD countries innovation policy increasingly addresses service innovation (Denmark, Finland, Germany, Ireland, Korea, Sweden and the United Kingdom) and many have adopted targeted support instruments (Australia, Austria, Denmark, Finland, France, Germany, Japan and Sweden). Service innovation is also being mainstreamed into broader STI policy agendas, for example to address societal challenges (Germany, Japan, Korea, Sweden and the United Kingdom) and to revitalise public-sector services.

However, many policies that support innovation have been developed from a mainly R&D or manufacturing perspective. They may be ill-adapted to the specific characteristics of services (*e.g.* more direct involvement of users) and to the market or systemic failures that inhibit service innovation (*e.g.* the intangibility of services limits appropriation and fragmented markets limit transparency). Furthermore, the justification for innovation policy is often based on indicators that are biased towards measuring manufacturing and R&D-based innovation whereas innovation in services may rely more on non-technological components. There is not enough quantitative and qualitative information to inform discussions on how to design new, or to perfect existing policy instruments to support service innovation. Improving the measurement of service innovation (in services and in manufacturing) remains a key challenge.

Recent policy trends

Given the complex nature of service innovation and the heterogeneity of service firms, the policy focus in many OECD countries has evolved from a sectoral perspective (*e.g.* ICT services, health services) towards mainstreaming or embedding service innovation in the overall innovation policy mix. This implies finding common policy levers across service activities that range from software development, to management consultancy, to communication, to tourism and retail services. At the same time there are key differences in services in terms of the use of ICTs to enable service delivery and the degree of innovation undertaken in different sectors (*e.g.* software and business services are highly innovative and R&D-intensive while tourism and retail are relatively less so).

Many OECD countries have launched specific policy instruments to promote service innovation or are currently reviewing how existing innovation policy instruments could better support service innovation (Table 6.3). Possibilities include: *i)* embedding service innovation in generic innovation policies such as R&D tax credits or grants (in the Netherlands the R&D tax credit was extended to include the development of service-based software); *ii)* adjusting demand-side innovation policies and instruments such as public procurement (Finland, United Kingdom) and regulations to better accommodate service innovation (Sweden, Denmark, Germany, United Kingdom); *iii)* embedding service innovation in R&D and innovation policies to address societal challenges such as services for an ageing population (Korea) and sustainable cities (Stockholm Royal Seaport); and *iv*) integrating service innovation in policies to better link industry and public research (commercialisation policies).

Table 6.3. **Major new policy options for fostering service innovation policy in selected OECD countries**

Policy option	Instrument	Examples
Launch a specific instrument to foster service innovation	*Service innovation research programmes*	Austria, Finland (Serve), Germany (innovation with services) and Japan (service science solutions research programme) have dedicated research and innovation programmes covering issues such as engaging users/employees in development, new business models and the "servitisation" of industry.
	Service cluster	Denmark introduced the Service Cluster Denmark which supports R&D-based co-creation for services by businesses and researchers.
	Innovation voucher	France introduced the green service innovation voucher for SMEs in the construction sector. Ireland has an SME voucher that supports new business models, customer interfaces or a new service delivery.
	Service lab	The United Kingdom introduced the public services innovation lab to test innovative solutions and bring them to scale across the country's public services.
Adjusting the scope of horizontal policy instruments	*Procurement of innovative services*	Sweden introduced an innovative procurement programme to spur procurement of innovation in the public sector.
	R&D tax credit	The Netherlands extended the R&D tax credit to include development of service-based software.
Adjusting the governance structure for innovation	*Fountain collaboration, i.e. user-defined scope within cross-sector collaborations*	Sweden has embedded service innovation in its new challenge-driven innovation approach which emphases co-creation with customers/users and cross-sector collaboration focused, for example, on sustainable cities and future health and care.

Source: Country responses to the *OECD Science, Technology and Industry Outlook 2012* policy questionnaire and national sources.

A key challenge for policy makers is to identify and adapt best practices for promoting service innovation. There is little evidence on the design and implementation of policy instruments for service innovation, many of which are new, and impact assessments are rare. Further policy learning is needed to guide OECD policy makers and meet country-specific needs by identifying policy priorities, involving all key stakeholders and designing an appropriate policy mix.

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Stimulating demand for innovation

Rationale and objectives

In spite of long-standing efforts to boost innovation performance through supply-side policies, such as public support to higher education and research, some OECD countries face a persistent "innovation paradox": high or rising research and development (R&D), but low rates of innovation. Today, demand-side innovation policies – from public procurement of innovation, to standards and regulations, to lead markets and user-/consumer-driven innovation initiatives – are gaining ground in OECD countries (see policy profile on innovation policy mix for business R&D and innovation in Chapter 6). This trend 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 innovation without creating new programmes. An additional focus is innovation to meet strong societal demand in key sectors (*e.g.* health, environment, energy).

Major aspects

There is no single definition of a demand-side innovation policy, but it is often understood as a set of public measures to increase 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 often aims at lowering barriers to the market introduction and diffusion of innovations. Demand-side innovation policies take a variety of forms, with innovation-oriented public procurement, innovation-related regulations and standards as the key instruments (Table 6.4). In addition, consumer policies or tax policies that affect demand for innovation (*e.g.* for green innovation) are also very important.

However, demand-side innovation policies, notably public procurement of innovation, are not without risk, as they may favour large firms over small firms or specific technologies and thus lead to technology lock-in.

Table 6.4. **Key features of demand-side innovation policy instruments**

Demand-side policy	Procurement	Regulation	Standards
Objective	Innovative product or service	Market uptake, increased competition and social goals	Market uptake, interoperability, transparency
Input	Finance, performance requirements, skills	Legal process, need to co-ordinate	Participation of standards agencies, co-ordination of participants in the standards development process
Participatory incentive	Sales, risk reduction, preferential treatment (*e.g.* SMEs), attraction of additional private-sector finance	Mandatory	Voluntary
Main player	Government	Government	Industry
Effects of success	Improved and less costly public services, stimulation of innovation	Reduced market risk, transparency, stimulation of innovation	Reduced market risk, transparency, increased interoperability, increased trade
Possible risks	Insufficient skills in the public sector, Lack of co-ordination across government, Idiosyncratic demand	Conflicting goals, length of the process	Technology lock-in, inadequate attention to consumer needs (with industry-driven standards)

Source: OECD based on Aschhoff, B. and W. Sofka (2008), "Innovation on Demand: Can Public Procurement Drive Market Success of Innovations", *ZEW Discussion Papers* 08-052, ZEW – Zentrum für Europäische Wirtschaftsforschung/ Center for European Economic Research.

Recent policy trends

The Australian Climate Ready programme provided small and medium-sized enterprises (SMEs) with support to undertake R&D, proof of concept and early stage commercialisation activities to develop innovative clean green products, processes and services to address the effects of climate change. The programme is closed to new applications. The Clean Technology Innovation Programme scheduled to open in mid-2012 will support the development of innovative clean technologies and services that reduce greenhouse gas emissions. At the strategic policy level the programme stimulates a market for technological and other innovative solutions to the challenge of climate change.

In Belgium, the Flemish government approved in July 2008 an Action Plan on Procurement of Innovation (PoI), which focuses on procurement of innovation requiring pre-commercial R&D and horizontal integration in the innovation policy mix. The government buys innovations from companies and knowledge institutes in 13 policy areas.

The Danish programme takes a user-driven perspective on innovation to strengthen the development of products, services, concepts and processes in companies as well as public institutions. The programme focuses on areas that have a strong business specialisation, that require innovative solutions to solve societal issues, or that concern public welfare.

Demand- and user-driven innovation policy is one of four key areas of Finland's Innovation Strategy adopted in 2008. Under the national innovation funding agency, Tekes, public procurement units and public utilities (at central and local level) can apply for funding for public procurement of innovations. Tekes funds can be used both for the planning and R&D stages. To support the procurement process, external advisors can be involved in the planning stage (to address legal, commercial and technological as well as user experience issues).

Korea's New Technology Purchasing Assurance scheme requires public agencies to give preference to SMEs when procuring goods and services. Under this programme, the Korea Small and Medium Business Administration finances the technological development of SMEs, and public institutions purchase the products for a certain period. The SMEs receive a technology guarantee from the government.

In the Netherlands, the Launching Customer Scheme promotes awareness and information on the use of public procurement by government procurers and suppliers. The Dutch Innovation Agency, NL Agency, complements the scheme by advising municipalities and other agencies on how to promote innovation through tendering.

The Spanish State Innovation Strategy (E2i) is developing innovation policy measures for specific markets: health and welfare, green economy, e-government, science, defence, tourism and information and communication technology (ICT). For these markets, public procurement policies encourage innovation through public-sector demand under the recently established legal framework on public contracts and on a sustainable economy.

The UK government supports standardisation in biometrics and technical standards involving interchangeability and interoperability. The objective is to reduce risk for the procurer, system integrator and end user by simplifying integration and enabling vendor substitution, technology enhancement and development.

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START-UP AND ENTREPRENEURSHIP

Rationale and objectives

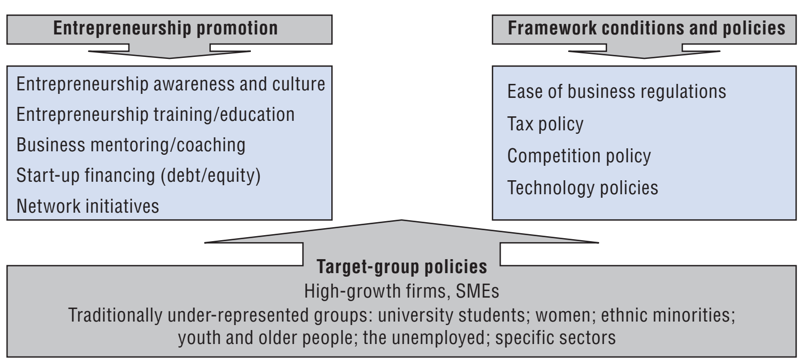
Public support of entrepreneurship is often justified by perceived market failures that affect business creation and by the positive impact of business dynamics on economic growth and job creation. Public policies for entrepreneurship are often motivated by evidence demonstrating the impact of young innovative firms on economic growth and job creation. Policy makers also seek to address perceived market failures for start-ups, including information asymmetries and financing gaps.

For example, information asymmetries in credit markets are greater for new firms that lack a credit history, while formal equity finance tends to fund lower-risk later stages of investment. As a result, entrepreneurship funding often comes from the three F's: founder, family and friends. Positive externalities also shape the entrepreneurial process. Innovative entrepreneurs tap into new knowledge that is commercially valuable but not commercialised by incumbent enterprises that prioritise profit maximisation from existing products.

Major aspects

Entrepreneurship policies can adopt supply-side or demand-side measures. In general, they can be grouped into four broad areas: programmes addressing entrepreneurship culture and ecosystems; access to finance; reduction of regulatory and administrative barriers; and programmes targeting specific groups (Figure 6.4).

Figure 6.4. **An entrepreneurship policy framework**



In the first group are entrepreneurship promotion programmes for raising awareness in the society (*e.g.* advertising campaigns, awards, profiling of role-models, etc.); training and education schemes to instil entrepreneurship skills through interactive and experiential teaching methods (*e.g.* business plan competitions, student virtual start-ups, etc.); mentoring and coaching programmes to help new entrepreneurs or those experiencing fast growth (*e.g.* business incubators, business accelerators, etc.); network initiatives to strengthen the competencies of co-located entrepreneurs through knowledge spillovers (*e.g.* cluster programmes and science parks).

In the second group are programmes for access to finance, including both debt and equity finance (*e.g.* seed funding, start-up grants and loans, programmes to support venture capital and business angels, investment readiness, loan guarantees).

In the third group are measures aimed at the simplification of business regulations (*e.g.* start-up administrative compliance, bankruptcy legislation, etc.); special *pro tempore* taxation and social contribution regimes for new firms (*e.g.* reduced corporate tax rate and tax reporting requirements); competition policy that affects market accessibility for new entrants (*e.g.* antitrust measures, banking legislation); and technology policy that creates opportunities for research commercialisation by new firms.

In the fourth group are policies that target specific groups, such as high-growth firms, innovative small and medium-sized enterprises (SMEs) or SMEs in general. There are also tailored entrepreneurship policies and programmes for traditionally underrepresented groups such as university students, women, ethnic minorities, youth and older people, the unemployed, and specific industry sectors.

Recent policy trends

In an effort to recover from the crisis, governments have given greater attention to improving access to debt and equity finance. For debt finance, a number of OECD countries' credit guarantee programmes have been ramped up during the crisis in terms of size of the guarantee fund, percentage of the loan guaranteed, or number of eligible firms (Chile, Hungary, Korea, Portugal, etc.). New elements have also been added and new programmes started, including counter-cyclical loan programmes for firms faced with liquidity problems owing to the recession (Finland, Italy, the United Kingdom) and start-up loans combining loan guarantees and business advice (Denmark).

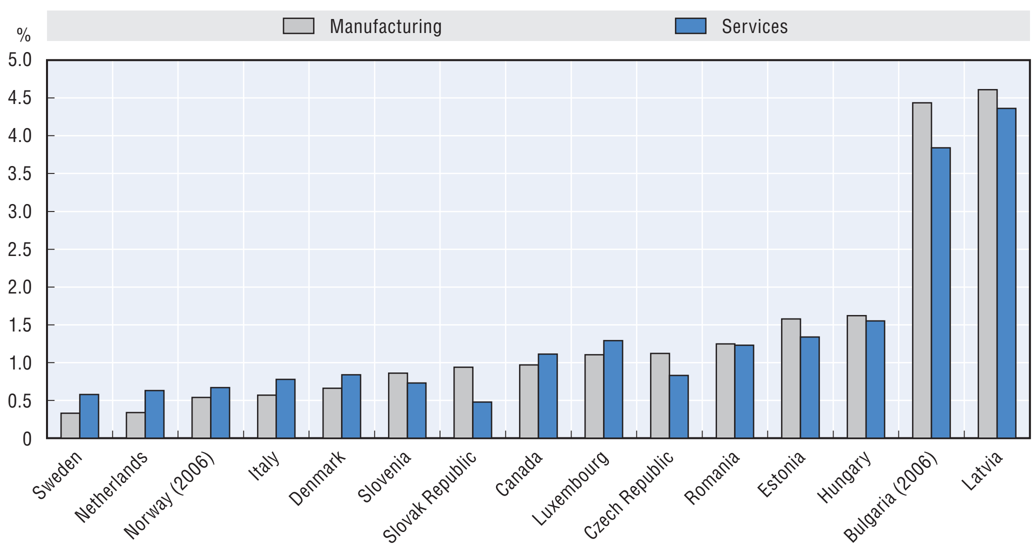
Many countries have also been proactive in stimulating equity financing (Canada, Chile, Denmark, Finland, France, Italy, the Netherlands, New Zealand, Sweden and the United Kingdom). Canada has allocated USD 390 million (CAD 475 million) for the venture capital programme of the National Business Development Bank and removed impediments to foreign venture capital investment. A growing number of countries have measures in place to support angel and venture capital investment, including through the creation of public-private co-investment funds to leverage private investment (the Netherlands, New Zealand, the United Kingdom, etc.).

Governments have also participated in funds of funds investing in local high-technology companies (Mexico, Germany). Through these funds of funds, governments support private venture capital funds, boosting the level of equity funding but leaving investment decisions to the private fund's management. Germany has a national public-private high-technology start-up fund, and at the local level some *Länder* have set up equity guarantee facilities for private investment in local SMEs.

Innovative entrepreneurship has been encouraged in many countries and in many different ways. France has supported cluster development through regional *pôles de compétitivité*; Finland has backed high-growth start-ups through business accelerator programmes in knowledge-intensive sectors such as the life sciences, information and communication technologies (ICTs), and clean technology; Germany has taken a comprehensive approach to university entrepreneurship support through the EXIST scheme, which fosters entrepreneurial culture, start-up grants and technology transfer in higher education institutions. A formal partnership approach has been followed in the Netherlands with Techno-Partner, a programme to bolster new technology-based firms through regional partnerships involving universities of applied science, incubators, experienced entrepreneurs, banks and equity finance.

"Gazelles", young high-growth innovative firms, have been a focus of entrepreneurship policy and have drawn policy makers' attention because of the number of jobs they are estimated to create. In this case, public support has generally been geared towards accelerating their growth and internationalisation. Mexico has a national programme to help gazelles through training, specialised consultancy and support for the commercialisation of products and services in international markets, mainly the United States. Spain has introduced a grant-based scheme for young innovative firms which subsidises R&D-related expenditures such as research staff costs, intellectual property rights, and research facilities. For more mature firms (beyond the start-up stage), the Netherlands offers banks and private equity enterprises a 50% guarantee on newly issued equity or mezzanine loans.

Figure 6.5. **Share of gazelles (turnover definition) by sector, 2007**



Note: Gazelles are firms that have been employers for a period of up to five years, with average annualised growth in employees (or in turnover) greater than 20% a year over a three-year period and with ten or more employees at the beginning of the observation period. The share of gazelles is expressed as a percentage of the population of enterprises with ten or more employees.

Source: OECD (2011), *OECD Entrepreneurship at a Glance*, OECD, Paris.

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Policies aimed at framework conditions have been common, too. Mexico has simplified regulations through an online registration process that makes it possible to start a business in less than three days; and France has introduced the new legal status of the *auto-entrepreneur*, a form of self-employment benefiting from a favourable tax regime. Special *pro tempore* fiscal measures for new firms (*e.g.* tax exemptions and tax deferments) have been tested in France, Italy, New Zealand and Sweden.

Finally, specific target programmes for under-represented groups are less common but available in many countries. Youth entrepreneurship has been encouraged in Canada and Spain through dedicated lines of start-up financing. Spain has also devoted a specific programme to women's entrepreneurship. The most outstanding target programme in terms of size is Germany's self-employment scheme for the unemployed, which absorbs 17% of national active labour market policy spending and reaches out to 9% of the country's unemployed.

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PUBLIC RESEARCH POLICY

Rationale and objectives

Public research, *i.e.* research primarily funded with public money and carried out by public research institutions (PRIs) and research universities, plays an extremely important role in innovation systems by ensuring the provision of new knowledge. Public-sector research is considerably smaller than business research and development (R&D) in the majority of OECD countries: government intramural expenditure on R&D was on average 0.29% of gross domestic product for the OECD area in 2009, and higher education expenditure on R&D was 0.44% (including a small percentage funded by business), while business expenditure on R&D stood at 1.69%.

The fundamental justification for government support of research is the classical market failure argument: the market does not provide sufficient incentives for private investment in research owing to the non-appropriable, public good, intangible character of knowledge and the risky nature of research. In addition to basic research, public research is also needed to meet specific needs of national interest, such as defence, and of the population at large, *e.g.* regarding health. A recent OECD study of public research (OECD, 2011a) found that university research has now taken the place of PRIs as the main performer of public research in many OECD countries.

Major aspects

Conducting scientific research requires significant amounts of funding and research infrastructure. *Discretionary institutional funding* ("block grants") and *competitive R&D project grants* have been the mainstay of funding for PRIs and research universities. Block grants are the traditional funding instrument for allocating funding to *PRIs* and *research universities* according to various criteria (*e.g.* formulae, performance indicators, budget negotiations). They provide these organisations with stable funding over the long term and a certain degree of autonomy for their research. Competitive R&D project grants are instruments for distributing public funds on a competitive basis to researchers in research universities and PRIs. Competitive R&D project-based funding regimes put more emphasis on the outcomes and quality of the research performed by researchers in the shorter run. Achieving the optional impact of the two funding mechanisms is a challenging balancing art for policy makers.

With rapid changes in how innovation takes place in the knowledge economy and in a global context, PRIs and universities need to reform and modernise their management to increase the efficiency and responsiveness of their research and to redefine their role in the globalising R&D space. Indeed, there is ongoing fierce debate regarding how much autonomy PRIs and universities should have in order to improve the efficiency, responsiveness and impact of public research.

Policy measures introduced in this regard focus on balancing stable institutional funding with a fair level of pressure from competitive R&D project grants, on encouraging the commercialisation of public research, and on improving science-industry relations and other linkages within the national innovation system and internationally.

Boosting PRIs' links with industry and their contribution to innovation is another main policy objective, because there is increasing pressure for public investments in research to be held accountable for their contribution to innovation and growth. Two types of measures are typically used: one to link PRIs and universities to other innovation system actors, particularly firms, through *collaborative R&D programmes*, *technology platforms*, *cluster initiatives* and *technology diffusion schemes*; and another to better commercialise the results of public research through *science and technology parks*, *technology incubators* and *risk capital measures in support of spin-offs*, technology transfer offices, and policies on intellectual property of public research.

Provision of infrastructure for scientific research is another important aspect of public research policy. Investment in large, expensive, key research equipment and facilities, such as information archive systems, which are essential for public and private R&D and innovation, are at the heart of the government's role in encouraging innovation.

Recent policy trends

Despite the stringent budgetary situation in many countries following the economic crisis, public funding for research has increased in recent years in Argentina, Australia, Austria, Belgium, Chile, the People's Republic of China, the Czech Republic, Denmark, Estonia, Finland, Germany, Korea, Norway, Poland, Portugal, the Russian Federation, Slovenia, South Africa, Turkey and the United States (for civil R&D). The adoption of national STI strategies (in many countries in the above list), including targets for R&D spending, has provided governments with strong legitimacy to increase spending on R&D or to prevent severe cuts due to their fiscal austerity measures. The stimulus plans introduced in many countries since 2008 in response to the economic crisis have played a role in offsetting, at least in part and temporarily, the negative impact of the crisis on public and private R&D spending (*e.g.* Canada, Israel). However, despite such contingency efforts, R&D spending declined in a few countries (*e.g.* Ireland, Spain) in the last few years.

While Argentina, China, the Russian Federation and South Africa are expected to continue to increase public funding for R&D strongly, few OECD countries (*e.g.* Austria, Belgium) expect increases in absolute terms in the coming years. In most countries the outlook for an increase in public funding for R&D is guarded, owing to uncertainty about the extent to which the budgetary capability to do so may be further weakened. In crisis-strapped countries that envisage a decrease in R&D funding, governments consider it imperative to allocate their limited resources to selected priorities.

On ways to distribute institutional funding for research, Belgium, the Czech Republic, Denmark, Hungary, Norway, the Slovak Republic, Slovenia, and South Africa have introduced competition mechanisms by adopting or strengthening performance-based criteria (*e.g.* bibliometric index, number of university graduates). Block funding of PRIs and universities is expected to decrease in Greece and the Netherlands. In parallel, there is a trend towards strengthening the share and importance of competitive project funding in France, Hungary and Norway; Slovenia already allocates 80%, and Australia at least 60%, of government funding for R&D through competitive funding.

In contrast, Israel significantly increased the share of block funding for research in 2010, from approximately 40% in previous years to 51%, against the background that Israeli project funding is allocated entirely based on competition of bottom-up research proposals without predefined research themes. In parallel, there is a trend to strengthen the autonomy of PRIs and universities. Reforms are also under way in Germany, where the funding system for higher education is going through a period of change; in Sweden, which is now working on new methods of reallocating direct grants; and in the United States, where several changes to funding mechanisms for universities and PRIs are to be proposed in 2012.

In emerging and transition economies the reforms tend to focus on creating new funding and management mechanisms so that PRIs can fulfil their new roles in a market environment. For example, the Russian Federation has introduced performance assessment of PRIs and included evaluation in its federal targeted programmes; in Poland five new Acts aimed at reforms of PRIs came into force in 2011; and in China and the Czech Republic there are calls for continued reforms of PRIs. In many OECD economies the focus is different. Apart from ensuring the quality and effectiveness of research, the current round of PRI reforms aims at better articulating the role of public research in the firm-centred national system of innovation and at allocating resources to top-level research and strategic focus areas ("excellence" and "relevance").

Wide-ranging reforms have been carried out in the PRI and university sectors in Finland, Hungary and Spain. A new department was established in 2011 in Japan's Science and Technology Agency to make recommendations on the reform of Japan's science and technology system. Turkey is planning to launch a new reform initiative in 2012. Many of the United Kingdom's public laboratories have recently gone from contractor status, to "arm's-length" executive agency status, to full privatisation. This has led to a shift in the relationship between these agencies and their former parent departments or ministries, as the latter have become customers (rather than sponsors) of their research and services. The laboratories now have to compete against one another and against universities for government contract research funds.

As mentioned, some reforms aim at making the management and research of PRIs and universities more autonomous, in recognition of the need for greater autonomy given today's more dynamic and multifaceted mode of innovation. Finland's new *Universities Act* (2010) grants universities independent legal status; Hungary's new *Academy Law* (2009) gives the Hungarian Academy of Sciences self-governing rights; and Portugal's new law on higher education provides PRIs with greater autonomy for their management and activities.

PRIs and universities continue their internationalisation. For example, Finland's current university reform aims at facilitating operating in an international environment by tapping into international research funding, in addition to co-operating with foreign universities and research institutes.

Other trends include structural reforms to reduce overlapping of PRIs, to enhance the systemic efficiency of the PRI sector and to create critical mass through mergers and restructuring.

Enhancing linkages within the national innovation system, including science-industry relations and relations between PRIs and universities, continues to be a focus of public research reforms in many countries.

Australia, the Czech Republic, Denmark, Estonia, Finland, the Netherlands, Poland and Slovenia have adopted in recent years roadmaps to guide future infrastructure development. China and the Russian Federation have invested heavily in expanding and modernising their R&D infrastructures. R&D infrastructures in emerging platform technology areas (nanotechnology, biotechnology, grid computing and information and communication technologies [ICTs] more generally) have been a particular focus in Australia, Israel, the Russian Federation, Slovenia and South Africa, while infrastructure for research on social challenges such as health have received special attention in Germany and Italy. ICT-based information infrastructures are another focus in China, Hungary, New

Zealand, Portugal and South Africa. Improvement of national R&D infrastructures has also been carried out with the objective of creating world-class centres for R&D and innovation (Ireland, the United Kingdom) and, where possible, through participation in international infrastructure initiatives such as ESFRI (Hungary, Norway, Spain) and the European Spallation Source (Denmark, Sweden).

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PUBLIC-SECTOR INNOVATION

Rationale and objectives

Innovation in the public sector refers to significant improvements to public administration and/or services. Drawing on definitions adopted for the business sector (*Oslo Manual*) and their adaptation in the Measuring Public Innovation (MEPIN) project, public-sector innovation can be defined as the implementation by a public-sector organisation of new or significantly improved operations or products.

Today, increasingly sophisticated public demand and new challenges due to fiscal pressures require innovative public-sector approaches. However, knowledge about public-sector innovation, and its results, costs and enabling environment, is fragmented. Public-sector innovation is rarely institutionalised in government budgets, roles and processes, and there is limited knowledge and awareness of the full range of tools available to policy makers for accelerating innovation.

The OECD is currently working on developing analytical and measurement frameworks to understand and foster public-sector innovation. This includes developing an Observatory of Public Sector Innovation that will build a classification of the components of the innovation process with a view to understanding the factors that support the development of innovations, and their results, in order to map existing innovation approaches and policies.

Major aspects

Public-sector innovation involves significant improvements in the services that government has a responsibility to provide, including those delivered by third parties. It covers both the content of these services and the instruments used to deliver them. OECD countries pursue various types of innovation in public service delivery. Many of these approaches create services that are more user-focused, are better defined and better target user demand. Innovation can alter both the supply of services, by improving their characteristics, and demand for services, by introducing new ways to articulate demand for and procure them.

Recent policy trends

Countries have adopted various approaches at national level to foster public-sector innovation. They range from developing whole-of-government innovation strategies that address the role of the public sector as innovator (*e.g.* Finland) to creating structures to support individual organisations in their innovation processes (*e.g.* Denmark). There are also dedicated strategies and action plans for innovation in public services, such as Australia's Centrelink Concept Lab which enables the testing and evaluation of potential service delivery improvements in actual workplace conditions. Innovation strategies can also be adopted in individual public-sector organisations, but tend to be driven by individuals with sufficient vision and determination to push the innovation process (Koch and Hauknes, 2005).

Some innovative approaches in service delivery found during initial research (OECD, 2012, forthcoming) include:

Digital technologies (web 2.0): Information and communication technologies (ICTs) enable governments to meet new demand for online services, to tailor services to individual needs through service personalisation, and to reduce transaction costs.

Governments use ICTs to transform service delivery and engage users in the planning or delivery of services through the use of web 2.0 tools. The US Federal Emergency Management Agency uses Twitter to share information with citizens during crises. Mexico has explicitly named ICTs as a key component of their strategy to modernise public service delivery.

Partnerships with citizens and civil society: The engagement of individual citizens and civil society organisations as partners in the delivery of public services (also known as co-production) can lead to higher user satisfaction and may reduce costs. Partnerships that offer greater user control and ownership can transform the relationship between users and service professionals. Such practices are still mainly at the developmental stage, but pilot programmes in the United States and the United Kingdom have shown promising results in terms of increased satisfaction and value for money, for example in health and social protection (OECD, 2011). The UK Expert Patient, the US Diabetes Self Management Program and the Canadian Chronic Pain Self Management Program are examples of co-production practices in which peers help other patients.

Partnerships with the private sector: Commissioning or partnering with the private sector can reduce the costs of service provision to government and provide innovative approaches. Public-private partnerships (PPPs) are increasingly used for services traditionally obtained through public procurement. They can offer innovative ways to manage risks and improve efficiency in designing and procuring public services. Australia, France, Germany, Korea and the United Kingdom increasingly rely on PPPs to provide capital for construction, maintenance and provision of infrastructure projects (*e.g.* hospitals).

Solutions to improve access condition: Some approaches to innovation in service delivery focus on bringing the service closer to the user by improving access conditions. Examples include changes to the physical location of services, such as multi-service centres that provide one-stop shops for users and integration of different channels of service provision to provide greater choice and personalisation. For example, the mission of Shared Service Canada is to consolidate IT infrastructure, including email, data centres and networks, across 43 departments and agencies.

The choice of the solution depends on external as well as internal factors such as the country's system for service delivery (rules and regulations, financial frameworks, organisational settings) and the extent of involvement of external actors in the delivery process. Different approaches have also been combined (*e.g.* the use of ICT in coproduction approaches with service users).

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PART III

Chapter 7

STI policy profiles: Strengthening interactions for innovation

This part presents, in a series of policy profiles, the main trends in national science, technology and innovation (STI) policies, with a particular focus on policies and programmes introduced between 2010 and 2012. It discusses the rationale for public policy intervention, major aspects of STI policies and STI policy instruments, and recent policy developments across countries, in a large variety of STI policy areas. This chapter focuss on the strengthening of knowledge flows and transfer mechanisms (e.g. ICT infrastructures, intellectual property rights, clusters, open science and commercialisation of public research results, international linkages).

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.

ICT INFRASTRUCTURES AND ICT POLICIES FOR INNOVATION

Rationale and objectives

Successful development and application of information and communication technologies (ICTs) can boost innovation productivity and output. At firm level ICTs feed into many types of innovation processes and create efficiency gains that free up scarce resources for use elsewhere. Existing empirical studies, including ongoing OECD work, point to a positive link between increased adoption and use of ICTs and economic performance at the firm and macroeconomic level (OECD, 2012).

Over the past two years, cloud computing has emerged as one of the most important platforms for innovative services. In particular, it significantly reduces information technology (IT) barriers for small and medium-sized enterprises (SMEs), thereby allowing them to expand faster and innovate. Instead of making significant, up-front investments in IT infrastructure and software, they can adopt a pay-as-you-go model for computing resources. Cloud computing providers also have much lower operating costs than companies with their own IT infrastructure because of their global scale and ability to aggregate the demand of many users, especially in public clouds. They can provide computing resources rapidly and flexibly in response to changing needs (OECD, 2011).

Major aspects

One consequence of the recognition of the transformational character of ICT is the general economic dimension of ICT-related policies. Indeed, ICT-related policies have become mainstream economic policies for underpinning growth and jobs, increasing productivity, enhancing delivery of public and private services, and achieving broader socioeconomic objectives.

Survey results show that governments see ICTs and the Internet as a major platform for research and innovation across all economic sectors (OECD, 2012). Policy makers recognise that policies to promote development of ICTs are important for innovation processes and economic growth. The main policy areas of concern are: broadband deployment, support for ICT research and development (R&D), provision of venture finance to innovative entrepreneurs, and technology diffusion to businesses.

Recent policy trends

As recovery from the financial crisis is still very tentative and budget deficits and unemployment rates are at historically high levels, governments have raised the priority of measures that promote ICT-based innovation, diffusion and uptake of Internet technologies.

OECD countries' top ICT policy priorities in 2012 are: broadband deployment, ICT skills and employment, government online, and the security of information systems and networks. R&D programmes, technology diffusion to business, electronic settlement/payment and digital content also rank highly.

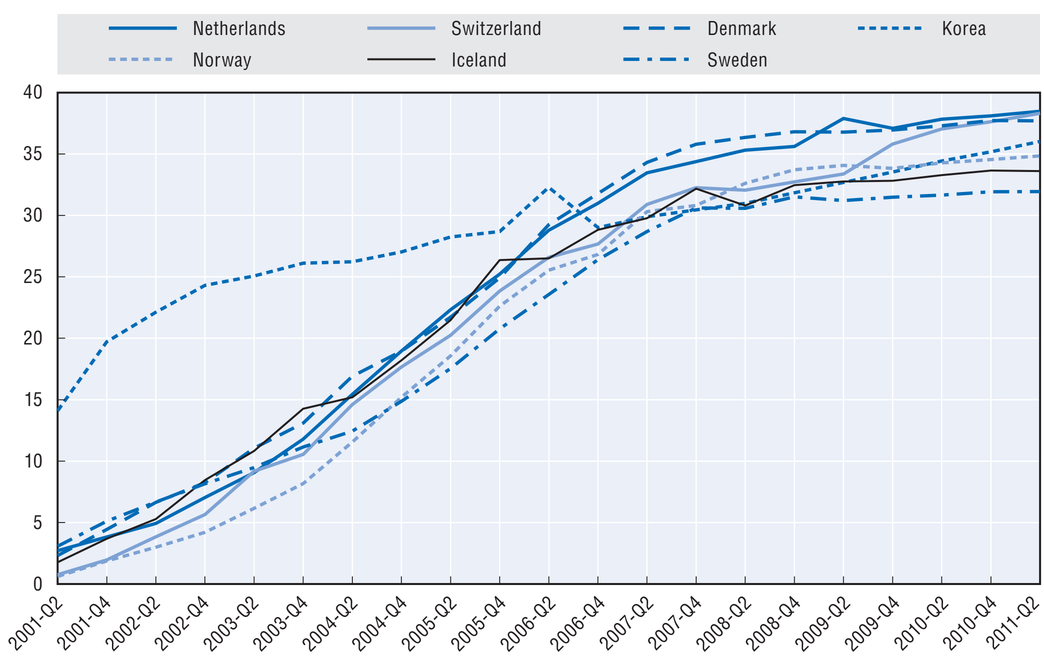
Broadband infrastructure is a policy area that is considered very significant for innovation. Available high-speed broadband is viewed as a driver of innovation, growth and jobs in the ICT industry and beyond. High-quality broadband infrastructures must reach a critical mass of potential users to enable the development and uptake of broadband applications in sectors such as health care, education, and entertainment.

The past few years have seen the development and implementation of national broadband plans. Many governments help fund, or provide targeted interventions for, the geographic expansion of broadband access networks, the upgrading of existing networks to higher speeds, and the adoption of broadband by specific social and economic groups. As governments wind down stimulus spending, they emphasise the role of private-sector investment in high-speed broadband networks. Many have reviewed their legal and regulatory frameworks to ensure they are appropriate for the levels of investment necessary to achieve their policy goals.

National plans differ in terms of their approaches to and funding of technology. In Belgium, the Netherlands and Switzerland they are technology-neutral, while Australia, Japan, Luxembourg and Singapore focus on deployment of fibre. For funding, Spain has adopted public-private partnerships, whereas Australia has chosen a largely public funding model.

Figure 7.1. **Fixed (wired) broadband penetration, historically leading OECD countries, June 2001-June 2011**

Number of subscriptions per 100 inhabitants



Source: OECD broadband statistics, 2012, *www.oecd.org/sti/ict/broadband*.

StatLink http://dx.doi.org/10.1787/888932690016

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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 facilitates 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 and many OECD governments are keen to enhance their competitive advantage and to help firms and entrepreneurs within 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 an increase in the competitiveness of firms.

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 which 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 and Portugal have made cluster policies an integral element of their national innovation strategies or plans. Other countries have programmes to promote the creation of new clusters or to strengthen existing clusters. Recently, Belgium, Germany and the Netherlands have explicitly 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.

Technology specialisation: There is also a growing effort to foster cluster development around enabling technologies (*e.g.* information and communication technologies [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 revealed technological advantage index for 2007-09, reveals a strong biotechnology and nanotechnology specialisation in Denmark, Singapore, New Zealand, a

Table 7.1. **Cluster development support policies and specialisation patterns in selected OECD countries, 2012**

Creating and consolidating clusters	Creation of new clusters through co-ordinated action for R&D activities (*e.g.* through public funding programmes).	Argentina, Canada, Chile
	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, Sweden
Networking platforms	Science-science (*e.g.* promotion of collective research centres, centre of excellences)	Belgium, Canada, France, Norway, South Africa, Spain, Switzerland
	Industry-science (*e.g.* promotion of public-private networks)	Argentina, Australia, Belgium, Canada, Colombia, Denmark, Finland, France, Germany, Italy, Norway, Poland, Portugal
	Industry-industry: promotion of sectoral networks	Belgium, Colombia, Denmark, Germany, Poland, Portugal, Spain
Technology specialisation[1]	Relative specialisation in biotechnology and nanotechnology	Australia, Belgium, Canada, Denmark, Ireland, Israel, Netherlands, New Zealand, Poland, Spain, Switzerland, United States, Singapore
	Relative specialisation in environment-related technologies	Australia, Austria, Canada, Czech Republic, Denmark, France, Germany, Hungary, Japan, Norway, Poland, Russian Federation, Singapore and Spain
	Relative specialisation in ICTs	Canada, China, Finland, Ireland, Israel, Japan, Korea, Malaysia Singapore and Sweden
Internationalisation	Cluster competition and cluster excellence programmes	Austria, Belgium, Germany, France, Ireland, Japan, Netherlands
(Towards) smart specialisation	Australia, Austria, Belgium, Czech Republic, Estonia, Finland, Germany, Ireland, Israel, Poland, Russian Federation, Spain, Turkey, United Kingdom	

1. Based on Revealed Technology Advantage (RTA) index in Figure 7.2.
Source: Country responses to the *OECD Science, Technology and Industry Outlook 2012* policy questionnaire and OECD (2010), *OECD Science, Technology and Industry Outlook 2010*, OECD, Paris.

strong environment-related technologies specialisation in Denmark, Norway, Hungary, Poland and Japan, a strong ICT specialisation in Singapore, Finland, the People's Republic of China and Korea (Figure 7.2).

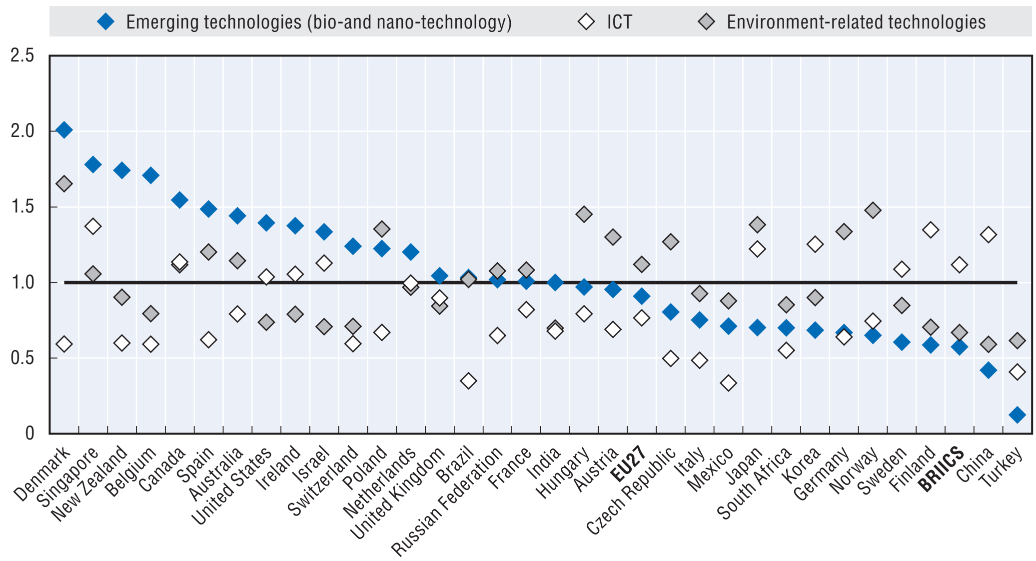
Recent policy trends

Many OECD countries and regions are combining clusters policies and specialisation strategies. For example, the states of Berlin and Brandenburg (innoBB) have developed a joint innovation strategy to focus public support on five clusters: health care; energy technology; transport, mobility and logistics; optics; and ICT/media/creative industry. This inter-regional strategy focuses on "entrepreneurial discovery", on market opportunities through intra-cluster co-operation and on the development of innovative technologies. It has developed an inter-regional structure for venture capital, the Business Angels Club Berlin-Brandenburg e.V. to support entrepreneurs and strengthen innovative enterprises.

Australia's rural development and corporation initiatives are funded by a co-investment model based on a combination of industry levies and matching government funding. They bring industry and researchers together to establish strategic research and development directions and to fund projects that provide industry with the innovation and productivity tools needed to compete in global markets. In recent years, Australia has adopted a hybrid model for developing specialisation precincts and hubs to build on

Figure 7.2. **Revealed technology advantage in selected fields, 2007-09**

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 500 patents over the periods are included in the figure.

BRIICS refer to Brazil, Russian Federation, India, Indonesia, China and South Africa.

Source: OECD, Patent Database, February 2012.

StatLink http://dx.doi.org/10.1787/888932690035

areas of existing research strengths, while also funding national collaborative research infrastructure networks. Precincts allow Australia to take advantage of the clustering of research infrastructure and collaboration, and national collaborative networks allow researchers to take advantage of the best expertise and infrastructure, wherever it may be physically located.

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Open science

Rationale and objectives

While science has always been open – indeed openness is critical to the modern scientific enterprise – there are concerns, and some anecdotal evidence, that the processes for producing research and diffusing its results have become less open. There are several reasons. First, science is increasingly data-driven and expensive, but access to scientific data is often subject to administrative, legal and privacy regulations. Access also requires adequate information and communication technology (ICT) infrastructure. Other limits on openness in science include policies and practices at universities that place a premium on patenting over publishing and weak incentives for researchers to share data. This can also act as a barrier to the replication and validation of scientific experiments. Finally, the policies and practices of scientific publishers that limit web-based access to research results may also make access to scientific data less open.

In response to these concerns, governments and the research community, including publishers, are seeking to preserve and promote more openness in research. "Open science" refers to an approach to research based on greater access to public research data, enabled by ICT tools and platforms, and broader collaboration in science, including the participation of non-scientists, and finally, the use of alternative copyright tools for diffusing research results.

Open science has the potential to enhance the efficiency and quality of research by reducing the costs of data collection, by facilitating the exploitation of dormant or inaccessible data at low cost and by increasing the opportunities for collaboration in research as well as in innovation. Greater access to research data can also help advance science's contribution to solving global challenges by enhancing access to data on a global scale (*e.g.* in the case of climate change data). Open science can also be used to promote capacity building in developing countries while generating opportunities for scientific collaboration and innovation between OECD and developing countries.

Major aspects

Governments, as key funders of public research, play an important role in developing policies to foster greater access to and use of scientific research. For example, public policies and guidance from research funding agencies can facilitate the sharing of data resulting from publicly funded research. They can help research institutions better manage research data through the development of infrastructure and training. They can also provide guidance to researchers on compliance with the various policies governing data access and sharing (*e.g.* intellectual property rights, privacy and confidential issues).

Recent policy trends

Most OECD countries recognise the potential efficiency gains to research from data sharing and use of data generated by publicly funded research. Many countries have worked to strengthen regulatory frameworks and technical and human capabilities so as to encourage data sharing and collaboration (Table 7.2). A number of areas have received significant policy focus.

One is digital infrastructure. Most OECD countries as well as some non-member economies are developing the ICT infrastructure required for the collection, archiving, storage and dissemination of public data and publicly funded research results. Initiatives include the creation of online repositories, digital libraries, online platforms and public databases. In addition, some countries are trying to equip scientific institutions with modern technological resources in order to foster inter-institutional networks and collaboration between research institutions. The development of an information technology (IT) infrastructure also requires policy co-ordination to make the network of digital data repositories and digital libraries interoperable with other national and international data networks.

Several OECD countries are adopting policies to promote open research data, for example by requiring the archiving of research outputs in a digital format (*e.g.* digitised works, e-print archives and electronic databases, open software). This also requires the development of international open standards (*e.g.* the portal for the Systems Biology Markup Language, a free and open interchange format for computer models of biological processes).

A broad range of government data can be important for research purposes. Australia, Canada, France, the United Kingdom have launched open government data initiatives. In view of government's limited ability to create value and new services from public data, these initiatives increase the opportunities for entrepreneurial researchers to use government databases (OECD, 2011). Some OECD governments are also creating public databases to unify and standardise information about the country's research community, such as scientific publications, profiles of research expertise, research institutions, and research projects (Argentina, France, Norway), which allow researchers to interact.

There is a long-standing trend towards promoting open access to publicly funded research. The most common policy instrument is the requirement to publish in digital format. For example, the US National Institutes of Health (NIH) has made its public access policy mandatory: all funded researchers must submit an electronic version of their final peer-reviewed manuscripts to PublicMed Central (OECD, 2010). New Zealand and Spain also require publication of publicly funded research results in digitised format in an open access repository. A number of countries are promoting the use of free licences by research institutions and public bodies. Public research funding in Estonia, for example, covers the costs of publishing in open access journals.

The push towards open access has also led to the emergence of new business, public funding and co-operative financing models. One is the initiative developed by Co-Action Publishing with Lund University, the National Library of Sweden and *Nordbib* to adopt online guides to open access journals publishing and self-archiving for researchers; another is the creation of a Directory of Open Access Journals to rank countries' national policies on access.

There is a growing interest among policy makers in open collaborative work (Canada, the United States). This implies identifying and reducing barriers to inter-institutional, inter-disciplinary and international collaboration among research institutions, industry and citizen groups. For example, science-industry initiatives are increasingly used to reduce the costs of and barriers to drug discovery by applying semantic technologies to available data resources (*e.g.* Open PHACTS, Open Pharmacological Concepts Triple Store). Government is not the only actor: entrepreneurial initiatives are also emerging, such as ResearchGate, a social networking site for scientists to connect, raise and answer questions, and share papers and data.

Table 7.2. **Recent policy measures to promote open science**

	Digital data storage infrastructure (Creation of online)	Open Data (Promotion of)		Open Access (Promotion of)		Collaborative work (Online)
	Repositories and archives, libraries in research centres and governments	Digital format for research outputs (*e.g.* funds)	Open Government	Open licenses for datasets, libraries	Publication in open access journals or open resources (*e.g.* funds)	Researchers industry society
Argentina			×			
Australia	×	×	×	×		
Canada	×		×			
People's Republic of China	×		×	×		
Colombia	×					
Czech Republic	×					
Denmark	×			×		
Estonia	×			×	×	×
Finland	×			×		×
France	×		×	×		
Germany	×	×		×	×	
Greece	×			×		
Hungary	×		×	×		
Luxembourg	×			×	×	
New Zealand	×		×		×	
Norway	×		×	×		
Poland	×			×		
Russian Federation	×					×
Slovak Republic	×					
Slovenia					×	
South Africa	×					
Spain	×	×		×	×	×
Switzerland	×					
Turkey	×	×			×	
United Kingdom	×		×			×
United States	×		×	×	×	

Source: Country responses to the *OECD Science, Technology and Industry Outlook* 2012 policy questionnaire and OECD (2010), *OECD Science, Technology and Industry Outlook* 2010, OECD, Paris.

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COMMERCIALISATION OF PUBLIC RESEARCH

Rationale and objectives

The transfer, exploitation and commercialisation of public research results is a critical area of science, technology and innovation policy. Efforts to ring-fence public research in a context of fiscal austerity in many OECD countries – as well as competition from new players in Asia – have increased pressure on universities, public research institutions (PRIs) and governments to increase the economic outputs from and impact of investments in public research.

While knowledge and research generated by the public research system is diffused through a variety of channels – mobility of academic staff, scientific publications, conferences, contract research with industry and the licensing of university inventions – much of the policy focus in OECD countries has centred on promoting knowledge transfer via a dual, but rather linear, model of commercialisation. This model is characterised by supply-push forces whereby universities and PRIs transfer academic inventions via the sale, transfer or licensing of intellectual property, often on an exclusive basis, to existing firms or to new ventures (*e.g.* academic spin-offs). The converse of the supply-push model is a demand-pull model based on contract research or collaborative research and development (R&D) whereby universities and PRIs are solicited by industrial actors to find solutions to production and innovation problems.

These two previously distinct models or paths for commercialisation are increasingly integrated, with research and innovation relying on greater "openness" and collaboration both upstream, on the research side, and downstream, on the commercialisation path. Openness in science (open science) increases the channels for transferring and diffusing research results while open innovation in business firms creates a division of labour in the sourcing of ideas and their exploitation. This has given rise to intermediaries that broker commercialisation activities, notably intellectual property (IP) services.

Major aspects

Building the required institutional capabilities at universities and PRIs is central to public efforts to commercialise public research. Following the passage of the Bayh-Dole legislation in the United States – which gave public research institutions incentives to patent and license academic inventions – many countries have developed technology transfer and licensing offices (TTOs/TLOs) at universities and PRIs. However, only a few countries and a few institutions have achieved a track record in commercialising the results of public research through TTOs/TLOs. Moreover, many countries, universities and PRIs continue to base the productivity of TTOs on traditional measures of technology transfer such as patents and licenses. Even if these have been increasing in OECD countries (Figure 7.3), they represent a very small share of the knowledge that is transferred from universities and PRIs.

In response, OECD countries such as Canada, the Netherlands, and Sweden have combined the institutional and legal support for technology transfer and commercialisation with support to entrepreneurial channels for commercialising knowledge: university start-ups, incubators and accelerators, mentoring and training for academic entrepreneurs, and policies to promote venture and angel capital, government seed funds or platforms to link angel investors and small and medium-sized enterprises (SMEs).

However, each stage of the commercialisation process has its own characteristics and further efforts may be needed to target the support instruments, with a special focus on the early stages of the process, the most difficult for SMEs and start-ups to overcome. Norway has developed measures for the commercialisation of research by publicly funded research institutes and organisations (the FORNY2020 programme) which supplies, among other things, proof-of-concept funding.

Recent policy trends

In recent years, many countries have sought to broaden the channels for commercialisation of public research by promoting two-way flows between industry and science, for example through 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. They have also sought to accelerate the pace of knowledge transfer in various ways. First, national patent systems have been enhanced to reduce risks and backlogs and to promote patenting by start-ups and SMEs (*e.g.* the US *America Invents Act*, the United Kingdom's fast track system for "green patent applications", the acceleration of patent examinations in Japan and in Canada since March 2011, while in New Zealand, a new Patent Bill consistent with efforts to promote innovation and technology transfer is being considered).

There is also targeted support for IP management at PRIs through funding, guidelines and skills training. The UK government is establishing the National Intellectual Property Management Office to support capacity building in technology transfer and commercialisation of IP, including via partnerships with UK technology transfer offices and staff secondments. Australia's Commercialisation Australia programme provides a range of commercialisation support services of the order of USD 180 million (AUD 278 million) to 2014. Korea has announced an IP fund of USD 60 million (KRW 50 billion) for technology transfer and commercialisation by PRIs. To increase awareness and proficiency, Norway offers since 2010 a grant scheme supporting the development of new educational programmes for IP at higher education institutions. Similarly the United Kingdom has established the IP Fund to provide financial support to institutions for the statutory protection and maintenance of intellectual property rights (IPRs). Denmark's IPR Package and Facilitation of Co-operation on IPR scheme provides about USD 1 million (EUR 0.7 million) to assist companies and entrepreneurs manage IPRs.

National funding agencies (*e.g.* the National Institutes of Health [NIH] in the United States, model contracts for R&D collaboration in Denmark) and individual institutions have also made efforts to develop standard licensing agreements for academic inventions and to use collaborative intellectual property mechanisms such as patent pools, IP clearing houses, and IP sharing agreements to create new commercial opportunities.

Anecdotal evidence suggests that many TTOs have expanded their role and services from managing technology transfer (invention disclosures, filing patents) to a wide range of IP management activities and have increased the quality of technology transfer staff through training and competitive employment policies.

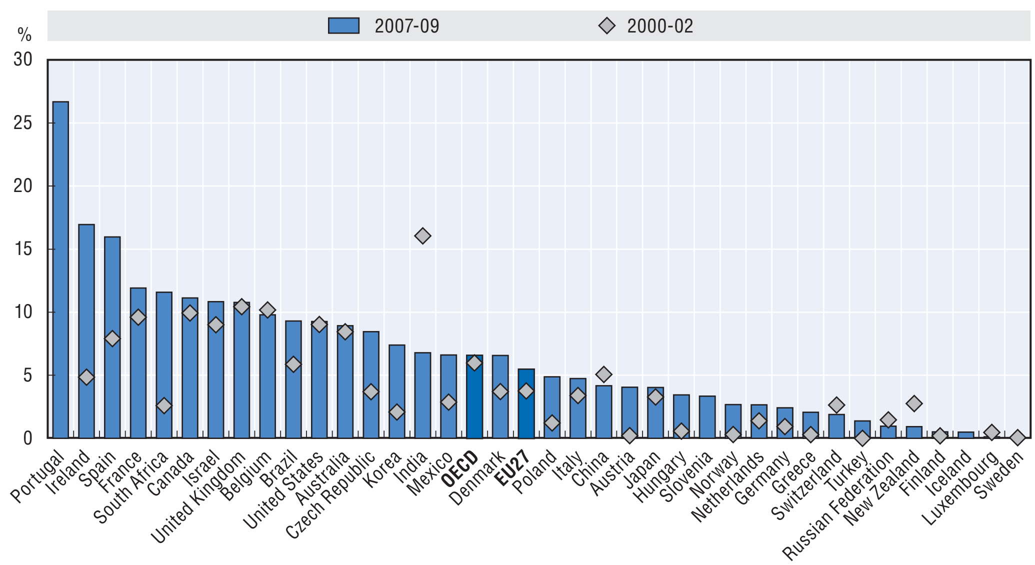
Some countries and funding agencies such as the NIH in the United States and Canada's Natural Science and Engineering Research Council (through its new IP Policy) have made efforts to develop good practice policies for patenting and licensing of IP from public research with a view to encouraging broader diffusion of public research results, fostering knowledge spillovers and creating additional opportunities for commercialisation.

Another trend concerns efforts to align or co-ordinate a range of public instruments to support SMEs' capacity to commercialise knowledge. Commercialisation programmes tend to be decentralised and target support to a range of actors owing to the multi-phase process of commercialising research results. However, this can result in the loss of economies of scale or synergy effects. Efforts to diversify support while bringing support programmes under one "roof" are increasingly encouraged (*e.g.* France's SATT for creating companies to accelerate technology transfer or Japan's Innovation Network).

Finally, commercialisation policies tend to focus on national commercialisation pathways, yet the markets for IP and technology are increasingly international. Barriers to international commercialisation may include national differences in regulations, technology standards or IP rules. This situation contrasts with the well-established system of international research collaboration within and outside OECD countries.

Figure 7.3. **Patents filed by public research institutions, 2000-02 and 2007-09**

As a percentage of patent applications filed under the Patent Cooperation Treaty (PCT)



Note: Public research institutions cover the government sector, higher education and hospitals. Patent applicant's names are allocated to institutional sectors using a methodology developed by Eurostat and *Katholieke Universiteit Leuven* (KUL). Owing to the significant variation in names recorded in patent documents, applicants be misallocated to sectors, thereby introducing biases in the resulting indicator. Only economies having filed for at least 250 patents over the period are included in the figure.

Source: OECD Patent Database, February 2012.

StatLink http://dx.doi.org/10.1787/888932690054

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 more of the benefits they generate: without such a mechanism inventions would be immediately imitated and inventors' return on their investment would be reduced. Patents are granted in return for disclosure of the invention: they 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 (domestic market), in accordance with their legal statute. Most patent offices are national; the main exception is the European Patent Office (EPO).

Major aspects

Patent filings have exploded worldwide, rising from 997 000 applications filed in 1990 to 1 980 000 in 2010, according to the World Intellectual Property Organization (WIPO). Some observers have raised concerns regarding a decline in patent quality owing notably to lower legal standards of novelty and to the work overload of examiners in patent offices. Since the mid-2000s patent offices and court decisions have sought to raise quality. Patents of poor quality are often held responsible for the rise in dubious litigation for alleged infringement ("trolling") in certain jurisdictions over the past two decades.

Over the last decades patent subject matter has expanded to emerging 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, and many patents have been filed in these fields. Some observers have noted however that patenting in these fields potentially hampers the diffusion of technology, with possible negative impacts on inventive activities in areas that are close to science and to mental processes (which are non-patentable areas). The law, court decisions and practices regarding patenting have tended to be more restrictive in the recent past in many countries.

According to WIPO, the average share of non-residents among patent owners worldwide increased from 31% in 1990 to 38% in 2010, in parallel with the globalisation of the economy. Over this period, efforts have been made to make the patent system more global. In particular, the Patent Cooperation Treaty (PCT), handled by WIPO, facilitates simultaneous patent applications in a number of countries (although the processing and the grant remain national). Discussions among patent offices have sought to improve the compatibility of patent laws across countries. The Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) was a first step in this direction. This international treaty, established in 1994 and implemented by the World Trade Organisation (WTO), established strict rules 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; for example, the "patent prosecution highways", a number of bilateral agreements between national offices to exchange work on particular applications.

Developing countries were granted a delay for implementing the TRIPs until 2013, but many have already translated at least part of it into law, with the view that it would serve domestic innovation. The inclusion of drugs in the compulsory subject matter has raised the issue of the access of the poor to essential care. Therefore, some flexibility has been introduced, notably since the Doha agreement (which allows poor countries to import drugs from countries in which the corresponding patents are not necessarily enforced). Another issue in some developing countries is enforcement of patent rights. This requires a strong and independent judicial system, without which infringement will flourish. Countries such as the People's Republic of China and India have made significant efforts in this area.

Recent policy trends

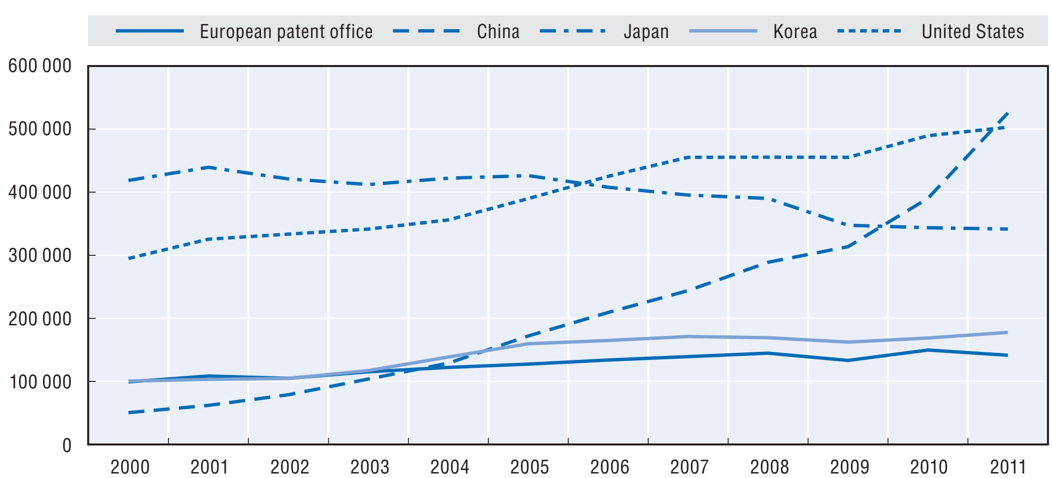
The United States passed in 2011 the *American Inventor Act*, the most complete reform of its patent system since 1952. It adopts the principle of "first inventor to file" (instead of "first to invent"), and a post-grant opposition system aimed at revoking early in the process and at relatively low cost patents deemed invalid.

In 2011-12, the European Union made significant progress towards a "unitary patent" that would cover all signatory countries and complement the current cumbersome and costly bundling of national patents granted by the EPO. European countries have agreed on a reduction of translation requirements and on setting up a unitary judicial system for these patents.

In 2011 China and Korea updated and intensified their national strategies aimed at encouraging the use of intellectual property by industry (the IP Protection Action Plan, which includes financial incentives for businesses, in China, and the IP Basic Law in Korea). In 2008 Japan drastically reduced fees for SMEs.

Figure 7.4. **Patent filings, 2000-11**

Number of applications in major patent offices



Source: WIPO, *www.wipo.int/ipstats/en/statistics/patents* and national patent offices.

StatLink http://dx.doi.org/10.1787/888932690073

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- See Chapter 2, Sections 2.2 and 2.3 on the legal foundations of patents.
- See Chapter 2, Section 2.4 on the rationale for patents and their economic impact.
- See Chapter 3 on patenting procedures across jurisdictions.

INTELLECTUAL PROPERTY MARKETS

Rationale and objectives

Intellectual property rights (IPRs) such as patents, trademarks, designs and copyrights are increasingly traded in markets. Public policy plays a role in shaping the evolution of IP markets and thus their impact on innovation. In today's highly networked world, the circulation of ideas is vital to innovation. Inventors, designers and authors are not always best placed to exploit their knowledge. Organisations are therefore increasingly adopting open innovation practices, but 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 defensive or litigation purposes. They may also be used to secure finance by pledging the IP as security. IP market activities may provide an incentive for investment in new knowledge creation but can also lead to opportunistic rent-seeking behaviour, with potential perverse effects. The experience of the recent financial crisis provides a reminder of the importance of transparency, market design and incentives for complex products such as IP.

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 10.6% between 2000 and 2010 (Figure 7.5), well above the growth of OECD gross domestic product (GDP) over the same 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 by Zúñiga and Guellec (2008) at 13% in Europe and 24% in Japan. Based on confidential US tax data for 2002, Robbins (2006) estimated domestic and international licensing of patents and industrial processes to be USD 66 billion, or 4.5% of the total private R&D stock (BEA, 2011). Arora and Gambardella (2010) use these figures to estimate the size of the global market for technology at USD 100 billion.

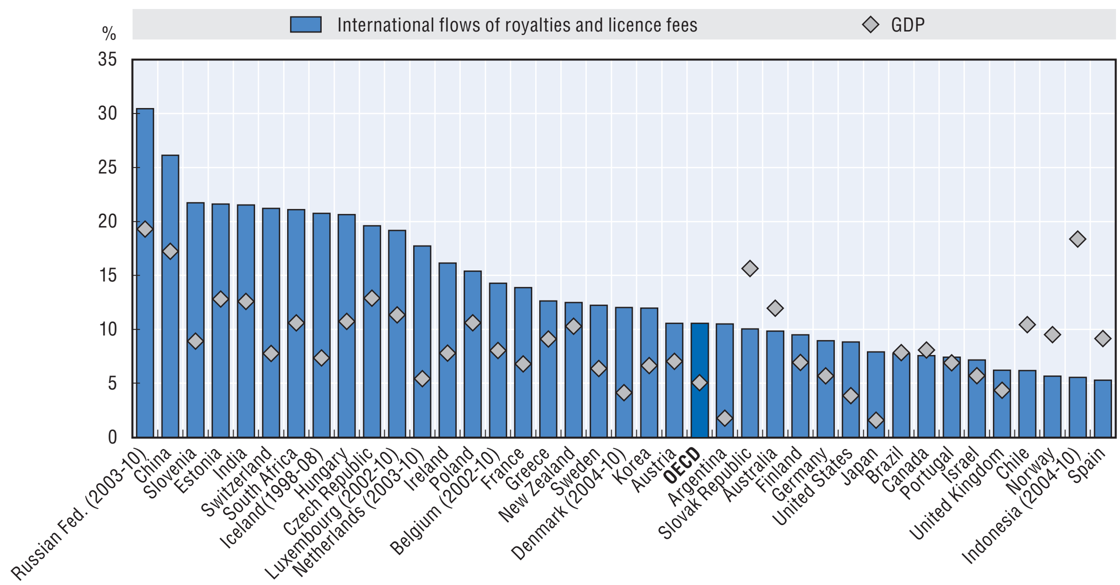
Acquisition of IP has become a key strategic tool for companies seeking to maintain and increase their markets while IP transactions and disputes, especially involving ICT patents, have been widely reported in the media. The patent marketplace has also been transformed with the appearance of new intermediaries and business models, such as those described below (Millien and Laurie, 2009; Yanagisawa and Guellec, 2009; Chien, 2010; Hagui and Yoffie, 2011).

Patenting funds aim to reduce transaction costs and litigation risk by pooling patents and licensing the entire portfolio to members. However, they may induce asymmetries between insiders or incumbents and outsiders.

Patent-assertion entities acquire IP to assert against practising companies. Although they bring liquidity into the market, their business model is controversial because non-practicers are immune from retaliatory IP suits. This allows them to extract a maximum surplus from unlicensed practising companies, which could in turn discourage innovation in complex areas of research.

Figure 7.5. **International IP flows through royalties and licence fees, 2000-10**

Average annual growth rate in USD, percentage



Sources: OECD, Technology Balance of Payments Database, March 2012; OECD, Trade in Services Database, March 2012; World Bank, World Development Indicators, March 2012; OECD, Annual National Accounts Database, March 2012.

StatLink http://dx.doi.org/10.1787/888932690092

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.

Recent policy trends

A number of policy initiatives and instruments are used to enhance the impact of IP markets on innovation. A report by the US Federal Trade Commission (2011) noted the importance of patent quality for market efficiency. Authorities are considering whether to encourage a more complete record of patent assignments. In most jurisdictions, post-filing identification of assignment changes is voluntary, even though registration is necessary to assert ownership against third parties (USPTO, 2010). In contrast, Japan's patent law has been amended to remove the requirement to register licensing agreements as a condition for licencees to assert their rights against third parties.

Many countries are reviewing taxation rules for IP revenue. Such rules can affect how companies exploit knowledge. 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 – often subject to fair, reasonable, non-discriminatory (FRAND) licensing pledges – in order to prevent abuse of market power.

Governments and public-sector organisations are considering playing a more active role where IP markets are perceived to be deficient. Denmark has set up a new web-based portal (IP-Handelsportal) to facilitate co-operation and trade in IP. The World Intellectual

Property Organisation (WIPO) has set up WIPO Green, a hub aimed at enabling environmental technology owners to make IP and know-how available to users through a searchable public database of available intellectual property assets and resources. *Re:Search*, a WIPO-led consortium, plays a similar role for research on treatments for neglected tropical diseases.

Some governments are also playing an active role in the assembly of patent portfolios. The Korean government helped launch Intellectual Discovery, a defensive fund which buys patents that might be asserted against domestic firms. Semi-public funds have also been set up to acquire and help commercialise research produced by public research institutions, such as Japan's Life Science Intellectual Property Platform Fund and the France Brevets fund. Beyond patents, the UK *Hargreaves Report* (2011) recommends the formation of a digital copyright exchange to simplify clearance for use of copyrighted content.

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Building international STI linkages

Rationale and objectives

Countries engage in international (including bilateral and multilateral) co-operation in science, technology and innovation (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 effectively challenges of a regional or global nature.

The economic growth and social development of all countries depend on advances in scientific and technological (S&T) knowledge, which require sustained research efforts and the widest possible circulation and exchange of ideas and information. Furthermore, the global challenges facing the world today require a collective response from all affected parties, and science, technology and innovation will play an essential role.

The need for international technological co-operation among enterprises is another reason for policies to promote international linkages in STI. Small and medium-sized enterprises (SMEs) should be a special focus, as they lack the financial, human and other resources needed to operate internationally.

Globalisation also offers reasons for governments to introduce policies to help maintain the competitiveness of their economy and preserve jobs, while taking advantage of the internationalisation of STI processes.

Major aspects

General policies for STI co-operation

The main approaches to developing mutually beneficial S&T exchanges and co-operation across borders include exchanges of students, scientists and engineers, dissemination of research results through international conferences and journals, open access to research data and networks, joint project calls and funds, and joint research projects, institutes and facilities. S&T co-operation agreements between countries serve as a framework for carrying out these activities bilaterally or multilaterally.

International public research co-operation to address global challenges

In the context of increasing globalisation of research and development (R&D), the internationalisation of public research continues to receive policy attention, and measures supporting the internationalisation of public research institutions (PRIs) and universities are on the rise in recent years. There is also increasing recognition of the need for international co-operation in STI to address global challenges.

Internationalisation of business research and locational policies

Policies to facilitate international technological co-operation by firms have traditionally focused on improving framework conditions, including protection of intellectual property, application of international standards, and enforcement of contracts, so as to facilitate the technological activities of firms and their co-operation with universities and PRIs in foreign countries. With globalisation, countries increasingly compete by providing conditions that attract foreign R&D and innovation activities, through so-called locational policies to attract foreign firms and institutions to conduct research and innovation and to retain these activities in national companies.

International linkages of the highly skilled

Human linkages play a key role in all aspects of international co-operation in STI. Policy measures to facilitate the mobility of the highly skilled have therefore been emphasised either in the framework for international STI co-operation, or as part of human resource policies for innovation and policies on education for innovation.

Recent policy trends

General policies for STI co-operation

Governments promote international co-operation in STI through bilateral, and to a lesser extent regional, agreements. Recent years have seen an increasing number of S&T co-operation agreements between OECD countries and non-OECD economies, such as Argentina, Brazil, the People's Republic of China, Colombia, India, the Russian Federation and South Africa. Such agreements occur not only at national but also at sub-national and institutional levels. Government agreements still feature a strong focus on science and research, although innovation is also targeted in some cases.

In recent years, Australia, Colombia, Finland, Germany and the United Kingdom have adopted STI internationalisation strategies with a comprehensive framework for international co-operation in STI. Belgium, France, and Hungary manage international co-operation in STI without such strategies.

While science co-operation has long been an aspect of diplomacy, Japan and Turkey have recently launched specific science diplomacy initiatives. Japan's Science and Technology Research Partnership for Sustainable Development (SATREPS) promotes international joint research projects based on developing countries' needs which address global challenges and aim to benefit society.

International public research co-operation to address global challenges

In recent years countries have opened up national research programmes and amended legal and framework conditions to allow foreign institutions and researchers to participate in research programmes and access research infrastructure funded by national sources. Australia, Finland, Ireland, Norway and Slovenia have opened key national funding programmes to foreign applicants. Funding agencies in Austria, Germany, Luxembourg and Switzerland have introduced the Lead-Agency Process under which researchers from two or more countries can submit a common proposal to a single funding agency. EU programmes such as the 7th Framework Programme for R&D has served as an important funding mechanism for international collaboration both among the EU countries and with non-EU partner countries.

The internationalisation of higher education has increased in recent years. Canada, Finland, Germany and Ireland have adopted international education strategies to promote national colleges and universities abroad. Meanwhile, universities and research institutes are establishing their presence in foreign countries. Examples include the Sino-Danish Centre for Education and Research, Germany's Max Planck Centres in seven countries and Fraunhofer (project) Centres in six countries, and France's Institut Pasteur in Korea.

A recent study on the governance of international co-operation in STI to address global challenges (OECD, 2012) examined existing multilateral co-operation mechanisms in STI, including the Consultative Group on International Agricultural Research, the Group on Earth Observations, the International Atomic Agency, the International Energy Agency, the

European Joint Programming Initiatives and the Bill and Melinda Gates Foundation. It found that international co-operation to address global challenges is difficult, as it requires effective governance mechanisms. The report sheds light on elements of good governance practices, such as flexible institutional frameworks for priority setting, flexible funding and spending mechanisms, tailored approaches to knowledge sharing and intellectual property, and an outreach strategy to involve actors with weak STI capacities. It called for further efforts to address emerging challenges through international STI collaboration.

Internationalisation of business research and locational policies

While the majority of countries still promote foreign R&D activities through general foreign investment promotion measures, Germany, Ireland, Israel, Japan, Spain, Sweden and the United Kingdom have created specific programmes to promote R&D investment. Brazil and Turkey have set up inter-agency bodies for that purpose, and the Netherlands and Sweden have installed innovation attachés in overseas missions with a special focus on emerging economies.

While many countries foster SMEs' international STI linkages through support for international trade and investment, some have created special programmes and measures. Belgium, Colombia, Hungary and Israel have specialised public agencies to provide innovative SMEs with advisory and consultation support and technical assistance. Canada provides financial support and guarantees for bank credits to help innovative SMEs expand internationally. Ireland's CSET Programme and Israel's Global Enterprise R&D Co-operation Framework both aim to facilitate linkages between the R&D activities of foreign multinationals and domestic SMEs and start-ups. South Africa has set up a national contact point for promoting networking of R&D-performing SMEs with like-minded SMEs abroad, in particular in connection with the EU 7th Framework Programme. With a special focus on research-intensive SMEs, the EU's Eurostars programme serves as an important supplement to national initiatives, especially for small EU countries.

Countries have adopted various measures to improve their attractiveness as international R&D and innovation hubs: tax incentives (Australia, Austria, Belgium, China, Denmark, Ireland, Russian Federation, Spain); subsidies to cover various costs of setting up R&D centres and hiring researchers (Hungary, Japan, Turkey); removing requirements for ownership of resulting intellectual property in the country (Australia); improving the business environment for foreign investment in R&D and innovation (Ireland, the Netherlands, Switzerland); and providing one-stop shops for foreign investors (Belgium, Brazil, Hungary, Japan, etc.).

International linkages of the highly skilled

OECD and non-OECD countries alike recognise the importance of international mobility of the highly skilled and have a range of measures to support brain circulation *i.e.* both inward and outward mobility, ranging from scholarships and financial support (Australia, Canada, China, Estonia, Korea, New Zealand, Norway, the Slovak Republic, Slovenia, Turkey); to simplification of visa procedures (Australia, Belgium, Canada, Estonia, the Netherlands, the Russian Federation, Slovenia); to amendments of immigration legislation (Ireland) and legislation regarding recognition of foreign professional qualifications (Germany); to national treatment of foreign researchers in social welfare entitlements (Sweden). Concrete examples of these measures include China's One

Thousand Talents Programme to attract high-level S&T talent from overseas and Ireland's streamlined immigration arrangements for PhD students, postdoctoral researchers and their families relocating to Ireland.

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PART III

Chapter 8

STI policy profiles: Human resources for innovation

This part presents, in a series of policy profiles, the main trends in national science, technology and innovation (STI) policies, with a particular focus on policies and programmes introduced between 2010 and 2012. It discusses the rationale for public policy intervention, major aspects of STI policies and STI policy instruments, and recent policy developments across countries, in a large variety of STI policy areas. This chapter focuss on the development of human resources for innovation (e.g. education and human resource policies, public awareness campaigns).

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.

STRENGTHENING EDUCATION FOR INNOVATION

Rationale and objectives

Education policies can increase national innovation capacity by equipping more people with the skills required to contribute to innovation and by inspiring talented young people to enter innovation-related occupations.

By raising attainment levels and the general quality of education, education policies can serve the need for diverse and complex skills in innovative activities. Still, the traditional focus of policies aimed at strengthening education for innovation is to improve, more specifically, the teaching of science and maths and to attract more people to science, technology, engineering and mathematics (STEM) at graduate level. This matches the emphasis of most innovation policies on technological innovation. Recently, a more comprehensive view of innovation has emerged, and has led to educational interventions that aim at fostering creativity and thinking skills, as well as non-disciplinary skills such as entrepreneurial capacities, in a wide number of contexts and for all pupils and students, irrespective of their field of study.

Major aspects

Formal education remains the main vehicle for improving the supply of skills for innovation. Some countries, for example Denmark and Estonia, set explicit graduation targets for young cohorts to ensure an adequate supply of advanced skills to the economy. More specifically, many countries invest in schemes to attract more students in STEM disciplines. There are several main types of schemes (also see Table 8.1).

Table 8.1. **Major policy options for increasing the quantity and quality of STEM (science, technology, engineering and mathematics) education, with recent examples**

Intermediate objective	Instrument	Examples
Increase tertiary enrolment in STEM disciplines	Financial incentives for students	Australia (see text); Argentina (undergraduate STEM scholarships and grants); Denmark (PhD scholarships).
	Free remedial classes or tutoring for marginal students	Sweden (see text); Denmark (2010-12) and Germany (2007-13) (MINToring project) have similar pilot schemes.
Improve instruction of science, technology and mathematics in schools	Increase in hours of instruction	Germany (in most *Länder*); Ireland re-introduced science into the primary curriculum in 2003; Norway increased hours of mathematics instruction at primary level.
	Introduction of new curricula, standards or assessments	Australia, Ireland and the United Kingdom (England) are reforming national school curricula. Austria and Norway recently introduced new national tests; Poland made the maths exam mandatory at the matura as of 2010. A German initiative provides early childhood STEM education (Little Scientists' House).
	New teacher education and training programmes	Australia, Austria, Belgium (Fl.), Ireland, Japan, New Zealand, Turkey, United Kingdom.
	Schemes to attract top STEM graduates into teaching	Australia ("Teach for Australia"), United Kingdom ("Teach First")

Source: Country responses to the *OECD Science, Technology and Industry Outlook 2012* policy questionnaire.

A first type of scheme lies in providing monetary and non-monetary incentives to study STEM at tertiary level. Australia's income-contingent student loans, for instance, provide incentives to study mathematics, statistics and science and take up related occupations by reducing the amount of an eligible graduate's compulsory repayments. In Sweden, the government offers free remedial classes to students with grades in science and maths that are too low to enter a university science or engineering programme. Upon completion of the remedial year, successful students are guaranteed a place in university.

Another is investments in K-12 education (from kindergarten to secondary education) to increase pupils' preparation in science and maths and their interest in scientific careers. This includes curriculum reforms that give more time to science and mathematics, and the development of new teacher training programmes, of new standards or of new assessments to trigger changes in teaching practices.

Other programmes target groups that are under-represented in STEM occupations (*e.g.* women or disadvantaged ethnic groups). Prizes for women in science and anti-stereotype campaigns exist in many countries. Belgium (Flanders), Spain and South Africa also use public research hiring or funding mechanisms to promote diversity in STEM.

It is difficult to evaluate these programmes in terms of their contribution to innovation. There is a lack of evidence for many of these programmes even on the intermediate objective of increasing the number of STEM graduates. However, a few programmes have demonstrated encouraging results. Sweden's free remedial classes have helped increase the number of graduates in STEM fields by more than 60% over the last ten years.

Finally, there are programmes to support doctoral and postdoctoral education. While innovation draws on a wide set of skills, excellence in scientific research is the basis of science-based innovation and research competence plays a key role in successful co-operation by science, business and society. Provision of scientific research skills through doctoral and post-doctoral training is thus an important aspect of education policy. Supportive measures for doctoral and postdoctoral studies consist of various forms of financial support designed not only to support the various stages and activities of study and research, but also to take into account cost of living and social benefits, as postgraduate students may already be at the age of family life.

Recent policy trends

Many countries have recently broadened their policy focus to strengthen education for innovation beyond STEM fields.

Schools and universities often offer specific programmes for entrepreneurship education which tend to use active, learner-centred and context-rich pedagogies (imitating real-world situations). Even where specific programmes do not exist, "entrepreneurial skills" are often seen as a competency to develop across subjects and school levels.

Denmark formalised in 2009 a strategy for education and training in entrepreneurship (targeting all levels of education) and in 2010 ran a competition to establish a University of Entrepreneurship. Finland has issued Guidelines for Entrepreneurship Education (2009); Ireland's National Strategy for Higher Education (2011) promotes entrepreneurship training as part of curricula; Norway has developed an action plan for entrepreneurship in education (2009-14) and included entrepreneurial skills as a core competency in the National Qualification Framework for Higher Education; in Norway and New Zealand, moreover, how to set up and develop a business is part of the business or economic studies curriculum in secondary schools. Belgium (Fl.), Estonia, Germany (Exist), Luxembourg, Portugal and Slovenia also have state-funded initiatives to include entrepreneurship training in the school or university curriculum.

Introducing innovative learning practices into traditional disciplines may also be a way to foster in all students the non-disciplinary skills that enhance their capacity to contribute to innovation, such as creativity, curiosity and collaboration, as well as entrepreneurial attitudes. However, teachers in traditional disciplines may face difficulties for adopting new ways of teaching in countries that rely heavily on traditional standardised testing for high-stakes evaluations of students and teachers. New assessments therefore need to be developed to encourage innovative teaching.

Supporting doctoral study and postdoctoral research remains a priority for government in many OECD countries and in non-OECD countries such as the People's Republic of China and Colombia. The new trends in this regard include: expanding and improving public financial support for postgraduate studies; reforming doctoral education and the relevant support programmes; and internationalisation of postgraduate study and support programmes, with a view to attracting international talent.

In terms of government support, Australia is in the process of doubling the number of Australian Postgraduate Awards in 2008 by 2012; Colombia doubled the number of doctoral grants from an average of 232 in 2002-08 to 500 in 2009 and will double again to 1 000 in 2012; and Denmark doubled the intake of PhD students between 2006 and 2010. Canada provided an additional USD 71 million (CAD 87.5 million) for three years in 2009 to expand graduate scholarship programmes and to attract excellent students, and Korea launched two new support programmes in 2011: a Global PhD Scholarship to support 300 doctoral students and the Presidential Post-Doc Fellowship with a budget of USD 2.7 million (KRW 2 250 million) in 2011.

Several countries have introduced reforms in their PhD education and support mechanisms. Finland, Germany and Ireland have adopted structured PhD programmes to enhance the quality and efficiency of doctoral education. In Canada, the three federal granting agencies have harmonised their policies on support paid to students and postdoctoral fellows from research grants and no longer restrict researchers from using some of their grant money to provide supplements to scholarship holders. France introduced the PhD contract system in 2009 to replace research grants with stable support for doctoral students in the form of salary coupled with entitlement to social benefits as for employees.

While doctoral education and support are already open to foreign students in many countries (Estonia, Greece, Hungary, Norway and Sweden) some have made efforts in recent years to internationalise their doctoral programmes with a view to improving quality and attracting talent from abroad.

Austria's Mariette Blau Grant, established in 2009, aims at producing more internationally competitive PhDs by enabling doctoral students to conduct scientific research abroad, and the German Academic Exchange Service promotes the creation of bi-national doctoral programmes. Canada allocated USD 37 million (CAD 45 million) over five years (2010-15) to establish a prestigious postdoctoral programme and attract top level talent to Canada.

HUMAN RESOURCES POLICIES FOR INNOVATION

Rationale and objectives

Human resources have an embodied stock of human capital – defined as the knowledge, skills, competences and attributes that facilitate the creation of personal, social and economic well-being – which is an essential input to innovation. Given the importance of human resources for innovation, key objectives of human resource policies have been to raise the level of knowledge and skills of the labour force. Particular policy objectives have included meeting the need for skills for innovation by enlarging the supply of the highly skilled workforce and by facilitating its mobility in order to optimise the use of human resources, to facilitate the cross-fertilisation of ideas and learning, and to address structural mismatches of demand for and supply of skills.

Major aspects

Policies for ensuring the supply of human resources for science, technology and innovation (HRSTI) include policy measures to increase student enrolments in science and technology disciplines in higher education and in postgraduate studies, so as to ensure an adequate supply of human resources to meet the anticipated future need for HRSTI. They are prompted by the combination of an observed decline in young people's interest in studying S&T relative to other disciplines and an anticipated rise in the demand for human resources for STI, as OECD economies are increasingly knowledge-based and as public and private investments in R&D and innovation have intensified in OECD and non-OECD countries alike. Because national education policies play an essential role in the supply of HRSTI, the supply-side of human resource policy is also discussed in this chapter in the Policy Profile on Education, while policy measures for improving the attractiveness of research and entrepreneurial careers are discussed in the Policy Profile on building a Culture of Innovation.

Policies for increasing the mobility of human resources for STI include measures to facilitate mobility across sectors within the economy, notably between academic research and industry, as well as international mobility of HRSTI. Measures to increase domestic mobility typically aim at reducing regulatory barriers in labour markets (*e.g.* pension rights portability) and institutions (*e.g.* research grant portability) in order to allow human resources to move between universities and research labs and the business sector. Another important aspect of mobility policy is to facilitate the transition from higher education and training to employment for the highly skilled. In the wake of globalisation, the international dimension of human resource policies has gained in importance in recent years in many countries. Governments put in place policy measures to support the international mobility of highly skilled workers both to fill in gaps in skills and knowledge for innovation and to benefit from international exchanges of ideas and learning.

Recent years have seen an increasing need for lifelong learning owing to the acceleration of technological change and the need to renew the skills and knowledge of the existing workforce. Policy measures for lifelong learning focus on the provision of training by government or work organisations to raise the skills of the existing workforce and to improve the employability of the unemployed. Such measures are often part of active labour market policy.

Other policies aim to improve the match between supply and demand. Innovation draws on technical and soft skills acquired not only in universities, but also in technical colleges and vocational training. The major challenges are to identify important skills for innovation and then for society to know what skills are most valued in the workplace. Policy measures to encourage demand for the highly skilled in the business sector, especially in small and medium-sized enterprises (SMEs), may also play a role in bridging the supply and demand of skills.

Finally, since women account for more than one third of total researchers in many OECD and non-OECD countries, and nearly or more than half university students as future HRSTI supply, there is a need for measures to address bias against women in workplaces (Figure 8.1), such as lower shares of senior positions held by female researchers.

Recent policy trends

Governments in OECD and non-OECD countries continue to focus on addressing perceived future shortfalls in the highly skilled workforce through a range of measures covering the career development of the highly skilled from attracting the interest of youth in S&T studies, to assisting the transition from academic study to employment, to improving career development opportunities of S&T professionals, to facilitating their mobility domestically and internationally. As a result, the trend in numbers of researchers employed in the public sector (People's Republic of China, Denmark, Germany, Italy, Korea, the Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia) and/or in the economy as a whole (China, Czech Republic, Luxembourg, Norway, Poland, Portugal, Slovenia, South Africa, Turkey) continues to rise in many countries. To reverse the impact of the economic crisis on HRSTI, the Netherlands created a special secondment programme for researchers facing unemployment to work temporarily in other knowledge institutions.

Recent years have seen a trend towards giving increasing importance to lifelong learning (LLL). Many governments attempt to address the rise in unemployment in the wake of the crisis by expanding capacity for training existing and future workforces. Austria adopted an LLL strategy in 2011, Finland sets out principles and objectives for lifelong learning in the government's development plan for education and research 2011-16, and Turkey adopted an LLL Strategy Action Plan in 2011. For its part, Australia appropriated an additional USD 90 million (AUD 143 million) over four years to expand the Language, Literacy and Numeracy Program (LLNP).

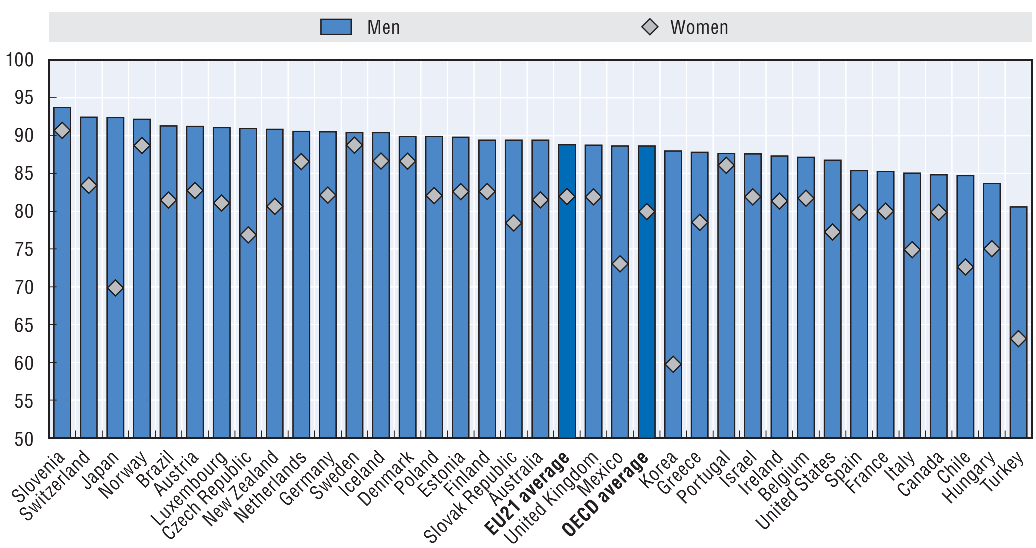
Australia, Colombia, South Africa and Switzerland have adopted new or amended existing qualifications frameworks in an attempt to strengthen the institutional infrastructure for lifelong learning, and to facilitate the mobility of skilled workforce in the economy by certifying skills and competencies acquired through informal channels. Examples include recognition of prior learning in Estonia, accreditation of prior experience in France, and recognition of formal and informal learning in Norway. In this respect efforts by the EU members tend to be based on the EU Recommendations for the Establishment of the European Qualifications Framework for LLL.

To link supply and demand for HRSTI more effectively, countries are making greater efforts to identify future skill needs at the sectoral level (*e.g.* ICT Action Plan in Ireland, the UK Sector Skills Councils and identification of skills needs in grand challenge areas in South Africa) and at the regional level (*e.g.* Poland). Other measures aim to support the transition from academic study to employment (*e.g.* Canada's Industrial R&D Fellowships Programme) and to better guide youth in choosing the disciplines of higher learning (*e.g.* Finland), often through partnership between government agencies, education institutions and the business sector. To encourage the demand for the highly skilled, Korea subsidises up to 50% of salaries when SMEs recruit unemployed engineers and scientists, while France allows doubling the salaries of newly recruited PhDs in the R&D tax base.

Increasing the mobility of highly skilled workers remains a high priority in many countries. Countries that have traditionally been hotspots for international students and highly skilled personnel, such as Australia, Canada, France, Germany, and the United Kingdom, have a range of measures to strengthen their positions by reducing entry barriers and providing attractive conditions in terms of scholarships and fiscal incentives. Countries such as Belgium and Sweden are following suit. The mobilisation of diasporas continues to be a main policy objective especially for non-OECD countries such as Argentina, China, Colombia and South Africa.

Figure 8.1. **Employment rate of university graduates by gender, 2009**

Number of university graduates in employment as a % of the population of university graduates aged 25 to 64



Note: University graduates include tertiary A level and advanced research programmes. Employment rates show not only the spread of unemployment (mismatch between skills supply and demand) but also the degree of participation of highly skilled workers in the labour force (discouraged workers from entering the labour market). Non-employment involves a rapid obsolescence of skills resulting in a loss of public investments on education systems.
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.

Source: OECD (2011), *OECD Education at a Glance 2011*, OECD, Paris.

StatLink http://dx.doi.org/10.1787/888932690111

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BUILDING AN INNOVATION CULTURE

Rationale and objectives

Three decades ago the OECD *Declaration on Future Policies for Science and Technology* underscored the importance of raising awareness of science and technology (S&T), and recommended public participation in the definition of major technological orientations. This includes public access to information concerning foreseeable long-term impacts of S&T and fostering public understanding of science and technology. Furthermore, it is increasingly recognised that innovation is influenced by certain social and cultural values, norms, attitudes and behaviours which may be described as an innovation culture. More and more governments therefore consider it important to foster and strengthen an innovation culture through policy measures, based on the assumption that cultures and social behaviours are amendable.

Today, public debates on the impact of S&T on human society are still unfolding. Indeed, recent incidences such as the Fukushima nuclear power plant accident and increasing public inquiries into the scientific evidences on global warming and the role of scientists in influencing the public, especially the governmental opinions on this issue have triggered off some serious rethinking and reassessment on the impacts of S&T on social and economic developments.

Major aspects

Policy measure aimed at raising public awareness of and interest in S&T seek to foster public respect for S&T and to appreciate and value the contribution of S&T and, increasingly, innovation as economic activities and professions, especially among young people, with a view to attracting more of them to pursue higher education in S&T disciplines.

As entrepreneurial uptake is an integral part of innovation, fostering an entrepreneurial spirit and attitude is another main objective of public policy. This involves changing, where necessary, cultural perceptions of entrepreneurial activities and their contribution to social and economic development, and fostering a positive attitude towards entrepreneurial risk taking and acceptance of failure.

Various policy measures also aim at specific weaknesses in social and professional cultures, such as the need for a research culture in universities, commercialisation of research results from public research, and the need to raise awareness of intellectual property rights in the research community and the general public.

Recent policy trends

Science is still the centre of focus in many countries, but some have already shifted towards a science-and-innovation focus. For example, a culture of science and innovation has been a policy objective in Belgium, and Spain has launched a National Programme for the Promotion of Scientific Culture and Innovation. To raise awareness, countries adopt a wide variety of measures. Alongside traditional awareness-raising measures such as hosting high-visibility international events (*e.g.* the annual meeting of the American Association for the Advancement of Science, hosted by Canada in 2012) and the science weeks held in Australia, Belgium (Flanders), Brazil, France, Norway, South Africa, etc., new forms that appeal to young people are being explored. Examples include Poland's Science Picnic, Europe's largest outdoor event for promoting science; Germany's highly successful

BIOTechnikum, which travels around Germany in a double-decker truck to spread information on modern biotechnology and on career prospects to encourage young scientists; the Slovak Republic's Innovative Deed of the Year, an annual competition to select the best young designer, and Chile's Chile VA! which aims at motivating interest rather than teaching specific knowledge. The Internet has also been used in various new ways to promote an innovation culture, from the first federal library mobile website in Canada to Israel's EUREKA web portal.

Specific policy measures may be refined to give attention to specific targets: women (*e.g.* Women in Science Awards of South Africa and Women in Science and Engineering [WISE] campaign in the United Kingdom); highly talented young people; closing the digital gap; or a specific scientific discipline, such as life sciences, biotechnology or space.

Compared to measures for raising awareness in science, initiatives to raise awareness of entrepreneurship lag behind in many countries, in terms of number of activities. Raising awareness of science tends to be primarily the purview of government, while raising awareness of entrepreneurship tends to be built on partnerships with the business community.

Entrepreneurship awareness raising focuses on youth in virtually all countries. The development of an entrepreneurial spirit and creativity is mainly pursued through targeted school activities and through curricula in which entrepreneurship is included as an optional or a compulsory subject of study from secondary school up to postgraduate study (Austria, Denmark, Norway, Portugal, Slovenia Switzerland, Turkey). Austria also includes entrepreneurship in the new teacher training model.

Improving the entrepreneurial environment at universities and research institutions and increasing the number of technology- and knowledge-based business start-ups are policy objectives in some countries. Germany has implemented in recent years programmes on the culture of entrepreneurship, business start-up grants and transfer of research that focus on research institutions and universities. Slovenia introduced mandatory entrepreneurship courses for fellows in the Young Researchers Programme to equip them with basic training on setting up a business and knowledge on support available in university incubators or intermediary institutions.

Raising awareness about the protection of intellectual property rights (IPRs) is a priority in countries where public awareness of the concept is weak. Many countries have programmes aimed at increasing awareness of IPRs in the population and boosting patent applications by small and medium-sized enterprises (SMEs). TUBITAK, the Scientific and Technological Research Council of Turkey, in collaboration with the Turkish Patent Institute (TPE), has implemented a Programme to Encourage and Support Patent Application for companies and individuals, and the Turkish Ministry of Science, Industry and Technology has organised workshops to raise awareness of IP and technology transfer in universities, public research institutions, technoparks and other public institutions. The People's Republic of China's new IP strategy adopted in 2008 includes promoting public awareness of IP and developing an IP culture by popularising information on IP through the media, by providing IP education in higher education institutions, and by teaching about IP in primary and high schools. To raise public awareness of IPRs, the Chinese government organises annually an IP week, and several government ministries and agencies carried out an IPR protection and anti-counterfeiting special action in 2011.

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PART III

Chapter 9

STI policy profiles: Facing new challenges

This part presents, in a series of policy profiles, the main trends in national science, technology and innovation (STI) policies, with a particular focus on policies and programmes introduced between 2010 and 2012. It discusses the rationale for public policy intervention, major aspects of STI policies and STI policy instruments, and recent policy developments across countries, in a large variety of STI policy areas. This chapter focuses on STI policies on thematic issues (green innovation and technology, technology to manage natural disasters and catastrophes, emerging technologies).

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.

Green technology and innovation

Rationale and objectives

Reducing global greenhouse gas (GHG) emissions and protecting environmental assets will require innovation and the large-scale adoption of green technologies. Without innovation, it will be very difficult and very costly to sustain current growth trajectories while addressing major environmental issues such as climate change. Consequently, OECD governments and emerging economies are giving priority to R&D activities and incentives for the diffusion and adoption of green technologies.

Major aspects

The building blocks of any effective Green Growth Strategy are clear and stable price signals on environmental emissions, *e.g.* carbon pricing or other market instruments such as taxation and regulation that reduce the environmental externalities caused by economic growth. However, better pricing will not be enough to decouple growth from environmental degradation. There is thus a clear role for government to ensure that framework conditions and policies towards firms and entrepreneurs provide incentives for private investment in green innovation. Government also has a role in supporting public R&D for green innovation. Evidence from government budget appropriations or outlays for R&D (GBAORD) by socio-economic objectives indicate that OECD countries such as Canada, Estonia, Finland, Italy, Japan, Mexico and New Zealand are devoting relatively high shares of public R&D budgets to energy and the environment (Figure 9.1).

Recent policy trends

Green innovation goals are increasingly part of national innovation strategies (Brazil, Canada, People's Republic of China, Finland, Germany, Japan); energy strategies (Austria, Australia, Norway, Portugal, Switzerland); water and transport strategies (Israel); strategies for small and medium-sized enterprises (SMEs) (France); or green growth strategies or action plans (Belgium, Denmark, Hungary, Ireland, Korea, Luxembourg, South Africa, Sweden).

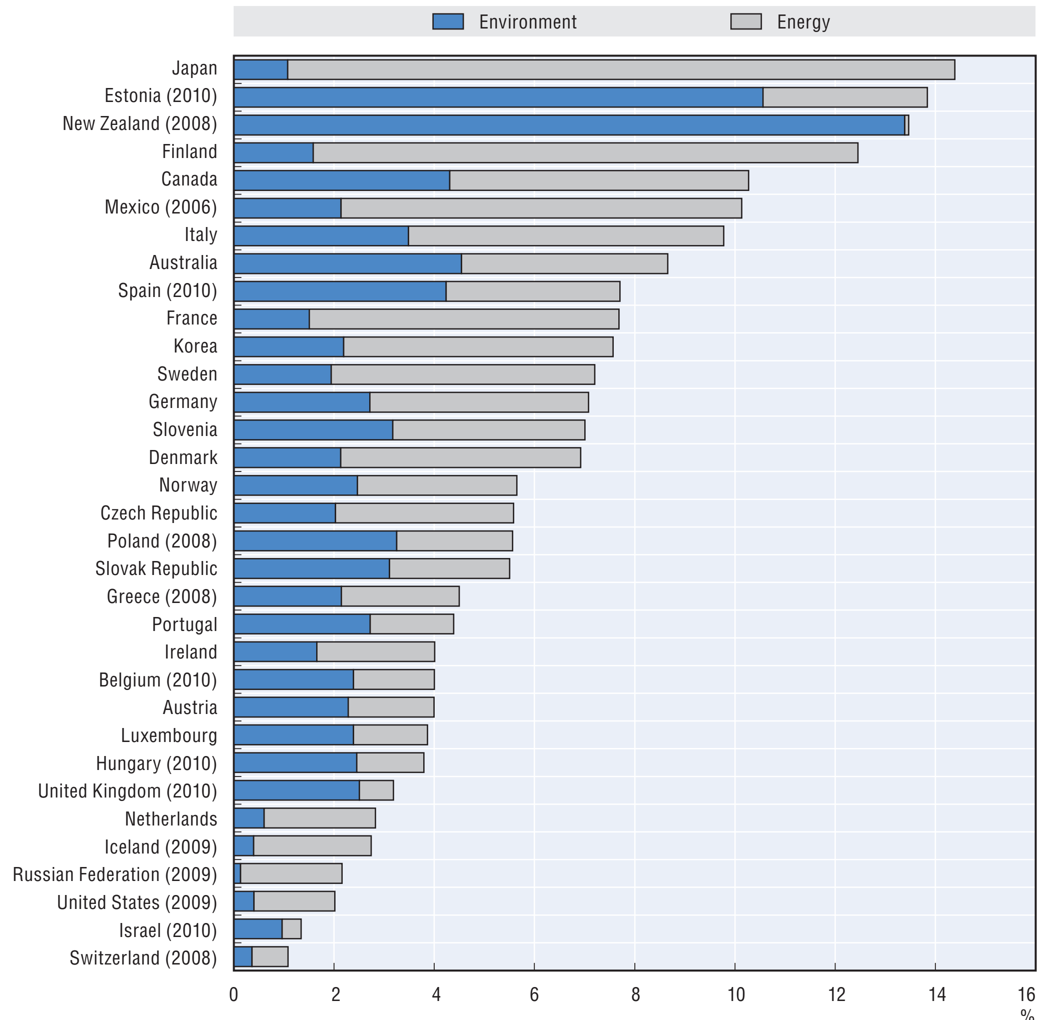
Beyond the EU, Australia and New Zealand, economy-wide carbon trading systems have had less priority. From July 2012, Australia introduced a fixed price on carbon emissions, starting at USD 14.5 (AUD 23) a tonne of CO_2 emissions with obligations placed on around 500 of the largest emitters.

The patent system is also being adapted to encourage green inventions. This includes the accelerated examination of patent applications directed to green technologies by national intellectual property (IP) offices in Australia (from 1 year to 4-8 weeks), Brazil (announced), Canada (within 2 months), Israel (within 3 months), Japan (from 2 years to 3 months), Korea (from 18 months to 1 month), the United Kingdom (from 2-3 years to 9 months) and the United States (terminated in February 2012).

Public support to green innovation mainly takes the form of direct R&D grants to SMEs, even if specific sectors (water, transport, energy) and general purpose technologies (information and communication technologies [ICTs], biotechnology and nanotechnologies) are being targeted. Governments are also expanding the supply of risk capital for green technology through equity and debt finance (*e.g.* the United Kingdom's Green Investment Bank, capitalised with USD 4.5 billion – GBP 3 billion). The US and UK governments as well as foundations and large companies are also using prizes to induce green technological

Figure 9.1. **Government R&D budgets for energy and the environment, 2011**

As a percentage of total government R&D budget



Source: OECD Research and Development Statistics (RDS) Database, February 2012.

StatLink http://dx.doi.org/10.1787/888932690130

innovations. In countries such as Norway, support for late-stage development (such as pilot plants) has increased strongly for green technologies generally and for energy technologies in particular.

For skills development, the focus in many OECD countries has been mainly on supporting on-the-job training and adapting tertiary and vocational training to meet new occupational needs. Germany's Green Talents programme intends to foster international exchanges among young researchers in the field of environmental and sustainability research.

Historically regulations, together with subsidies and feed-in tariffs, have been the main policy tools for fostering market uptake of greener technologies. Recently, many countries have started to use targeted demand-side innovation policies such as public procurement, standard-setting, and consumer policy to encourage demand for green technologies. Examples include green public procurement legislation in Finland, Italy, Japan, Korea, the Netherlands, Norway, Poland and Spain. Germany has modified its feed-in tariffs for renewable energy technologies by granting an additional premium for innovations.

Because greening the economy requires scientific discovery and inventions in areas other than energy or the environment, OECD countries continue to support public R&D in a broad range of scientific fields as well as targeted research programmes for climate change and biodiversity. Examples include the Finnish research programmes on climate change (USD 12.5 million – EUR 12 million) and on aquatic resources (USD 11.5 million – EUR 11 million).

OECD countries are establishing institutions and agencies to co-ordinate and manage the diverse array of green growth strategies, programmes and initiatives. Australia's Renewable Energy Agency and Multi-Party Climate Change Committee, Chile's Renewable Energy Centre, Korea's Presidential Committee on Green Growth, New Zealand's Green Growth Advisory Group, the Slovak Republic's Innovation and Energy Agency, South Africa's Energy Finance Subsidy Office, Switzerland's Federal Energy Research Commission, the United Kingdom's Technology Strategy Board and Low Carbon innovation Group are just a few of the institutions created to improve vertical and horizontal policy governance for green innovation (see Chapter 2).

Technology to manage natural disasters and catastrophes

Rationale and objectives

The economic cost of natural catastrophes and man-made disasters worldwide amounted to USD 370 billion in 2011, a huge increase over the previous year. The Japanese earthquake and tsunami alone cost the national economy at least USD 210 billion. Science and technology play an increasingly vital role in managing natural disasters. To this end, a growing number of OECD countries have recently established programmes or incentives to develop and deploy information and communication technologies (ICTs), geographic information systems, and remote sensing and satellite data (Table 9.1).

National emergency warning capabilities

The effective response to a disaster includes timely information and early warning of potential hazards. Countries are continually improving their national emergency and early warning capabilities, and federal governments often defer to their states, provinces or territories for the choice of the systems to adopt. Warning systems usually include radio broadcasts, cable over-ride systems, sirens and phone messaging systems.

Using ICT to streamline emergency responses: Australia, Finland, Germany, Israel, Luxembourg, the Slovak Republic, Turkey and the United States are working to integrate new ICT tools to streamline links among organisations in charge of disaster management. In Turkey for example, a new National Emergency Management Information System is currently being put in place, in parallel to an Uninterrupted and Secure Communication System (USCS) Project, to link authorities during disasters and emergency situations.

Improving weather forecasts: National meteorological agencies are often responsible for initial warnings concerning weather-related disasters (storms, floods, cyclones). In most countries, they rely on ground-based networks of radars, but increasingly also on satellite data, which allow nearly continuous observation of global weather. As satellites provide information for wide geographic areas, including oceans, improvements in forecasting have made warning systems more efficient (see Box 9.1). Almost all OECD countries have national meteorological agencies, and all G20 countries have satellites in orbit (OECD, 2011).

Warning by phone: The use of telephone-based capabilities for emergency warnings is expanding rapidly, owing in particular the explosive development in mobile networks. For example, Australia's Emergency Alert enables states and territories to issue warnings to landline and mobile telephones linked to properties in areas identified as being at risk. It works across all telecommunication carrier networks. Since it became operational in December 2009, it has been used 330 times for flood, tsunami, bushfire, storm surge, chemical and oil spill incidents, as well as missing person emergencies, and has issued more than 7 million messages.

Preparedness for earthquakes and tsunamis

Countries such as Colombia, Italy, Japan, Mexico, Spain and the United States are vulnerable to earthquakes and are upgrading their seismic surveillance networks. Although earthquakes cannot be predicted and very few are preceded by clearly identifiable precursory events, the networks can facilitate emergency response (by giving the intensity and location of the tremors) and can provide early warning to tsunami-prone regions.

Following two major tsunamis in 2004 in the Indian Ocean and in 2011 in Japan, several regional and local warning system centres were set up. These centres are co-ordinated via UNESCO's Intergovernmental Oceanographic Commission, which set up regional co-ordination groups for the Caribbean and adjacent regions, the Indian, Pacific, the North-eastern Atlantic Oceans and the Mediterranean. In late 2011, 23 countries on the Indian Ocean rim participated in an ocean-wide tsunami exercise. At the same time, three regional tsunami service providers in Australia, India and Indonesia became operational, adding warning capacity for the Indian Ocean.

Table 9.1. **Adoption of new technologies to tackle disasters (selected countries)**

Improved seismic surveillance networks	Australia, Canada, Colombia, France, India, Indonesia, Italy, Japan, Mexico, Turkey, United States
Improved tsunami early warning and monitoring	Australia, Colombia, India, Indonesia, Italy, Japan
Improved telephone-based information and warning capabilities	Australia, Austria, Estonia, France, Italy, Japan, Luxembourg, Netherlands, Slovak Republic
Countries currently members of the international charter on "Space and Major Disasters" for sharing data from their satellites in case of disasters	Algeria, Argentina, Brazil, Canada, China, France, Germany, India, Japan, Nigeria, Korea, Turkey, United Kingdom, United States and European Space Agency

Source: Country responses to the *OECD Science, Technology and Industry Outlook 2012* policy questionnaire.

Tackling risks related to climate change

Mexico, Norway, Portugal, South Africa and Switzerland are using geographic information systems, technical models, and satellite data time series to prepare for potential risks related to climate change. Norway's Climate Change and Its Impacts in Norway (NORKLIMA) aims to identify regions and sectors that may be particularly vulnerable to climate change over the next 30-50 years, and to provide input for a national strategy for adaptation to projected climate change.

Progress in the use of remote sensing techniques and improved international co-ordination

Considerable attention has been given in recent years worldwide to the potential of remote sensing satellite data for providing useful information and assistance in all phases of the disaster management cycle. Besides the currently expanding use of the international charter for major disasters, several countries and organisations (Argentina, Brazil, Canada, the People's Republic of China, France, Germany, India, Italy, Japan, Korea, Spain, the United States, the EU, EUMETSAT and more) are deploying satellite systems which offer a wide range of capabilities (all weather observations, high to very high resolution images, digital terrain models, land, ocean and ice monitoring, etc.) which are extremely useful in the preparation, assessment and relief phases of disasters. International co-ordination of these resources is improving continuously. In this regard the Committee for Earth Observation Satellites (CEOS) created in 2011 a dedicated task force for better co-ordination of satellite observation in disaster risk management chaired by Italy.

Box 9.1. **Weather satellites for early warning**

The World Meteorological Organisation's Global Observing System (GOS) provides daily observations on the state of the atmosphere and ocean surface. These observations are used to prepare weather analyses, forecasts, advisories and warnings. The system relies on thousands of national ground stations, upper-air stations, reporting ships at sea, drifting buoys, and aircraft providing reports on pressure, winds and temperature during flight. But it also depends on observations from operational geostationary satellites (situated in a 36 000 km arc around the Earth) and low Earth-orbit satellites.

Countries contributing satellites to the space-based part of GOS include: China, France, India, Japan, Korea, the United States, members of the European Space Agency, and Eumetsat, an intergovernmental organisation specifically in charge of maintaining and exploiting European operational meteorological satellites. It has 26 member states (mainly EU countries) and 5 co-operating states: Bulgaria, Estonia, Iceland, Lithuania and Serbia.

Source: EUMETSAT (2012), *www.eumetsat.int*; World Meteorological Organisation (WMO) (2012), *www.wmo.int*.

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Policies for emerging technologies

Rationale and objectives

A range of dynamic new disciplines and technologies are reshaping the landscape in terms of what science can achieve. Biotechnology, genomics, nanotechnology, synthetic biology and new developments in information and communication technologies (ICTs), physics, engineering, sustainable growth and the search for alternative sources of energy are now part of national research agendas and are seen as instrumental in meeting global challenges as well as societal needs at home. They are also seen as strong contributors to future economic growth in an increasingly technology-driven world.

The emergence of these new technologies, and their increasing convergence, presents both opportunities and challenges for policy makers. National research agendas, historically focused on long-term strategies and basic research funding, must now be continuously reviewed and updated to take account of the emergence of new fields in science and to optimise ways to take discoveries from these new fields forward.

Major aspects

Defining which technologies are truly "emerging" is difficult because so few of the usual metrics – journal citations, number of researchers in a new field, budgets and products on the market – are readily available. Technologies such as synthetic biology are clearly emerging: little was known about them even a few years ago. Technologies such as ICTs have been in existence for some time but in recent years have accelerated so rapidly in terms of size and scope that they bear little resemblance to those of a generation ago. Moreover, many emerging technologies are defined less by the parameters of a particular field (biology, physics, etc.) than by the global challenges they seek to address (the search for new sources of clean energy, the effort to deal with Alzheimer's disease and dementia in an ageing society, the provision of safe drinking water, etc.). Any of these challenges is beyond the grasp of a single traditional scientific discipline. They are being addressed by scientists who work together in decentralised and multidisciplinary and interdisciplinary contexts.

A discussion about emerging and converging technologies is therefore a discussion about both the technology platforms themselves and the new ways in which scientists are collaborating to use them. The process of developing these emerging technologies is greatly aided by advances in ICTs, especially the massive shifts in computational power, and by the Internet, which breaks down the barriers of time and space. They allow the engineer in Sydney to work alongside the biologist in San Francisco and they both can collaborate with the bioinformatician in Bangalore to try to solve a problem in, say, systems biology. New research platforms, such as "next generation" gene sequencing, in and of itself an emerging technology that is reshaping the study of the life sciences, are also strong contributors to this process. Aside from the core scientific competencies required, new ancillary career fields are emerging, with bioinformatics but one example of a career field developed in response to the convergence of ICTs and the life sciences.

The move towards emerging and converging technologies is also raising challenges for integrating concepts such as intellectual property (IP) between fields that have developed distinctly different IP doctrines over time. Biotechnology may be heavily patent-oriented, while software has taken the path of copyright. Other challenges include the development of statistics and metrics to measure emerging and converging technologies adequately, the development of new funding models to promote emerging technologies, the need to overcome the challenges to interdisciplinary research and to re-examine the structure of research institutes, and public engagement and acceptance of emerging technologies.

Recent policy trends

Most countries are clearly trying to harness advances in emerging technologies and these are being well integrated in national research strategies (Table 9.2). They respond to these developments in a myriad of ways. In developing their national research agendas, some have adopted policies that focus on developing specific technologies; examples include Canada's Non-reactor-based Isotope Supply Contribution Program, Finland's fuel cell technologies programme, Greece's technological clusters in microelectronics known as Corallia and the United Kingdom's efforts to advance a low-cost constellation of operational small satellites, known as NovaSAR. Some choose to exploit specific resources in which the country might have a competitive advantage; examples include Argentina's efforts to promote production and productivity of textile products based on the camelid fibres found in the Andean region, and Canada's FPInnovations which addresses R&D and the forestry value chain. Others focus more on global challenges in areas such as the environment, energy or health, and less on specific platforms; examples include Australia's Climate Change Science Program, Germany's The New Future of Old Age programme, and Israel's investments in oil-substitute technologies. Still others have adopted a hybrid approach. They have programmes designed to advance certain priority platforms (Stem Cells Australia, Norway's R&D policy emphasis on nanotechnology, biotechnology and ICTs) and programmes focused on priority needs of the world at large and the local population (Argentina's efforts on clean water, Norway's Parliament Majority Agreement on Climate Policy).

Countries' responses to the *OECD Science, Technology and Industry Outlook 2012* policy questionnaire showed that energy (including the development of clean energy and next-generation energy resources) is a top priority, as is fostering advances in biotechnology and genomics, nanotechnology and ICTs.

In addition to the prioritisation of emerging technologies in their research agendas, countries are also making a more definite link between the development of these technologies and the serving of society, particularly in terms of social justice and addressing the needs of the less economically advantaged. The development of efficient work and living environments (Finland), safe drinking water (Argentina), and sustainable and smart cities (Sweden and Italy) for instance, were mentioned several times as both a technological and a societal goal.

Finally, countries see the development of emerging technologies more in terms of an eco-system than in terms of basic research. They are clearly interested in the applicability of these technologies and in ways to optimise their commercialisation. Brazil's SIBRATEC programme and the UK Knowledge Transfer Networks are two examples.

Table 9.2. **Policy priorities in emerging fields of research in national STI strategies**

Emerging technology area	Number of mentions as a national priority
Energy (including clean energy, alternative energy, etc)	26
Genomics, biotechnology for human health	22
Nanotechnology	15
ICTs	12
Climate change, environmental sustainability and preservation of natural resources	11
Physical/material sciences and engineering	11
Food, agriculture and industrial biotechnology	9
Space exploration	5
Development of new modes of housing/habitat	5
Safer or more abundant drinking water	3
Marine biotechnology	3
Security/safety	3
Forest resources	1
Others	14

Source: Country responses to the *OECD Science, Technology and Industry Outlook 2012* policy questionnaire.

PART IV

Assessing STI performance

PART IV

Chapter 10

Science and innovation: Country profiles

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.

Reader's guide

The *OECD Science, Technology and Industry Outlook 2012* country profiles present the individual science, technology and innovation (STI) performance of OECD countries and some non-OECD countries, their national context and current major policy issues. Profiles describe national STI priorities and recent STI policy developments in each country on the basis of the responses provided by countries to the *OECD Science, Technology and Industry Outlook* policy questionnaires 2010 and 2012, as well as various additional OECD and non-OECD sources (including the EC-ERAWATCH database).

The *STI Outlook* country profiles are linked to the *STI Outlook* policy profiles which present the main global STI policy trends. They focus on the same issues of policy interest and areas of public policy intervention: national STI strategy and priorities; STI governance and evaluation; the science base (public-sector research); support to business R&D and innovation (direct and indirect financing, targeted programmes, demand-side policies); support to start-ups and entrepreneurship; public-sector innovation; deployment of information and communication technologies (ICT) and scientific infrastructures; clusters; support to knowledge flows and commercialisation (open science, technology transfer, intellectual property rights); globalisation (international STI linkages); and human resources (education, policies and innovation culture). Special attention is paid to emerging fields of technology and green innovation.

A box reports the "hot STI issues" for the country, usually the three or four most topical issues currently discussed in policy making circles as they are seen as sources of risk or opportunities, *e.g.* barriers to innovation, main areas and directions for investment, reform, etc. The issues were identified from countries' responses to the *OECD STI Outlook* policy questionnaire.

A table with selected key figures presents the country's economic performance (labour productivity), environmental performance, the size of the research system (gross domestic expenditure on R&D-GERD), the share of GERD that is publicly financed, and changes in these indicators over the past five years.

The first (double) graph reflects each country's strengths and weaknesses compared to other OECD countries. A standard set of indicators is used to describe national innovation systems and their performance in different areas: science base, business R&D and innovation, entrepreneurship, Internet infrastructure, knowledge flows and commercialisation, and human resources. The dot represents the country's position compared to the five top and bottom five OECD values and to the median of OECD values. Non-OECD countries are also compared to OECD countries and may therefore appear out of range (*e.g.* lower than the lowest OECD country). Indicators have been normalised (by GDP or population) to take account of the effect of the country's size and are presented in indices (median = 100) to make them comparable. Methodological notes, data sources, description of the indicators and statistical tables are provided in Annex A and Annex B.

The second graph shows the structural composition of business enterprise expenditure on R&D (BERD) according to various dimensions: main industries of performance, firm size and national affiliation. It reflects the country's industry structure and positioning in terms of innovation.

The third graph presents the country's revealed technological advantage (RTA) as measured by international patent applications (filed under the Patent Cooperation Treaty) in key technology fields (bio- and nano-technology, ICTs and environment-related technologies), and indicates the role played by universities and public research institutions in patenting in these fields.

The fourth graph gives an overview of the country's innovation policy mix, *i.e.* orientation and funding modes of public research and features of public financial support to business R&D and innovation. It also illustrates how the policy mix may have changed over the past five years.

Where data are not available, substitute charts may be included.

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Synthetic table

Table 10.1. **Comparative performance of national science and innovation systems, 2011**

Country relative position: in the top 5 OECD (★), in the middle range above OECD median (●●), in the middle range below OECD median (●) and in the bottom 5 OECD (❍)

	Competences and capacity to innovate									
	Science base			Business R&D and innovation				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)	Patenting firms less than 5 years old (per GDP)	Ease of entrepreneur-ship index
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
Argentina	●	●		❍	❍	❍	●			
Australia	●●	●●	●●	●●	●●	●	●●	●●		●●
Austria	●●	★	●●	●●	❍	●●	●●	●●	●●	●●
Belgium	●	●●	●●	●●	●●	●●	●	●●	●	●
Brazil	●	●	❍	●	●	●	❍			●
Canada	●●	●●	●●	●	●	●●	★	●	●	●●
Chile	❍	●	❍	❍	❍	❍	●			●
China	●	●	❍	●●	●	●	❍		❍	❍
Colombia	❍	❍		❍	❍	❍				
Czech Republic	●	●	●	●	❍	●	❍	●	❍	●
Denmark	★	●●	★	●●	★	●●	●●	●●	★	●●
Egypt		●			❍	❍				
Estonia	●●	❍	●●	●	❍	●	●	●		●
Finland	★	★	●●	★	●●	★	●	●●	★	●
France	●●	●	●	●●	●●	●●	●●	●●	●	●●
Germany	●●	●●	●	●●	●●	★	●●	●	●●	●
Greece	❍	●	●	❍	❍	●	❍	●		●
Hungary	❍	●	●	●	❍	●	❍	❍		●
Iceland	★	❍	★	●●	❍	●	★			❍
India	●	❍	❍	❍	●	●	❍		❍	❍
Indonesia	❍	❍	❍	❍	❍	❍	❍			
Ireland	●	●●	●●	●●	★	●●	●●	★	●●	●●
Israel*	●●	★	★	★	●●	●●	●●	★		❍
Italy	●	●●	●	●	●	●	●	❍	●	★
Japan	●	●	●	★	★	★	●		❍	●
Korea	●●	●	●	★	●●	●●	●	●		●●
Luxembourg	●	❍	❍	●●	★	●●	★	❍		●
Mexico	❍	❍	❍	❍	❍	❍	●		❍	❍
Netherlands	★	●●	●●	●	●●	●●	●●	●●	★	★
New Zealand	●●	★	●●	●	❍	●	★			●
Norway	●●	●●	●●	●	●●	●	●	●●	★	●●
Poland	●	●	●	❍	❍	❍	❍	❍		❍
Portugal	●	●	●	●	●	●	●	●		●●
Russian Federation	●	●	❍	●	●	❍	❍			●
Slovak Republic	❍	❍	❍	❍	❍	❍	●		❍	●
Slovenia	●	●●	●●	●●	❍	●	●●	❍		★
South Africa	❍	●	❍	●	❍	●	●			❍
Spain	●	●	●	●	●	●	●	●	❍	●●
Sweden	★	★	★	★	●●	★	●●	★	★	★
Switzerland	●●	●●	★	●●	★	★	★	★	●	●●
Turkey	●	●	❍	●	❍	❍	❍			❍
United Kingdom	●	●●	●●	●	●●	●●	●●	●●	●●	★
United States	●●	●	●	●●	●●	●●	●●	★	●●	●●

Table 10.1. **Comparative performance of national science and innovation systems, 2011** *(cont.)*

Country relative position: in the top 5 OECD (★), in the middle range above OECD median (●●), in the middle range below OECD median (●) and in the bottom 5 OECD (❍)

	Interactions and human resources for innovation											
	Internet for innovation				Knowledge flows and commercialisation				Human resources			
	Fixed broadband suscribers (per population)	Wireless broadband suscribers (per population)	Networks (autonomous systems) (per population)	E-government readiness index	Industry-financed public R&D expenditures (per GDP)	Patents filed by universities and public labs (per GDP)	International co-authorship (%)	International co-patenting (%)	Adult population at tertiary education level (%)	15-year-old top performers in science (%)	Doctoral graduation rate in science and engineering	S&T occupations in total employment (%)
	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)	(s)	(t)	(u)	(v)
Argentina	❍		❍	❍	❍		●	★	❍	❍		❍
Australia	●	●●	●●	●●	●●	●●	●	●	●●	★	●●	●●
Austria	●	●	●●	●	●	●●	★	●●	●	●	●●	●●
Belgium	●●	❍	●	●	●●	●●	★	★	●●	●●	●	●●
Brazil	❍	●	❍	❍		●	❍	●	❍	❍	❍	❍
Canada	●●	●	●●	●●	●●	●●	●	●●	★	●●	●●	●
Chile	❍	❍	❍	●	❍		●●	●●	●	❍	❍	●
China	❍		❍	❍	●●	●	❍	❍	❍			❍
Colombia	❍	❍	❍	●			●●	●●		❍		❍
Czech Republic	●	●●	★	❍	●	●	●	●●	❍	●●	●●	●●
Denmark	★	●●	●●	★	●	★	●●	●	●●	●	●●	★
Egypt	❍	●	❍	❍			●	●●				●
Estonia	●	●	●	●	●		●●	●●	●●	●●	●	●
Finland	●●	★	●●	●●	★	●	●●	●	●●	★	★	●●
France	●●	●	●	●●	●	★	●	●	●	●●	●●	●●
Germany	●●	●	●	●●	★	●●	●	●	●	★	★	●●
Greece	●	●	●	●	●	❍	●	●●	●	❍	●	●
Hungary	●	❍	●	●	●●	●	●●	●●	●	●	●	●
Iceland	●●	●●	★	●	★	●	★	★	●	●	❍	★
India	❍		❍	❍		●	❍	●●				❍
Indonesia	❍		❍	❍			★	★	❍	❍		❍
Ireland	●	●●	●	●	●	★	●●	●●	●●	●●	●●	●●
Israel	●	●	●●	●●	●●	★	●	●	★	❍	●●	●
Italy	●	●	●	●	❍	●	●	❍	❍	●	●	●
Japan	●●	★	❍	●●	●	●●	❍	❍	★	★	●	❍
Korea	★	★	●	★	●●	★	❍	❍	●●	●●	●	❍
Luxembourg	●●	●●	★	●●	❍	❍	★	★	●●	●		★
Mexico	❍	❍	❍	❍	❍	●	●	●●	❍	❍	❍	❍
Netherlands	★	●	●●	★	★	●●	●●	●	●	●●	●	●●
New Zealand	●●	●●	●●	●●	●●	●	●●	●	★	★	●●	●
Norway	★	★	●●	●●	●●	●	●●	●	●●	●	●	●●
Poland	❍	●●	●●	❍	●	●	❍	●●	●	●	❍	●
Portugal	●	●●	❍	●	❍	●	●●	●●	❍	●	●●	❍
Russian Federation	❍		●	●	●●	❍	❍	●	★	●		●●
Slovak Republic	❍	●	●	❍	●		●●	★	●	●	●●	●
Slovenia	●	●	★	●	★	●	●	●	●	●●	●●	●●
South Africa	❍		❍	❍	●	●	●	●	❍			❍
Spain	●	●	●	●	●●	●●	●	●	●	●	●	●
Sweden	●●	★	●●	●●	●●	❍	●●	●	●●	●	★	★
Switzerland	★	●●	★	●●	●●	●●	★	★	●●	●●	★	★
Turkey	❍	❍	❍	❍	●●	❍	❍	❍	❍	❍	❍	❍
United Kingdom	●●	●●	●	★	●	●●	●	●●	●●	●●	★	●
United States	●●	●●	●●	★	●	●●	❍	❍	★	●●	●	●●

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 reader's guide and methodological annex to the *OECD Science, Technology and Industry Outlook 2012* country profiles.

ARGENTINA

Hot STI issues

- Focusing innovation policy on developing capabilities in high-impact priority areas and sectors: the agri-sector, software, bio-and nano-technology, health and alternative energies.
- Increasing efforts to involve the private sector and other stakeholders in innovation policy design.
- Orienting R&D and innovation towards societal challenges, including inclusive development.

General features of the STI system: Argentina recovered strongly from the global financial crisis, which only marginally affected its economy. Its innovation system, like many in Latin America, suffers from weak R&D capabilities. Public and business R&D expenditures were low, at 0.46% and 0.14% of GDP, respectively, in 2010 (Panel 1[(a)(d)]). Only 14% of adults were tertiary-qualified in 2003 (1[(s)]), and the share of S&T occupations is below the OECD average (1[(v)]). However, Argentina performs well in terms of human resources for innovation when compared to other Latin American economies. Relations between industry and public research institutions are weak (1[(o)]), but the share of patents with foreign co-inventors over 2007/09 is on a par with the leading OECD countries (1[(r)]). This reflects to some extent the small number of actors engaged in such activities. In terms of ICT infrastructures there are only 10 fixed broadband subscribers per 100 inhabitants (1[(k)]). The e-government readiness index is among the lowest compared to the OECD area (1[(n)]).

Recent changes in STI expenditures: On average, GERD increased annually by 13.2% between 2005 and 2010, a faster pace than GDP over the same period. R&D intensity as a share of GDP was 0.62% in 2010, a low value compared to the OECD. To improve R&D intensity and boost innovation, the government raised the budget of the Ministry of Science, Technology and Productive Innovation (MINCYT) from USD 510 million in 2010 to USD 732 million in 2012.

Overall STI strategy: Argentina included a long-term strategy and guidelines for policy planning in the Bases for a Science, Technology and Innovation Strategic Plan (2005-15). The core objective is to improve national R&D capabilities while increasing social equality and promoting sustainable development. The National Plan for Science, Technology and Innovation (2012-15) sets possible scenarios for achieving these goals by 2015.

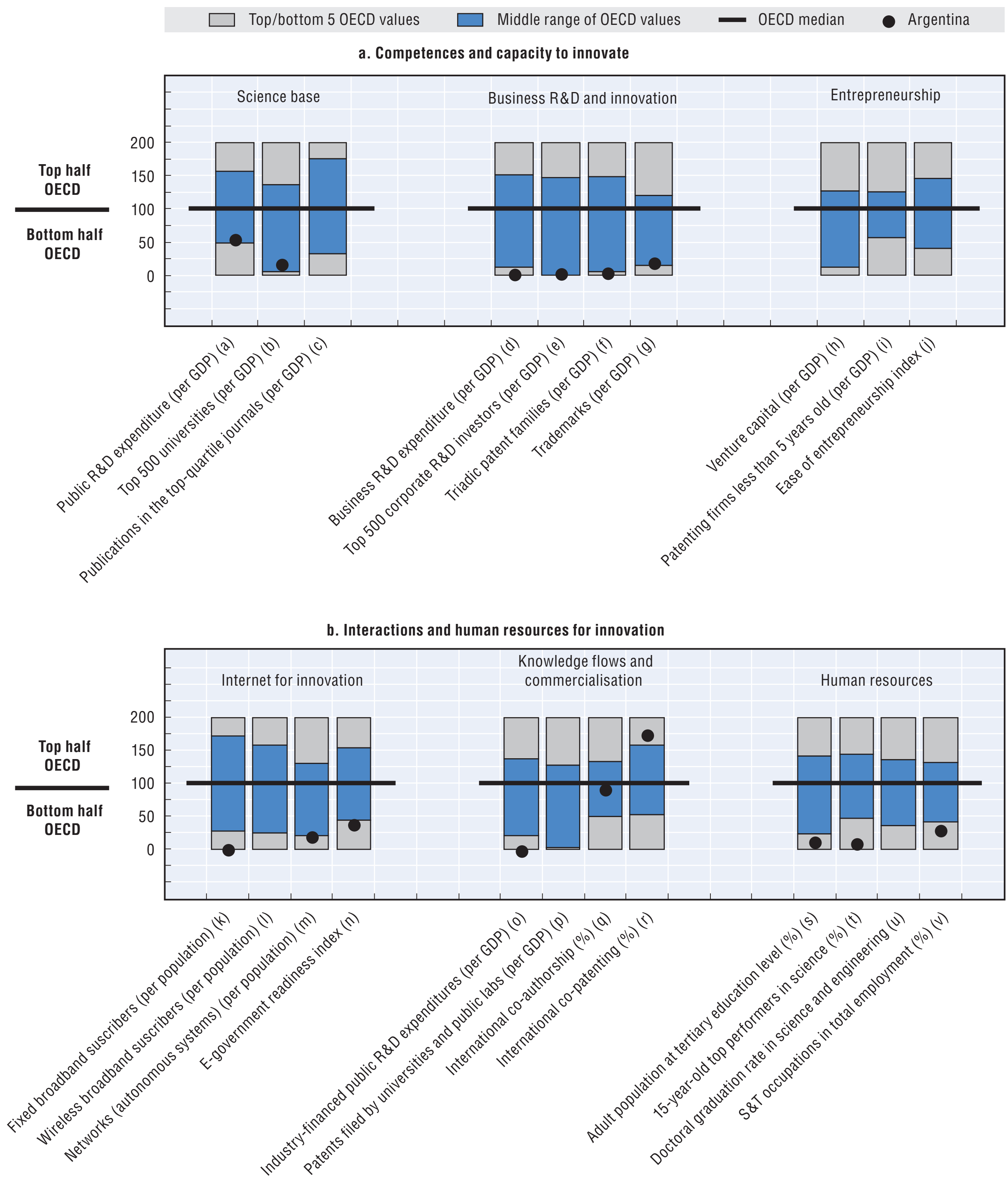
STI policy governance: In 2007, the Secretariat for Science, Technology and Productive Innovation became a ministry, MINCYT, with a view to restructuring the previously fragmented national STI system. Greater emphasis has been placed on soliciting the active participation of STI actors in policy design. The National Plan for Science, Technology and Innovation 2012-15 was developed in the context of an explicit public consultation framework.

Key figures

Labour productivity, GDP per hour worked in USD, 2010	**n.a.**	**GERD, as % of GDP, 2010**	**0.62**
(annual growth rate, 2005-10)	n.a.	(annual growth rate, 2005-10)	(+13.2)
Environmental productivity, GDP per unit of CO_2 emitted in USD, 2009	**3.53**	**GERD publicly financed, as % of GDP, 2010**	**0.47**
(annual growth rate, 2005-09)	(+3.5)	(annual growth rate, 2005-10)	(+16.2)

Figure 10.1. **Science and innovation in Argentina**

Panel 1. Comparative performance of national science and innovation systems, 2011



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

Business R&D and innovation: The budget of the National Agency for Promotion of Science and Technology (ANPCYT), in charge of funding for business innovation, increased by 18% in 2010.

ICT and scientific infrastructures: The development of research infrastructures is one of the objectives of the Bases for a Science, Technology and Innovation Strategic Plan. To this end, the Federal Infrastructure Plan for Science and Technology 2008-11 allocated USD 97 million for the improvement and expansion of 50 research centres and associated institutions. The Technology Platform Projects programme supports the establishment of centres of excellence with advanced facilities in the areas of genomics, proteomics and structural biology, stem cells, pre-clinical tests with experimental animals, new materials, software engineering and bioinformatics.

Clusters and regional policies: The MINCYT has put more emphasis on cluster policies. The main instruments are the Productive Clusters Integrated Projects Programme (PI-TEC), which promotes the creation of clusters, and the Strategic Areas Programme (PAE), which was established in 2006 to foster the creation of knowledge clusters in priority sectors with high potential for economic and social impact.

Knowledge flows and commercialisation: To address weak linkages between academia and industry, the government established the sectoral funds, including FONSOFT for the software industry and FONSARSEC for areas critical for national socioeconomic development (agri-sector, health and energy). They have promoted the creation of 35 public-private partnerships in these strategic fields. Additionally, sectoral mobility of researchers is encouraged through programmes such as Researchers in Business and Scholarships in Businesses.

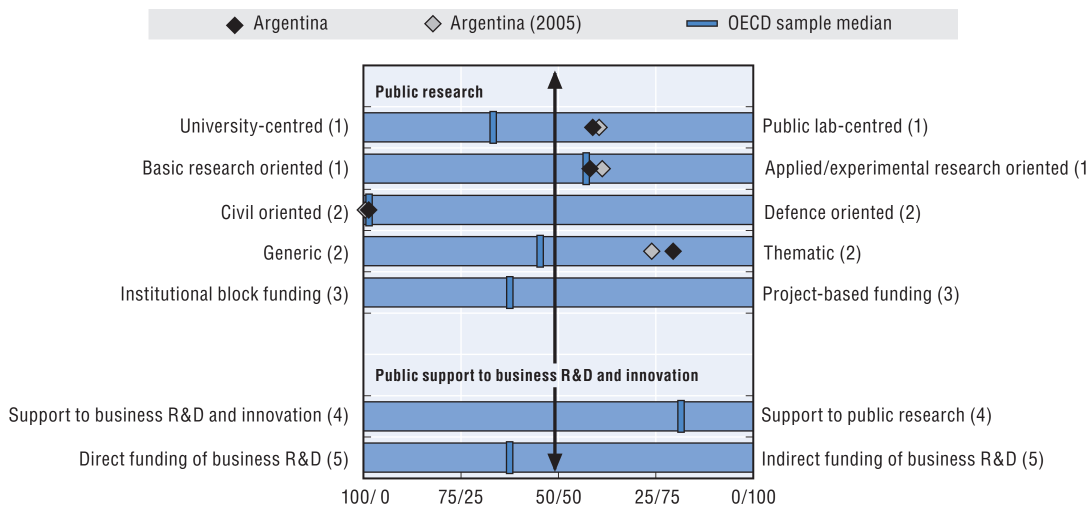
Globalisation: Argentina has signed several bilateral agreements to foster research co-operation. It also has several bi-national centres, such as the Centre of Plant Genomics with Spain, and the Centre for Research in Neurosciences, Cancer and Stem Cells with the German Max Planck Society. Moreover, the government introduced the Raíces programme to reach out to expatriate researchers and encourage them to contribute to the national S&T system. The objective is both to create stronger links with expatriates and to encourage their return to Argentina.

Human resources: Argentina has already achieved the target of three full-time researchers for 1 000 employees set for 2015 in the Bases for a Science, Technology and Innovation Strategic Plan. Policy instruments to attain this objective include scholarship schemes to raise the number of students with tertiary education in specific strategic fields, and the National Research and Technology Council (CONICET), which plays a pivotal role in training of S&T human resources, had its budget increased threefold in recent years. Initiatives such as Eager Minds: Science and Technology and Education aim at raising awareness of science and increasing interest in research across society by encouraging scientists to visit schools.

Emerging technologies: MINCYT has identified areas in which R&D and innovation can foster economic growth and address social needs, specifically social inclusion and sustainable development, by drawing on Argentina's natural and dynamic advantages. These areas include the agri-sector, health, bio- and nano-technology, as well as software. New sectoral funds have been established to support these policies. In 2009-10 FONSOFT had a budget of USD 24 million to promote R&D and technological upgrading in SMEs in the ICT sector by supporting their R&D projects, providing education projects, helping them export, and facilitating the creation and consolidation of such firms. Between 2009 and 2010, FONARSEC (agri-sector, health and energy), which is funded with grants from the World Bank and the Inter-American Development Bank, provided USD 88 million for 113 projects.

Green innovation: Some of MINCYT's sectoral funds address environmental and energy issues. Specific projects include a new bio-energy project for the development of alternative sources of energy and a fund for clean and safe water to provide arsenic-free water to isolated populations.

Panel 2. Overview of national innovation policy mix, 2010



1. Balance as a percentage of the sum of HERD and GOVERD.
2. Balance as a percentage of total GBAORD.
3. Balance as a percentage of total funding to national performers.
4. Balance as a percentage of the sum of HERD and GOVERD funded by government and higher education and components of (5).
5. Balance as a percentage of the sum of indirect funding of business R&D and innovation through R&D tax incentives and direct funding of BERD through grants, contracts and loans.

Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888932690149

AUSTRALIA

Hot STI issues

- Transitioning to a low-carbon, globally connected and productive economy through advanced skills.
- Increasing R&D collaboration, commercialisation and internationalisation.
- Improving returns on science and research investments.
- Exploiting emerging/enabling frontier technologies, such as space and health.

General features of the STI system: Australia's economy has been one of the world's most resilient during the past five years and has benefited significantly from the global commodities boom. Primary and resource-based industries account for a much larger share of BERD than the OECD median (Panel 2) and are responsible for much of the recent increases in business funding of R&D. Manufacturing (particularly high-technology manufacturing) accounts for a smaller share of BERD. At 1.3% of GDP in 2009, the intensity of BERD was slightly above the OECD median. Triadic patents are below the OECD average (Panel 1[(f)]). Levels of public research funded by industry (1[(o)]) are slightly above average, an indication of sound academic-industry linkages. International linkages appear somewhat weaker, with 44% of scientific articles and 16% of PCT patent applications produced with international collaboration (1[(q)(r)]). Australia's RTA shows robust growth over the past decade in bio- and nano-technologies and a slight decline in environment-related technologies (Panel 3). The country has a strong skills base: 37% of the adult population have tertiary qualifications (1[(s)]) and 37% of the labour force are employed in S&T occupations (1[(v)]). PISA scores in science for 15-year-olds are the fourth highest in the OECD area. IT infrastructures compare well internationally, with wide wireless broadband coverage (1[(l)]), and the e-government readiness index accounts for 0.84 (1[(n)]).

Recent changes in STI expenditures: Australia's R&D intensity is slightly below the OECD average, but higher than that of the EU27. GERD grew by a strong 10% a year in real terms between 2004 and 2008 to 2.24% of GDP. The share funded by industry increased to 62% over the decade to 2008, while the share of government funding declined to 34%. Funding from abroad also decreased.

Overall STI strategy: The key STI strategy document is *Powering Ideas: An Innovation Agenda for the 21st Century* (2009-20). It commits to strengthen public research, improve science-industry collaboration and international linkages, strengthen human capital and improve governance. In 2011 a review of publicly funded research recommended the establishment of an Australian Research Committee to provide integrated and strategic advice on future research investments. The 2011 Strategic Roadmap for Australian Research Infrastructure also identified 19 research infrastructure capability areas critical to Australian research over the next five to ten years.

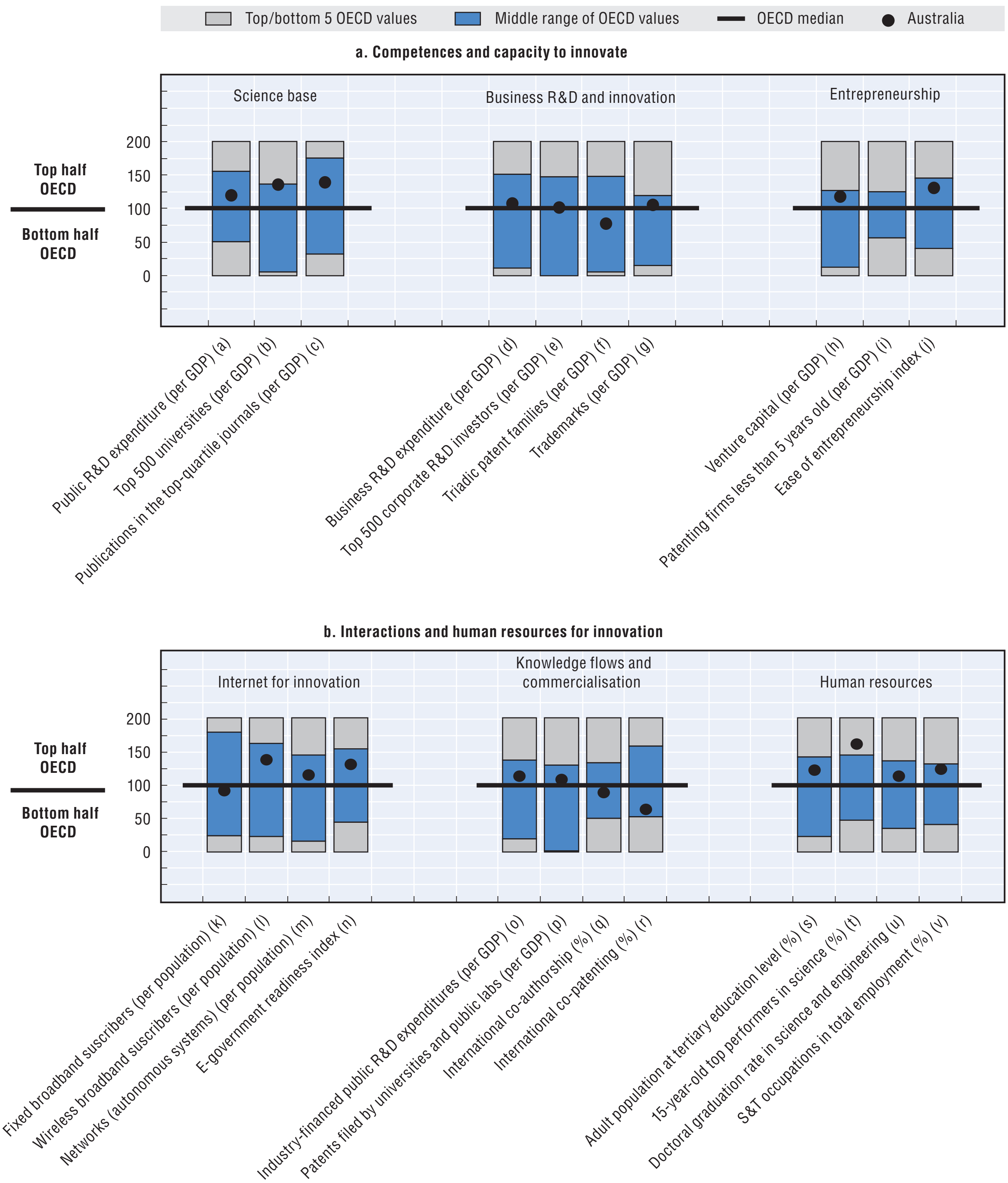
STI policy governance: The Department of Industry, Innovation, Science, Research and Tertiary Education (DIISRTE) is responsible for innovation, research, science and tertiary education policy and AusIndustry is one of its programme delivery divisions. The Commonwealth State and Territory Advisory Council on Innovation (CSTACI), the Coordinating Committee on Innovation (CCI) and the Prime Minister Science, Engineering and Innovation Council (PMSEIC) were established to improve governance and collaboration and provide policy advice. The Framework of Principles for Innovation Initiatives provides guidance to enhance consistency

Key figures

Labour productivity, GDP per hour worked in USD, 2010	**46.8**	**GERD, as % of GDP, 2008**	**2.24**
(annual growth rate, 2005-10)	(+0.7)	(annual growth rate, 2004-08)	(+10.0)
Environmental productivity, GDP per unit of CO_2 emitted in USD, 2009	**2.24**	**GERD publicly financed, as % of GDP, 2008**	**0.78**
(annual growth rate, 2005-09)	(+2.2)	(annual growth rate, 2004-08)	(+5.6)

Figure 10.2. **Science and innovation in Australia**

Panel 1. Comparative performance of national science and innovation systems, 2011



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

across the ecosystem and to improve the accessibility and efficiency of innovation initiatives across Australia. The major national science agencies are included in the DIISRTE portfolio, as are the Australian Research Council (ARC) and Intellectual Property Australia.

Science base: Australia's science base is strong, as shown by its high public-sector expenditure on R&D, the high international ranking of its universities and publication rates in top scientific journals (1[(a)(b)(c)]). HERD was 0.54% of GDP (2008) and 24% of GERD, high by OECD standards. While the academic research system is largely based on investigator-led research, there has been a shift towards funding directed to thematic priorities (Panel 4). The Industrial Transformation Research Programme (2011-14) will pursue industry-driven research in universities.

Business R&D and innovation: The government's goal is to achieve a 25% increase in the proportion of businesses engaging in innovation over the next decade. To that end, the government encourages business innovation through a combination of direct and indirect measures. Australia replaced its R&D tax concession in 2011 by a R&D tax incentive scheme based on a tax credit. This scheme also targets support to R&D by SMEs and is open to foreign-owned companies.

Public-sector innovation: The Australian Public Service Innovation Action Plan was drawn up to deal with increasingly complex issues in the public sector. It was endorsed by agency secretaries in 2011. The aim is to drive innovation in the public sector through initiatives such as the Public Sector Innovation Network, an innovation blog and an innovation toolkit. Since 2011, the Australian Public Service Innovation Indicators (APSII) project has been collecting detailed information about innovation in the Australian public service that will be comparable with European data.

Entrepreneurship: Australia has favourable conditions for entrepreneurship. Regulatory barriers are low, and attitudes towards the fear of failure and perceived opportunities are positive. There is relatively little venture capital for seed and start-up stages of investment and it has declined during the financial crisis. However, a range of investment funds are available to develop the VC industry. The Renewable Energy Venture Capital Fund (REVC) was announced in 2011. Broader business support to SMEs is provided by a network of twelve Enterprise Connect centres.

ICT and scientific infrastructures: Australia's strong ICT infrastructure is sub-optimal in certain areas. NBNCo was established in 2009 to provide a high-speed broadband network. The Digital Education Revolution has invested USD 1.5 billion to align ICT in schools with broader government initiatives. Important investments have been made through the National Collaborative Research Infrastructure Strategy (NCRIS), the Super Science Initiative (SSI) and the Education Investment Fund (EIF) to produce a collaborative network of research infrastructure.

Knowledge flows and commercialisation: International co-operation on publications and patenting are below the OECD median (1[(q)(r)]). Initiatives to strengthen bilateral knowledge exchange include the Australia-China Science and Research Fund and Australia-India Strategic Research Fund.

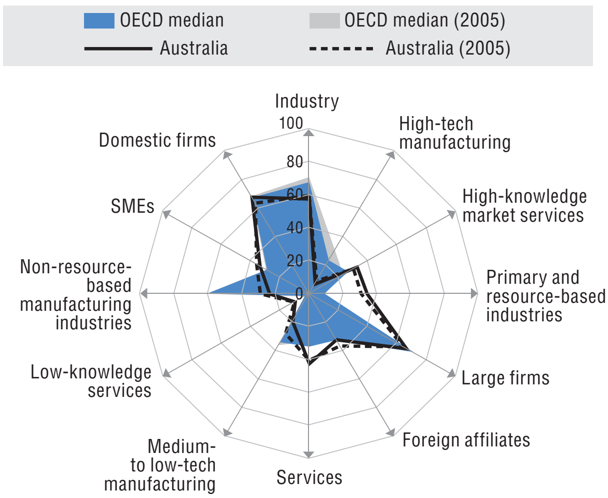
Human resources: Australia has a strong skills base. Questacon, the National Science and Technology Centre, manages the Inspiring Australia Programme which focuses on engagement of the Australian community with the sciences. The Australian Curriculum and Building the Education Revolution programmes intend to strengthen overall education, especially maths and science skills.

Emerging technologies: The Super Science Initiative, with funding of USD 705 million, has recently focused on space science and astronomy, marine and climate science, enabling technologies and future industries, such as bio- and nano-technology, ICT and clean energy. The Australian Space Research programme (ASRP) is developing niche space capabilities and the Stem Cells Australia does cutting-edge health research.

Green innovation: Australia passed legislation in 2011 to tax carbon emissions as of 2012. As part of the Clean Energy Futures Plan, the Clean Technology Innovation Programme supports the development of technology with reduced greenhouse gas emission. The Clean Energy Finance Corporation will invest USD 6.4 billion in renewable energy and low-emissions technologies, with the new Australian Renewable Energy Agency (ARENA) investing a further USD 2 billion.

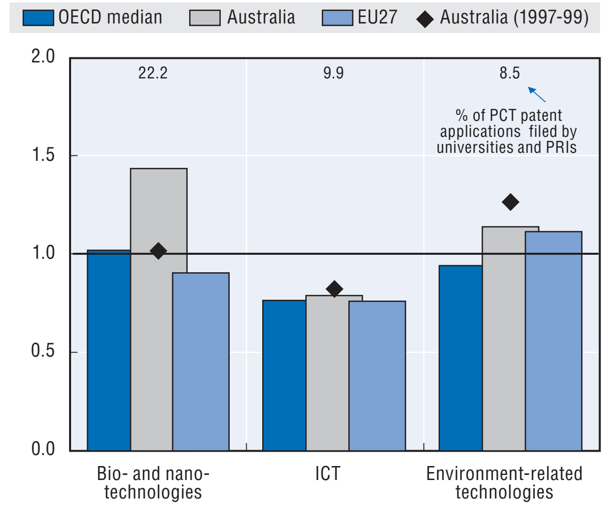
Panel 2. Structural composition of BERD, 2009

As a % of total BERD

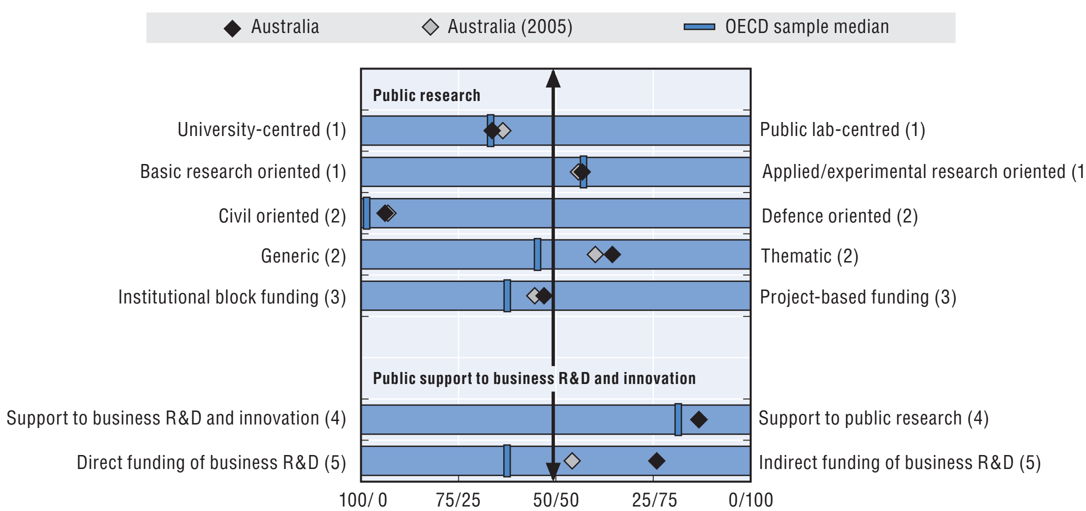


Panel 3. Revealed technology advantage in selected fields, 2007-09

Index based on PCT patent applications



Panel 4. Overview of national innovation policy mix, 2010



1. Balance as a percentage of the sum of HERD and GOVERD.
2. Balance as a percentage of total GBAORD.
3. Balance as a percentage of total funding to national performers.
4. Balance as a percentage of the sum of HERD and GOVERD funded by government and higher education and components of (5).
5. Balance as a percentage of the sum of indirect funding of business R&D and innovation through R&D tax incentives and direct funding of BERD through grants, contracts and loans.

Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888932690168

AUSTRIA

Hot STI issues

- Reforming and restructuring education as part of the broader innovation system.
- Raising tertiary attainment and overall STI skills more generally.
- Increasing innovation in the services sector and longer-term R&D investment.

General features of the STI system: Austria's STI system has been steadily expanded and upgraded. BERD increased from 1.42% of GDP in 2002 to 1.88% of GDP in 2010. Links between industry and science are sound; and a high share of public research is funded by industry (Panel 1(o)). Integration with international networks is good: 57% of scientific articles and 26% of PCT patent applications (above the OECD median) were produced through international collaboration (1(q)(r)). The relative number of PCT patents filed by universities and public labs is close to the OECD median (1(p)). PCT patent applications suggest an RTA in environment-related technologies (which has however declined somewhat in recent years), catch-up in emerging technologies, and weak performance in ICTs. Only 19% of the adult population is tertiary-qualified (1(s)), but a relatively high 32% of the labour force is employed in S&T occupations (1(v)). Austria has only 8.7 researchers per thousand total employment, but the PISA science scores of 15-year-olds are close to the OECD median (1(t)). ICT infrastructure indicators vary around the median. Austria has 25 fixed broadband and 33 wireless subscribers per 100 inhabitants 1(k)(l)). It has a relatively large number of autonomous networks (1(m)). The e-government readiness index is slightly below the median, similar to that of Iceland and Spain (1(n)).

Recent changes in STI expenditures: GERD was 2.75% of GDP in 2011, well above the OECD average. It grew by 3.6% a year between 2005 and 2011, the fastest growth among EU countries. Austria aims for GERD to increase to 3.76% of GDP by 2020, ideally with up to 70% financed by the private sector. In 2011, industry funded a relatively high 45% of GERD, while government funded 39%. The share of GERD financed from abroad (16% in 2011) is one of the highest among OECD countries.

Overall STI strategy: In March 2011, the Austrian Council of Ministers announced a new Research, Technology and Innovation (RTI) Strategy: The Way to Become a Leader in Innovation for 2011-20. It focuses on improving the links between education and innovation, developing risk and venture capital, stimulating competition, improving innovation governance, and implementing structural change to encourage more dynamic research, innovation and knowledge-intensive industries.

STI policy governance: STI policy continues to be formulated and implemented by three key ministries. The Federal Ministry of Science and Research (BMWF) is responsible for tertiary education and basic research; the Federal Ministry of Transport, Innovation and Technology (BMVIT) manages the public budget in applied research; and the Federal Ministry of Economy, Family and Youth (BMWFJ) is responsible for the Christian Doppler Research Association (CDG) and the Josef Ressel Centres. The Federal Ministry of Finance is in charge of allocation of funds. Austria has a good evaluation culture. Recent evaluations include the Science Conference, the CIR-Ce Network Projects, the Laura Bassi Centres of Expertise and the Josef Ressel Centres.

Key figures

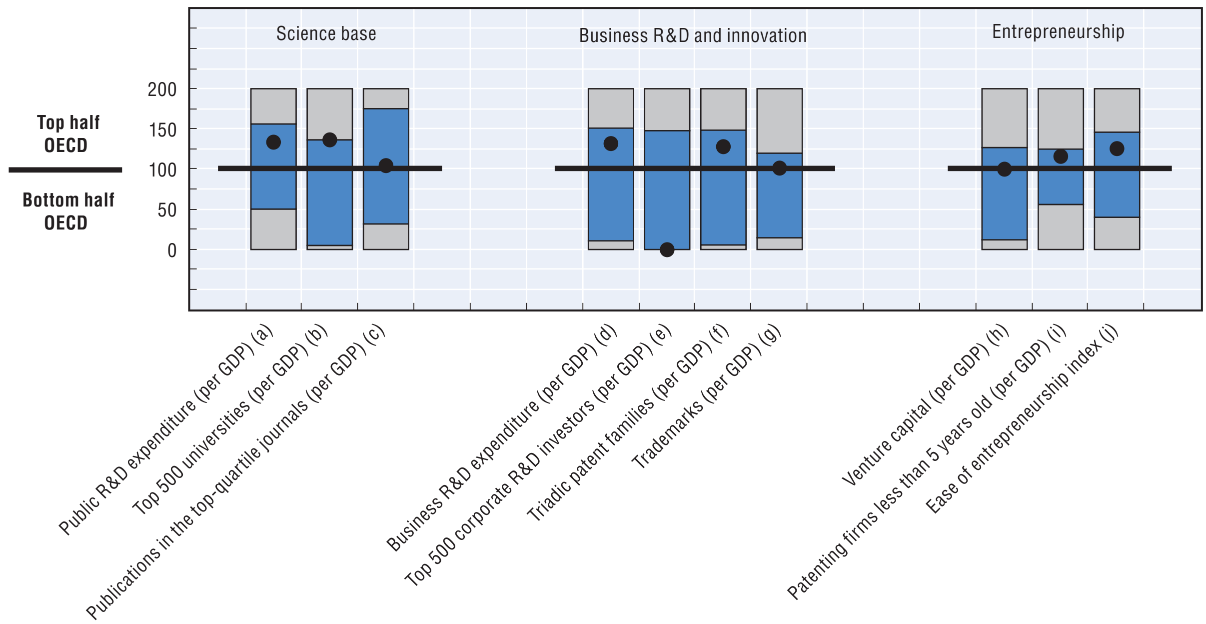
Labour productivity, GDP per hour worked in USD, 2010	**49.6**	**GERD, as % of GDP, 2011**	**2.75**
(annual growth rate, 2005-10)	(+1.5)	(annual growth rate, 2005-11)	(+3.6)
Environmental productivity, GDP per unit of CO_2 emitted in USD, 2009	**5.16**	**GERD publicly financed, as % of GDP, 2009**	**0.97**
(annual growth rate, 2005-09)	(+5.7)	(annual growth rate, 2006-09)	(+7.0)

Figure 10.3. **Science and innovation in Austria**

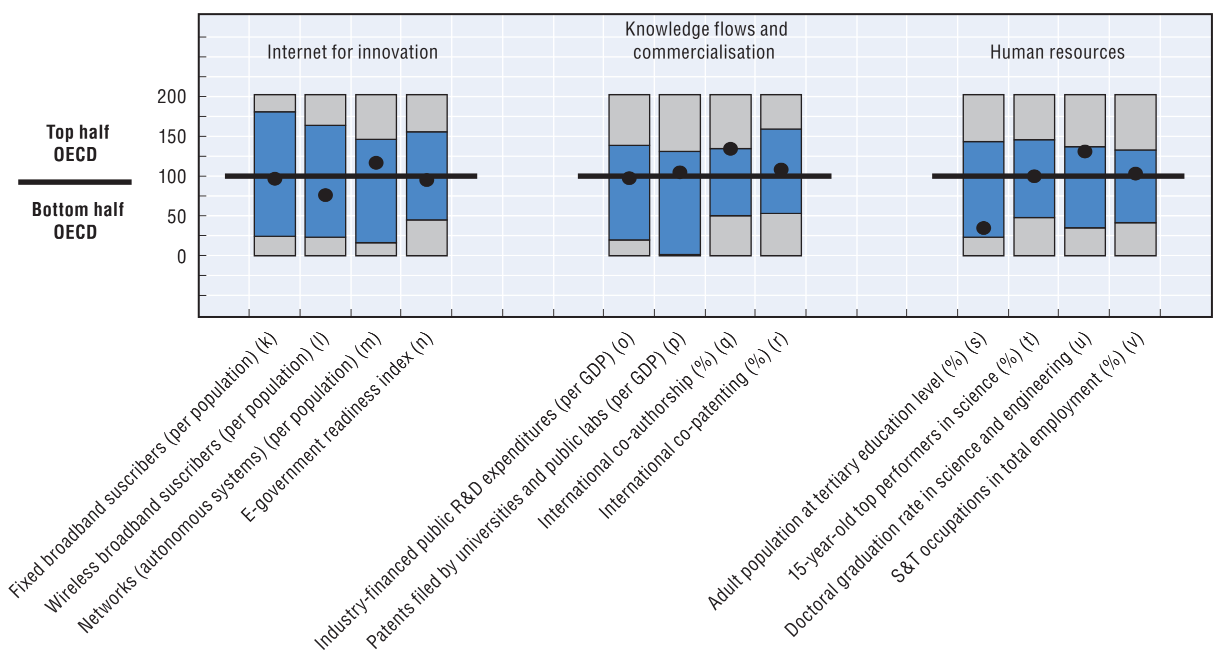
Panel 1. Comparative performance of national science and innovation systems, 2011

Top/bottom 5 OECD values | Middle range of OECD values | OECD median | Austria

a. Competences and capacity to innovate



b. Interactions and human resources for innovation



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

Science base: Austria has a sound science base, with comparatively high public-sector R&D expenditure (1[a]), competitive university rankings (1[b]) and good international publications (1[c]).

Business R&D and innovation: Austria has a competitive export-oriented sector, including innovative SMEs with strong performance in niche markets, and provides a balanced mix of direct and indirect support for business R&D. Overall, public support leans more towards the business sector (Panel 4). In 2011, the innovation voucher was doubled to USD 13 891 and the tax credit was changed to a simpler tax premium and was raised from 8% to 10%. Firms conducting R&D are expected to increase by 10% between 2010 and 2013 and by 25% by 2020. During 2011-14 an additional USD 1 billion will go to support the RTI system through the tax premium. Another measure is the Services Sector Initiative (*Dienstleistungsinitiative*).

Entrepreneurship: The RTI Strategy aims at an increase of 3% a year in research-intensive firms (particularly SMEs) over the medium term. To address gender imbalances, the BMWF fForte Coaching programme (Women in Research and Technology) offers courses to assist women with grant proposals and finance.

ICT and scientific infrastructures: Development of an information society is a national priority. *Kompetenzzentrum Internetgesellschaft,* an Internet competence centre, was established in 2010 and made recommendations for developing ICT infrastructure. Use of the Internet has increased: more than 90% of 16-to-24-year-olds have access to personal computers and the Internet.

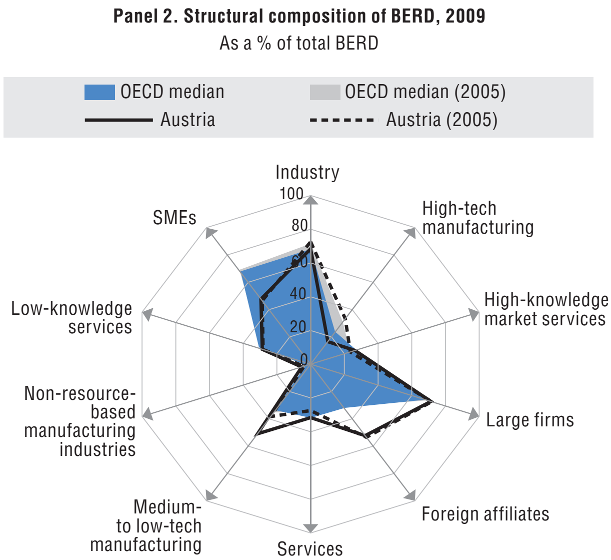
Clusters and regional policies: A national platform for clusters was established in 2008; there are now around 50 cluster initiatives, with 3 500 participating enterprises, and 20 technology parks. Almost every federal state runs a cluster initiative or incubator to link companies and research institutions around thematic priorities. Nationwide, there are more than 100 innovation infrastructure sites (*Impulszentren*).

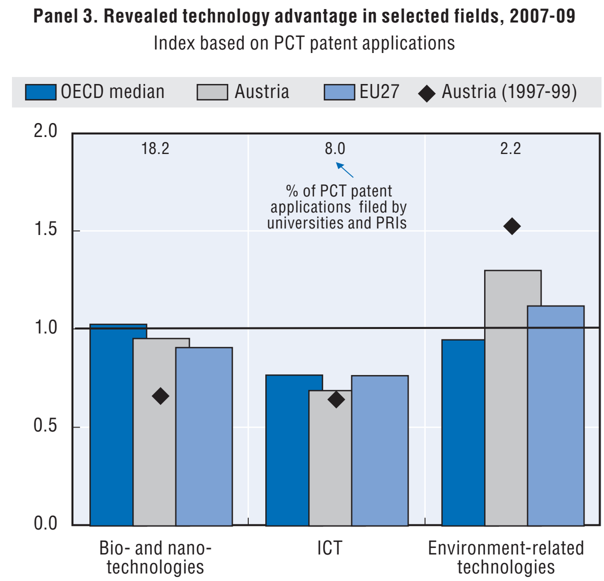
Knowledge flows and commercialisation: Because of past weaknesses in strategic R&D collaboration between academia and industry, programmes to improve collaboration have been established: the competence centres for excellent technologies (COMET), co-operation and innovation networks (COIN-Net), and initiatives of the Christian Doppler Society and the Josef Ressel Centres. The Laura Bassi centres of expertise support a forum in which skilled female and male researchers from academia and the private sector work together. Recent initiatives include new rules and guidelines governing ownership and licensing of publicly funded research results and IPR licensing support for PRIs.

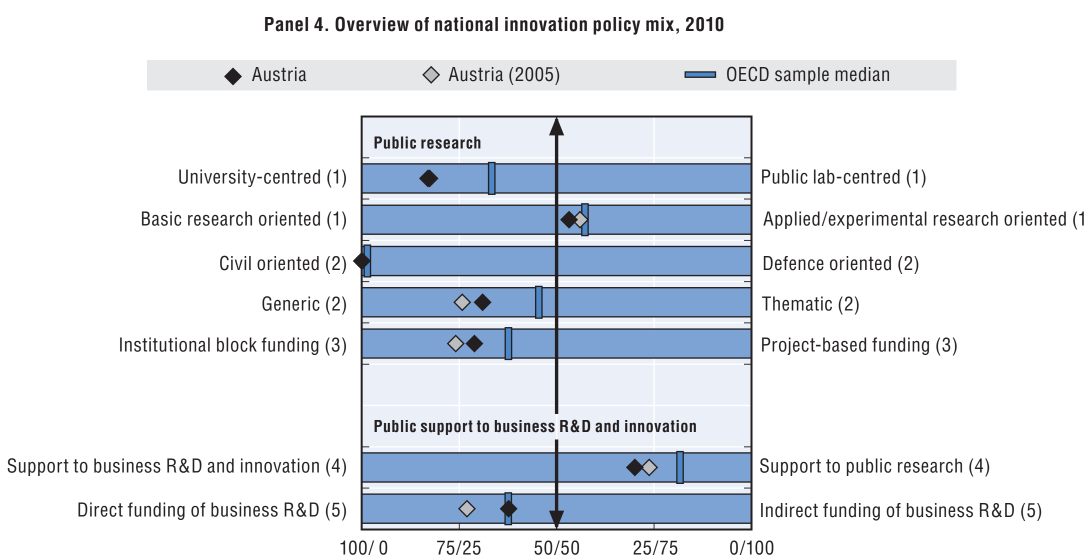
Human resources: Education is a key part of the RTI Strategy. Better education is critical for improving Austria's innovation system and raising standards of living. The New Secondary School (*NeueMittelschule*) programme is a major educational reform and the MINT-Initiative aims to improve maths, IT, natural sciences and technology education. *Forschungskompetenzen für die Wirtschaft* is an initiative to build R&D skills. The Lifelong Learning Strategy and the Lifelong Guidance Strategy aim to increase human capital at all levels. Joint ministerial programmes to stimulate overall STI skills include *Jugend innovativ,* Sparkling Science and Generation Innovation. There are several programmes at the tertiary and higher education levels.

Globalisation: The goal of the go-international programme of the Austrian Chamber of Commerce is to improve internationalisation and technology transfer; the USD 54 million *Internationalisierungsoffensive* helps Austrian exporters and investors to remain competitive.

Green innovation: Based on the 2010 Energy Strategy, an Energy Research Initiative (ERI) is planned to support the development of technologies notably for the production of renewable energy sources and the storage of CO_2. The Cleantech Initiative was launched to provide risk capital for innovative enterprises in energy and environmental technologies. The AWS Bank's capital injection of USD 8.3 million is expected to make around USD 42 million available in funding. Priority is also given to the development of a more sustainable and efficient transport system though initiatives such as E-Mobility.







1. Balance as a percentage of the sum of HERD and GOVERD.
2. Balance as a percentage of total GBAORD.
3. Balance as a percentage of total funding to national performers.
4. Balance as a percentage of the sum of HERD and GOVERD funded by government and higher education and components of (5).
5. Balance as a percentage of the sum of indirect funding of business R&D and innovation through R&D tax incentives and direct funding of BERD through grants, contracts and loans.

Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888932690187

BELGIUM

Hot STI issues

- Addressing expected shortages in human resources in S&T.
- Attracting inward foreign investment.
- Encouraging further commercialisation of R&D projects.

General features of the STI system: Belgium is a small economy, largely open to international trade and FDI, and highly exposed to external shocks. Poorly endowed in natural resources, it has highly developed transport networks and some strong manufacturing industries (chemicals), but is heavily service-oriented. The business sector accounts for 66% of GERD. Investment in R&D is moderate compared to the rest of the OECD (Panel 1[(a)(d)]). BERD was 1.32% of GDP in 2010, similar to 2003, with R&D activities concentrated in pharmaceuticals (28%), chemicals (9%) and computer services (8%). Foreign affiliates play a key role in business R&D (54%) (Panel 2) and the research system is well integrated in international networks: 57% of total scientific articles and 43% of patents filed under the PCT are produced through international co-operation (1[(q)(r)]). Industry and academia have good connections: the business sector finances 14% of public R&D activities (0.07% GDP) (1[(o)]). Belgium has a strong RTA in bio- and nano-technologies (Panel 3) and is active in patenting (1[(f)]). Framework conditions for entrepreneurship are mixed: while financing opportunities through venture capital exist (1[(h)]), the tax burden and regulatory barriers impede market adjustments (1[(j)]). ICT infrastructures are unevenly developed: fixed broadband infrastructures are widespread but wireless access is far below the OECD median (1[(k)]). Skills are modest (1[(s)(u)(v)]): a third of the adult population holds a tertiary education degree and graduation rates for PhDs in S&E are modest.

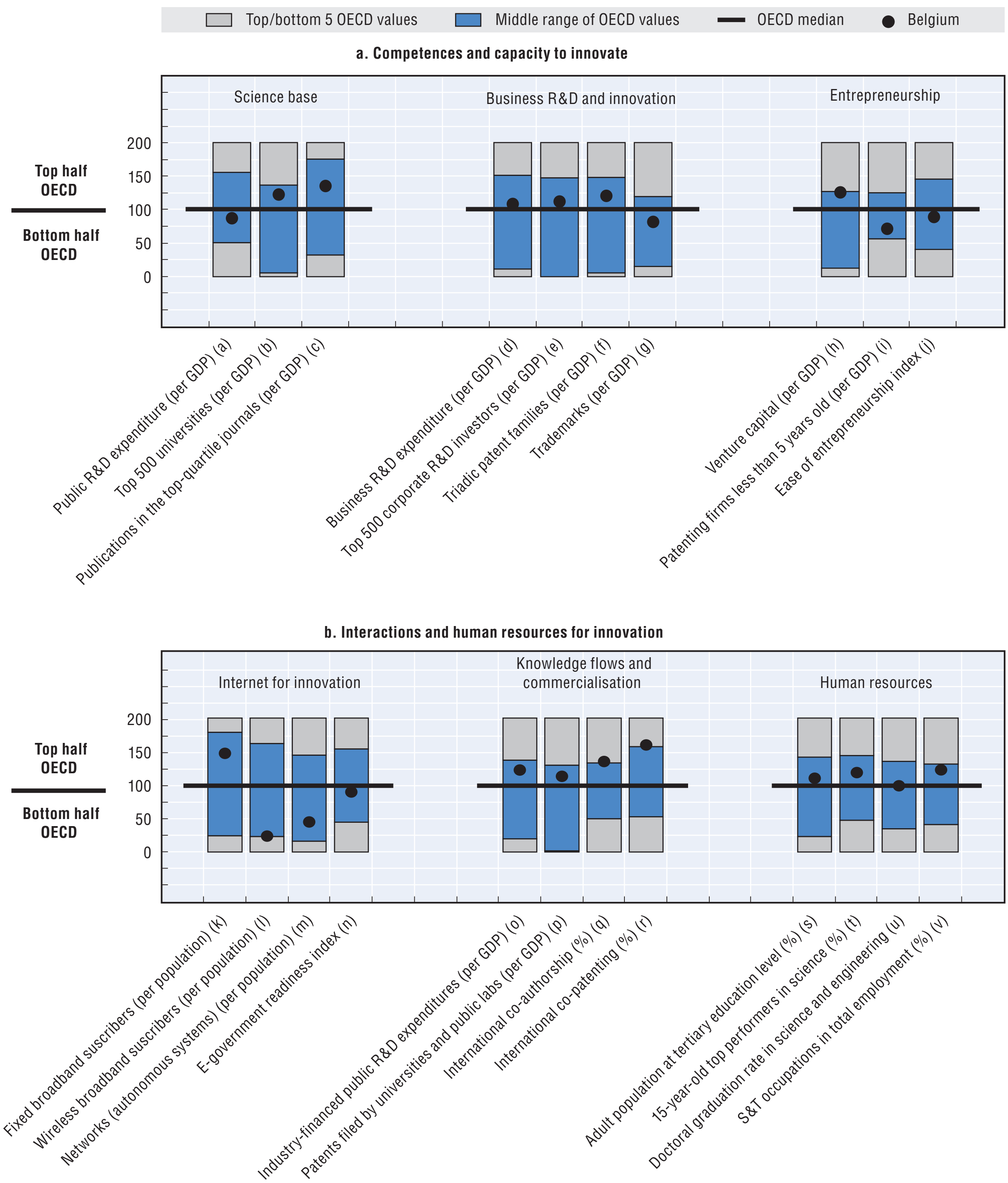
Recent changes in STI expenditures: GERD increased by 2.9% a year in real terms between 2005 and 2010 to 1.99% of GDP (USD 8 billion). Industry remains the main funder (59%) but government funding (25%) increased in relative terms as business investments in R&D receded. Funding from abroad (12%) is significant because of large MNEs in R&D-intensive industries and remained stable over the period.

Overall STI strategy: Belgium is a federation with three regions (Brussels-Capital Region [BCR], Flanders and Wallonia) and three communities (Flemish-, French- and German-speaking). The regions' competences are strictly separated. They account respectively for 8%, 67% and 25% of total R&D. The Federal Government Agreement adopted in 2008 set the main STI policy objectives: to reduce the employment costs of researchers; to support the creation and development of SMEs; and to increase R&D intensity. All competent Belgian authorities have included the EU Strategy 2020 3% target in their STI strategies and aim to increase expenditures on R&D. Flanders in Action (2009) focuses on research talent and the commercialisation of research results in strategic fields. The Innovation Centre Flanders concept note approved in May 2011 defines a long-term vision for innovation policy based on six vertical and transversal "innovation crossroads". The Walloon Marshall Plan 2. Green (2009) seeks to strengthen human resources and to consolidate regional cluster policy for sustainable development. The Creative Wallonia plan was also launched in 2010 to make Walloon society more conducive to innovation; a strategy for an integrated research policy was approved in March 2011. The Brussels 2006-11 Regional Innovation Plan includes a focus on sector-oriented clusters, internationalisation of the innovation system, and better economic returns to innovation.

Key figures			
Labour productivity, GDP per hour worked in USD, 2010	**58.9**	**GERD, as % of GDP, 2010**	**1.99**
(annual growth rate, 2005-10)	(+0.3)	(annual growth rate, 2005-10)	(+2.9)
Environmental productivity, GDP per unit of CO_2 emitted in USD, 2009	**3.92**	**GERD publicly financed, as % of GDP, 2009**	**0.58**
(annual growth rate, 2005-09)	(+3.7)	(annual growth rate, 2005-09)	(+4.7)

Figure 10.4. **Science and innovation in Belgium**

Panel 1. Comparative performance of national science and innovation systems, 2011



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

STI policy governance: In 2010, regional bodies opened discussions on interregional co-operation on R&D policy and instruments, and Wallonia opened its Competitiveness Poles to Brussels' stakeholders. In 2011, discussions were launched on a "smart specialisation strategy" to reshape innovation policy instruments and governance in all regions.

Science base: Universities perform 71% of total public R&D. Public research in Belgium is generally thematic and mainly financed on a competitive project basis (Panel 4). Although public R&D investments are small (0.65% of GDP) compared to OECD levels (1[(a)]), Belgium has a few world-class universities (1[(b)]) and a fairly high share of publications in top scientific journals (1[(c)]).

Business R&D and innovation: In 2011 the BCR introduced a set of direct funding schemes to foster R&D and innovation actors (PhDs in enterprises, highly skilled personnel, young innovative firms). In 2009, the Flemish government set up the SME wallet to subsidise SMEs' access to training, advice or technology expertise. Since 2011 the SME wallet has covered environment and energy areas. Since 2009, Wallonia co-funds (with European structural funds) NOVALLIA, a scheme to promote innovative projects by SMEs via loans at fixed rates. At federal level, tax concessions on social contributions on R&D wages are accorded to the private and public sectors and have increased strongly over the past five years. They were estimated at USD 575 million in 2009.

Entrepreneurship: Investments in seed and early stage capital amounted to 0.07% of GDP in 2009 (1[(h)]). This puts Belgium among the leading EU VC investors (with Finland, Ireland, Sweden, Switzerland and the United States). The BCR launched a new VC fund to support the "pre-commercial" phase of research. Flanders created a second ARKimedes fund to invest in start-ups and fast-growing SMEs. The Brussels region created the BRUSTART II fund for small innovative companies.

Clusters and regional policies: Regions' proactive innovation policies target leading-edge sectors. Flanders has strategic research centres and excellence centres, Wallonia has competitiveness poles, and the BCR has The Brussels Enterprises Agency Clusters. Flanders and the BCR are now also involved in international policy debates on smart specialisation.

Knowledge flows and commercialisation: To accelerate knowledge transfer, the Flemish government launched in 2010 the Transformation and Innovation Acceleration Fund (TINA) with USD 233 million to support collaborative projects in industrial production. Two new knowledge centres and several centres of excellence have been set up to strengthen joint S&T capacities and co-operation. In 2011, Flanders introduced SOFI to support spin-off companies from the strategic research centres. The Technological Innovation Partnership in Wallonia (2009) and the BCR's strategic platforms (2010) also aim to encourage collaborative research. The federal government offers additional tax deductions for firms collaborating with PRIs.

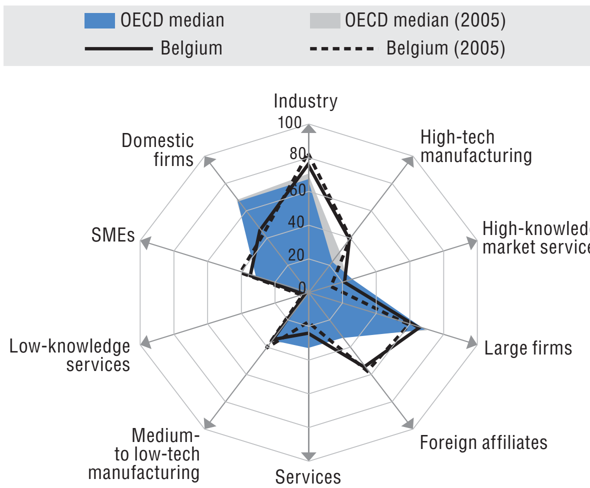
Globalisation: Attracting inward FDI is a major concern of the Belgian authorities. Flanders aims to become "a strong international network area for research and innovation". In 2010 Wallonia set up offices in its science parks and abroad to provide assistance to foreign investors. Since 2011, the BCR supports international partnerships by financing staff costs, travel costs, and legal and translation services.

Human resources: Flanders addressed the issue of skills availability by implementing the Action Plan for Researchers 2010-11 to improve the attractiveness of research careers, and a STEM-Action Plan (2012) which, combined with a science communication plan, aims to increase the number of students in STEM in secondary and higher education.

Green innovation: The Walloon Marshall Plan 2. Green emphasises environmental issues, and in 2011 Wallonia launched a competitiveness pole for green technologies. Flanders implemented the Flemish Climate Policy Plan 2013-20 and a second Energy Efficiency Action Plan 2011-16 to adopt new energy standards, especially in construction, housing and industry, through the Flemish Energy Agency, the innovation platforms Generaties for renewable energy, Smart Grid Flanders, and a Green Guarantee for entrepreneurs.

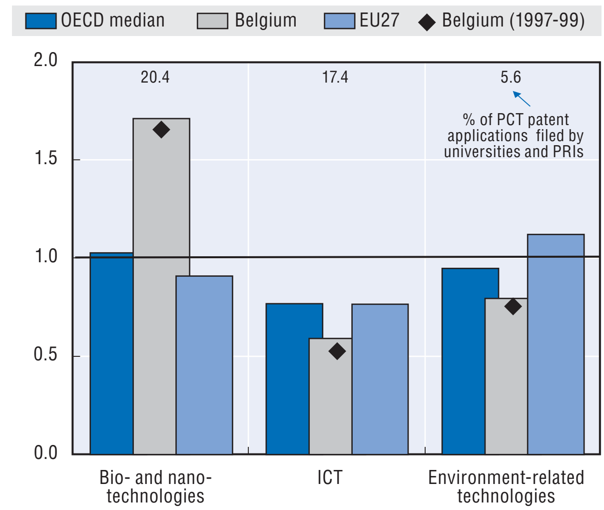
Panel 2. Structural composition of BERD, 2009

As a % of total BERD

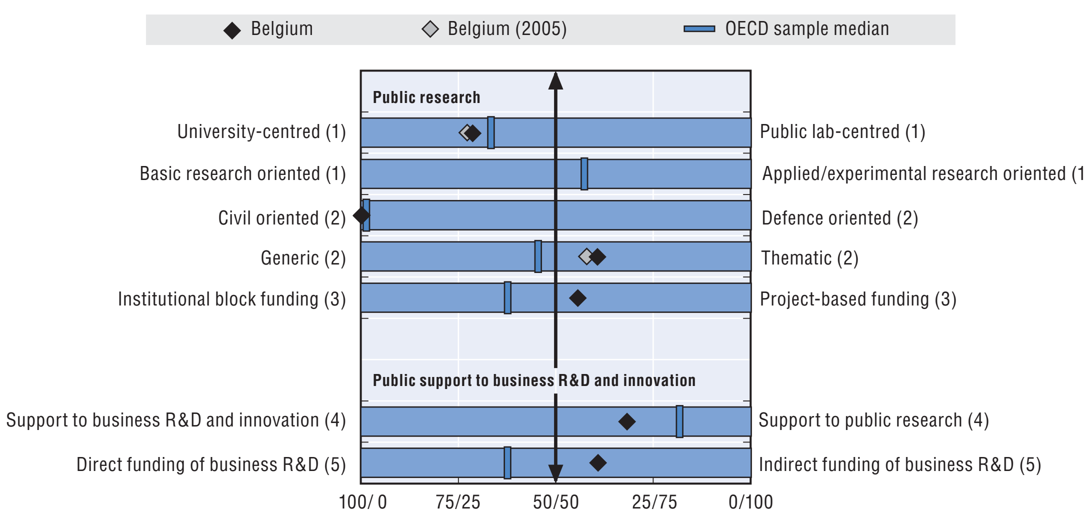


Panel 3. Revealed technology advantage in selected fields, 2007-09

Index based on PCT patent applications



Panel 4. Overview of national innovation policy mix, 2010



1. Balance as a percentage of the sum of HERD and GOVERD.
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Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888932690206

BRAZIL

Hot STI issues

- Supporting innovation to expand the basis for environmental sustainability and developing a low carbon economy.
- Promoting technological innovation in the business sector including SMEs.
- Supporting innovation to address social challenges (inclusiveness).

General features of the STI system: Brazil is an emerging economy which weathered the global financial crisis well with a continuing upward growth trajectory. Brazil has some well-known leading innovative firms (Panel 1[(e)]) and is at the forefront in high-technology fields such as deep water oil extraction. A few universities undertake high-quality research (1[(b)]). This performance, however, does not spill over to the entire, very diversified Brazilian economy. In particular, the many SMEs innovate very little. Challenging framework conditions and substantial social challenges, such as poverty, explain the generally weak STI performance. Research outputs are very low compared to the OECD in terms both of articles published in top-quartile scientific journal (1[(c)]) and of patents and trademarks (1[(f)(g)]). Over 2005-09, the relative number of patents filed by universities and PRIs per GDP was well below the OECD median (1[(p)]). Conditions are difficult for private firms; the ease of entrepreneurship index is low but is above that of some OECD countries (1[(j)]). In terms of international innovation-related linkages, 27% of total scientific articles involved international co-authorship (1[(q)]) and 17% of PCT patent applications were international co-inventions (1[(r)]). One of the reasons for these comparatively low numbers is the large size of the Brazilian economy. A major innovation system bottleneck is Brazil's human capital. In 2009 only 11% of the adult population had a tertiary education level (1[(s)]). The PISA science scores of 15-year-olds are also very low (1[(t)]).

Recent changes in STI expenditures: In 2008, Brazil's GERD was 1.08% of GDP, a share that is below the OECD median, but above other major Latin America economies such as Argentina, Chile and Mexico.

Overall STI strategy: The Greater Brazil Plan 2011-14, adopted in 2011, gives innovation a central role and includes proposals for significant changes in legal frameworks. Moreover, the National Strategy in Science, Technology and Innovation (ENCTI) was designed to: *i)* close the technological gap with developed economies; *ii)* support Brazil's leadership in the nature-related knowledge economy (including green innovation, agro-business and other natural-resource-based activities); *iii)* strengthen the internationalisation of the national research system; *iii)* foster the development of a green economy; and *iv)* address social and regional inequalities.

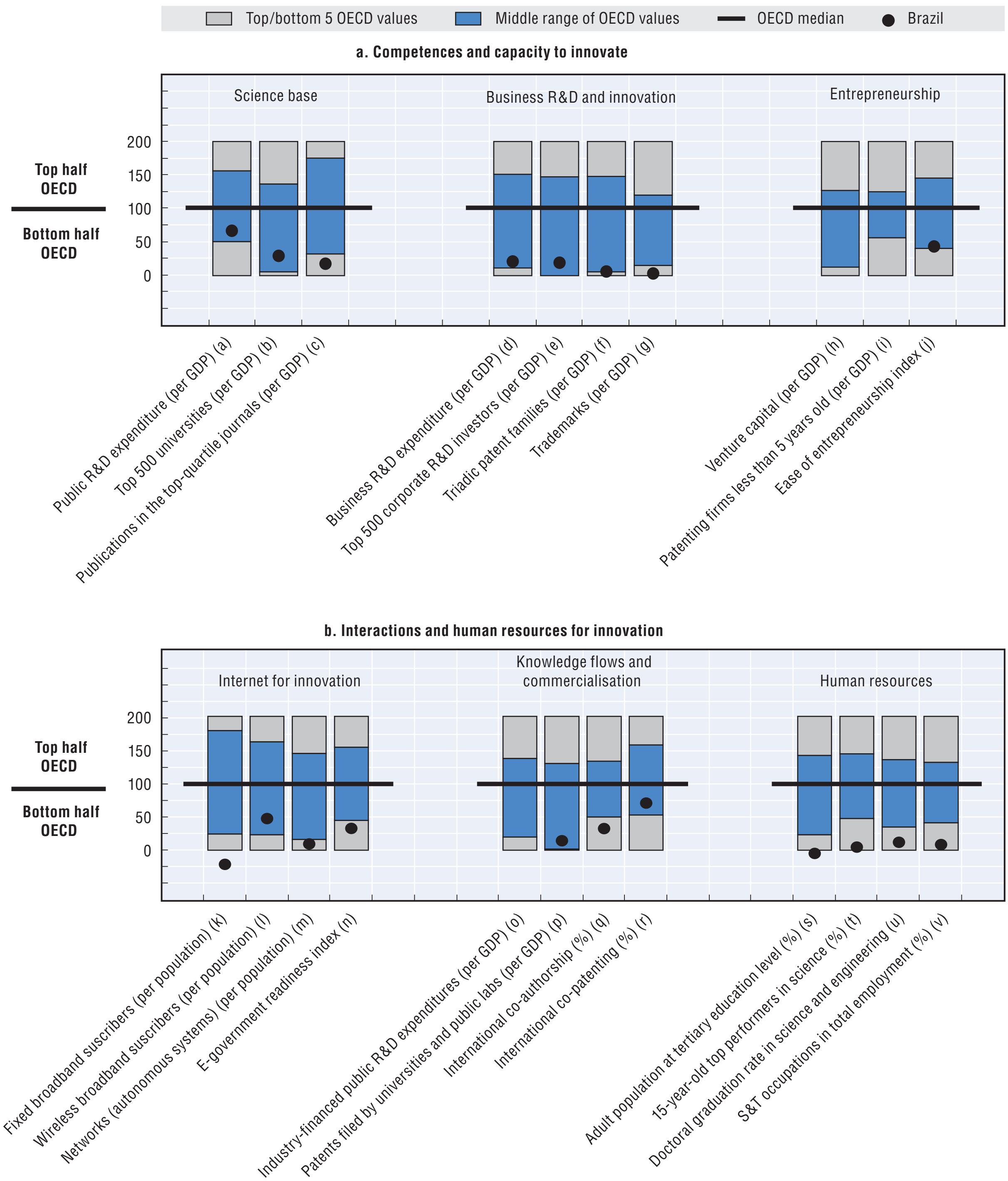
STI policy governance: Brazil's STI policy governance has not recently undergone major changes. However, several measures aim to improve co-ordination between institutions at the federal level and between federal and state bodies. The National Council for Industrial Development was redesigned in August 2011. It includes ministries, the president of the National Bank for Economic and Social Development (BNDES), private businesses, and industry and labour union representatives, among others. It aims at better co-ordination and greater involvement of stakeholders.

Key figures

Labour productivity, GDP per hour worked in USD, 2010	**n.a.**	**GERD, as % of GDP, 2008**	**1.08**
(annual growth rate, 2005-10)	n.a.	(annual growth rate, 2005-08)	(+8.9)
Environmental productivity, GDP per unit of CO_2 emitted in USD, 2009	**5.95**	**GERD publicly financed, as % of GDP, 2008**	**n.a.**
(annual growth rate, 2005-09)	(+3.6)	(annual growth rate, 2005-08)	n.a.

Figure 10.5. **Science and innovation in Brazil**

Panel 1. Comparative performance of national science and innovation systems, 2011



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

Business R&D and innovation: Brazil's innovation policy has moved from focusing mainly on the science base to stronger support for business R&D. Several changes in the legal framework allow for an increase in incentives: the *Innovation Law* (2004) permits direct funding of business through competitive grants; the annual budget amounts to some USD 348 million. The *Goodwill Law* (2005) introduced a wide range of fiscal incentives. Also, tax exemption rules for companies were modified in 2007 to link them to the use of IPRs. The Greater Brazil Plan includes proposals for further legal changes, such as the funding of private non-profit institutes and new fiscal incentives for investors. Moreover, funding agencies provide support for developing low-cost, easy-to-use applications that address social challenges. For example, HABITARE, an initiative of some USD 14 million, supports innovations in housing technology, including for social housing.

Entrepreneurship: Several initiatives support start-ups. Financial support is provided through grants (Programa Primeira Empresa Inovadora, PRIME, under which a total of 1 381 enterprises have received about USD 98 million), venture capital investments (INOVAR), or reduced interest loan programmes (Juro Zero Programme). In addition, the Pro-Innova programme introduced in 2008 encourages entrepreneurship by diffusing information about the legal tools, facilities and mechanisms available to support initiatives.

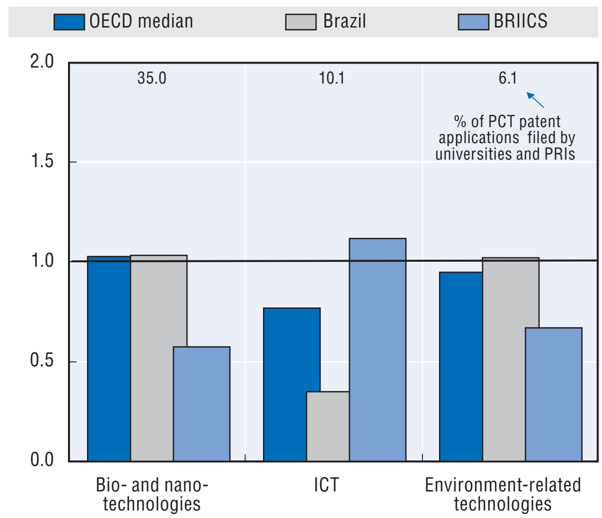
Knowledge flows and commercialisation: Greater emphasis has recently been placed on supporting individual firms and the commercial development of technological innovations. The *Innovation Law* (2004) helps establish innovative companies by offering incubation services in public S&T institutes, and facilities for public researchers to take part in joint projects and the establishment of start-ups. In addition to financial support schemes for collaborative research projects (*e.g.* SIBRATEC, with investments of USD 204 million from 2007), Brazil has several programmes to encourage researchers' sectoral mobility (*e.g.* PAPPE, the Programme for Support of Research in Enterprise, of some USD 146 million from 2007 to 2010, and SEBRAE, the Brazilian Support Service for Small Enterprises). These programmes seek to encourage knowledge flows between universities and PRIs and the business sector.

Globalisation: Recent programmes promote the internationalisation of the national research system. In December 2010, an inter-ministerial committee was established to act as a one-stop shop for potential foreign investors and to provide information on the legal framework and available innovation support instruments. Moreover, Ciência sem Fronteiras, a programme launched in 2011, supports the mobility of national students and seeks to attract young and internationally recognised researchers by providing funding to engage in research projects abroad and to attract foreign researchers.

Human resources: Efforts have been made to increase the quality of education at all levels, including the introduction of entrance examinations for teachers. To support bigger enrolment rates, funding for basic and professional education has increased and conditions for student loans have been eased. In addition, the Brazilian Mathematics Olympiad Competition for Public Schools (OBMEP) seeks to stimulate and promote mathematics studies among public school students. By awards to top participants and their schools, the programme also encourages the improvement of teaching.

Green innovation: The development and promotion of a green economy are objectives of Brazil's STI strategy. Support programmes include sectoral funds (CT-Energy, CT-Petro). In terms of the environment, the National Policy on Industry, Technology and Trade has programmes for the creation of a biotechnology centre and for biodiesel research. In February 2012, the creation of a new Climate Fund under BNDES was announced. Its purpose is to finance projects to reduce greenhouse gas emissions.

Panel 2. Revealed technology advantage in selected fields, 2007-09
Index based on PCT patent applications



Source: See reader's guide and methodological annex.

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CANADA

Hot STI issues

- Increasing the R&D intensity of firms via a mix of indirect and direct funding.
- Further developing labour force skills.
- Building on existing comparative advantages, including in resource-based sectors, and achieving higher productivity growth.

General features of the STI system: Canada's labour productivity grew slowly for most of the decade to 2010. Attention has therefore turned to the role of innovation in driving growth. With the economy's strong resource-based sectors, BERD stood at 0.91% of GDP in 2011, well below the OECD median. Much R&D activity is concentrated in the services sector (44%) and Canada's activity in non-technological innovation is reflected in the trademark data (Panel 1[g]). SMEs (38%) also play a key role. At the same time, industry funds a larger share of public research than in most OECD countries (1[o]). Canadian researchers are reasonably well networked internationally, with 45% of scientific articles and 30% of PCT patent applications produced with international collaboration (1[q][r]). Canada's RTA is strong in the three technology areas covered; it has risen sharply in ICT in recent years, but declined somewhat in environment-related technologies (Panel 3). Canada's human capital is of high quality; 50% of the adult population is tertiary-qualified (1[s]), and 30% of the labour force fills S&T jobs (1[v]). PISA science scores for 15-year-olds are the seventh highest in the OECD area (1[t]). ICT infrastructure is quite well developed, with 31 fixed broadband but only 32 wireless subscribers per 100 inhabitants (1[k][l]). In terms of e-government readiness, Canada is among the top ten OECD countries (1[n]).

Recent changes in STI expenditures: GERD in constant prices has declined by 1.2% a year during the latter half of the past decade to USD 24 billion and 1.74% of GDP in 2011. It fell sharply in 2008 and again in 2010. In 2009 in the wake of the economic crisis, the Economic Action Plan allocated USD 50 billion to assist industries. Investments to boost broadband Internet, modernise laboratories, and fast-track clean energy capabilities were made.

Overall STI strategy: Canada's STI policy is based on Mobilizing Science and Technology to Canada's Advantage launched in 2007. The strategy seeks to foster Canada's competitiveness through investments and activities in three key areas: the role of the private sector in innovation, research excellence and strategic R&D, and knowledge-based workers. The technology priority areas are environmental science, natural resources and energy, health and life sciences, and ICT.

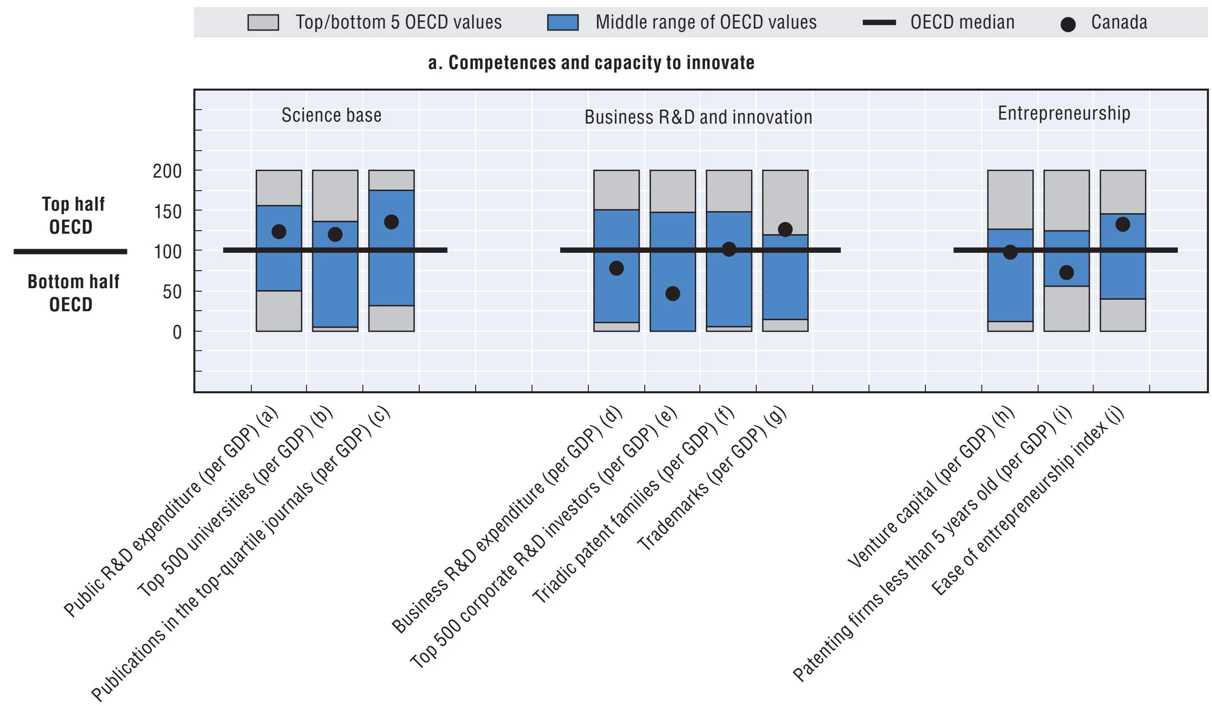
STI policy governance: Governance structures have remained largely unchanged. The Prime Minister and Cabinet formulate overall STI policy. Industry Canada and the Department of Finance implement policy with the science-based departments and agencies. The Natural Sciences and Engineering Research Council (NSERC), the Social Sciences and Humanities Research Council (SSHRC), the Canadian Institutes of Health Research and the Canada Foundation for Innovation fund research and science infrastructure at the federal level. Canadian provinces enjoy considerable autonomy; they develop and fund R&D policies for their

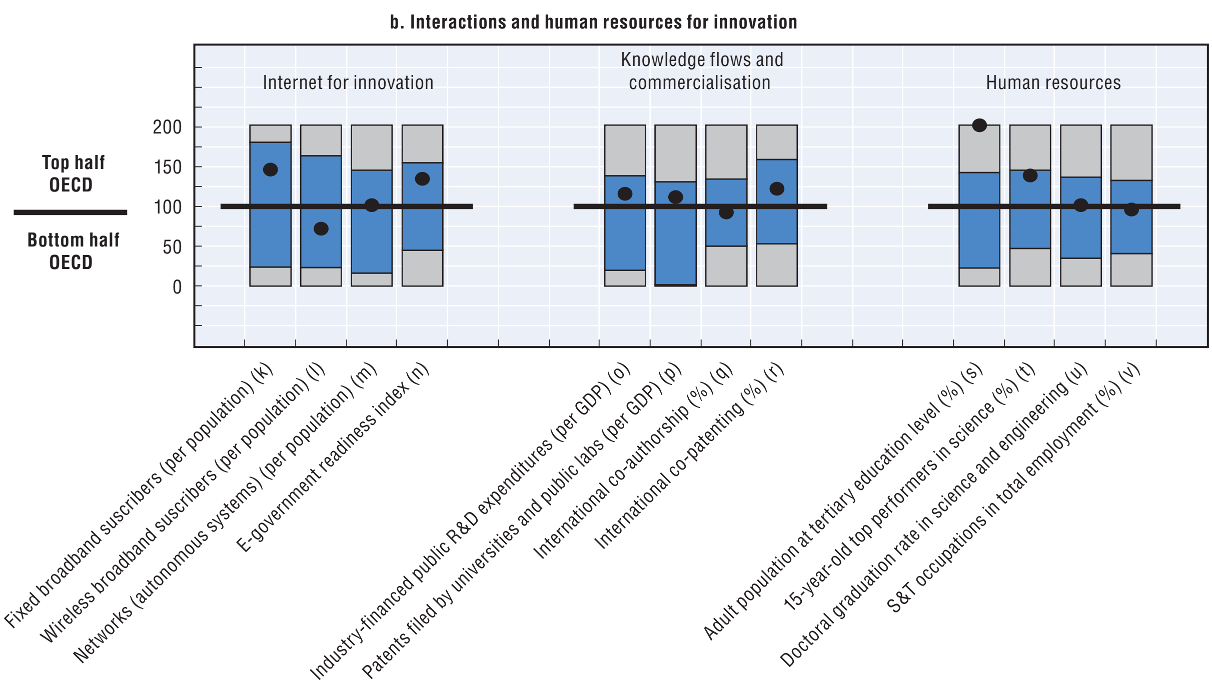
Key figures

Labour productivity, GDP per hour worked in USD, 2010	**45.2**	**GERD, as % of GDP, 2011**	**1.74**
(annual growth rate, 2005-10)	(+0.5)	(annual growth rate, 2005-11)	(–1.2)
Environmental productivity, GDP per unit of CO_2 emitted in USD, 2009	**2.45**	**GERD publicly financed, as % of GDP, 2009**	**0.83**
(annual growth rate, 2005-09)	(+2.4)	(annual growth rate, 2005-09)	(+1.6)

Figure 10.6. **Science and innovation in Canada**

Panel 1. Comparative performance of national science and innovation systems, 2011





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

economies and fund education. The Science, Technology and Innovation Council advises the Minister of State for Science and Technology and produces regular reports on the state of Canada's innovation system. The Canadian Council of Academies is an independent non-profit corporation that informs public policy development via science-based assessments.

Science base: Although Canada's R&D intensity is relatively low, public-sector expenditure on R&D is well above the OECD median (1[(a)]). The public research system is university-oriented (Panel 4): HERD, at 0.65% of GDP, makes up almost 38% of GERD (2011). Canadian researchers perform well in terms of publications (1[(c)]).

Business R&D and innovation: Following the recent government commitment to address the private sector's need to foster business innovation more effectively, the 2012 federal budget plans USD 902 million over five years for direct support for R&D and USD 410 million for venture capital. The Scientific Research and Experimental Development tax incentive programme was also modified by removing capital from the expenditure base and streamlining it to be more cost-effective and predictable.

Entrepreneurship: To promote entrepreneurship, Canada has improved SME access to the SR&ED tax credit. BDC Venture Capital assists and finances firms (especially SMEs) from seed to expansion phases. Export Development Canada (EDC) provides private equity capital to assist firms to expand through export guarantee programmes.

ICT and scientific infrastructures: As part of its efforts to help develop a stronger digital economy, the government supports the adoption of key ICTs by SMEs through the Industrial Research Assistance Program (NRC-IRAP), and increased student enrolment in digital economy-related disciplines. The *Copyright Modernisation Act*, introduced in 2011, adapts laws to the digital economy. Investments were also made in post-secondary institutions (USD 4.3 billion) through the Knowledge Infrastructure Program (KIP), and in state-of-the art research facilities (USD 728 million) by the Canada Foundation for Innovation (CFI).

Knowledge flows and commercialisation: With its strong public research base, Canada could translate knowledge into commercial success more effectively. Relevant initiatives to do so include the Idea to Innovation Program, the Canadian Innovation Commercialization Program (CICP), the centres of excellence for commercialisation and research (CECR), and the Forest Industry Transformation Program. Other programmes to improve collaboration are the Business-Led Networks of Centres of Excellence and the Applied Research and Commercialisation Initiative.

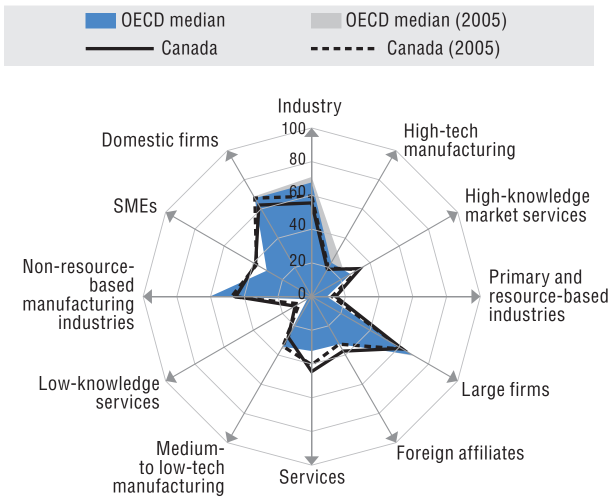
Human resources: Canada is among the leading OECD countries in terms of spending on higher education. The government has made strategic investments to strengthen Canada's knowledge advantage, including new Canada Excellence Research Chairs, enhanced eligibility for Canada Student Loans and Grants, expanded opportunities for adult basic education, tax relief and Registered Education Savings Plan assistance to post-secondary students who study abroad.

Emerging technologies: The federal government funds research for emerging technologies in areas ranging from health to nuclear research. Examples include funding to Genome Canada (USD 63 million), climate and atmospheric work through the NSERC (USD 34 million), the Canada Brain Research Fund (USD 97 million), the Perimeter Institute for Theoretical Physics (USD 49 million) and the National Optics Institute. The Strategic Aerospace and Defence Initiative (SADI) supports R&D in aerospace, defence, space and security technologies.

Green innovation: Canada has introduced a range of policies to encourage green growth. On the regulatory side are the Passenger Automobile and Light Truck Greenhouse Gas Emissions Regulations. The Canadian Intellectual Property Office (CIPO) expedites patent applications related to green technology. Funding initiatives – often coupled with forums for dialogue – include the Clean Energy Fund (USD 0.97 billion), the Clean Energy Dialogue, Sustainable Development Technology Canada (SDTC), the ecoENERGY Innovation Initiative, the Automotive Innovation Fund and Automotive Partnership Canada.

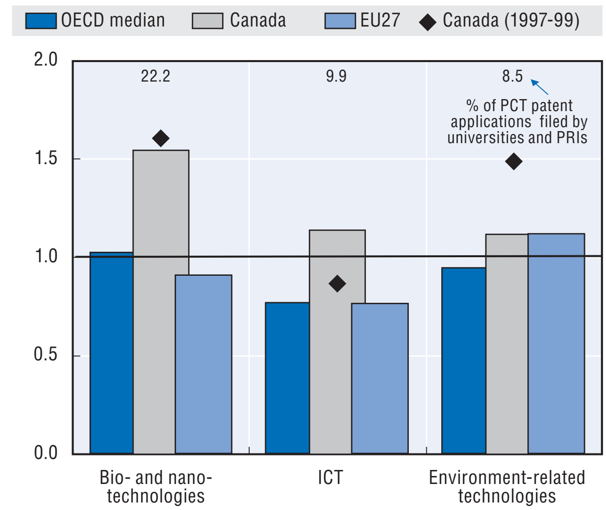
Panel 2. Structural composition of BERD, 2009

As a % of total BERD

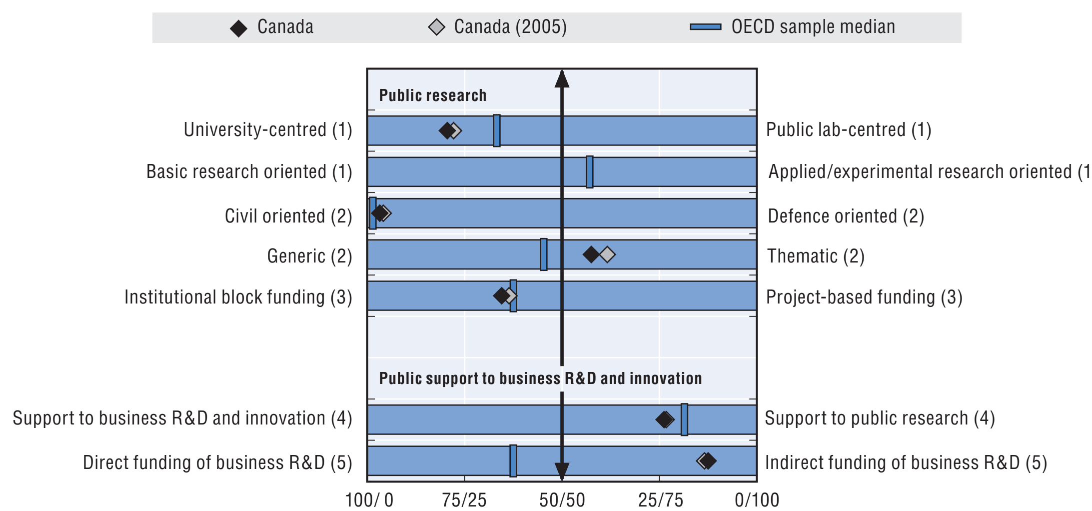


Panel 3. Revealed technology advantage in selected fields, 2007-09

Index based on PCT patent applications



Panel 4. Overview of national innovation policy mix, 2010



1. Balance as a percentage of the sum of HERD and GOVERD.
2. Balance as a percentage of total GBAORD.
3. Balance as a percentage of total funding to national performers.
4. Balance as a percentage of the sum of HERD and GOVERD funded by government and higher education and components of (5).
5. Balance as a percentage of the sum of indirect funding of business R&D and innovation through R&D tax incentives and direct funding of BERD through grants, contracts and loans.

Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888932690244

CHILE

Hot STI issues

- Strengthening the science base to reach OECD benchmarks.
- Improving the quality of education at all levels and increasing enrolment in quality tertiary education.
- Fostering entrepreneurship through more favourable framework conditions, improvement of related skills and easier access to finance.

General features of the STI system: Chile is a small open economy. It is the world's leading producer of copper, on which its exports largely depend. Chile's economic performance over the last decades was driven by economic reforms and institution building. However, average GDP growth has slowed markedly in the 2000s, owing in part to the need to strengthen various aspects of the innovation system. The business sector plays a modest role in R&D; BERD accounted for only 0.16% of GDP in 2010 (Panel 1[d]), the lowest among OECD countries. Business R&D performance suffers from a relative lack of the competitive pressures that stimulate innovation. Many firms innovate through adaptation of imported technologies, which is not tracked by R&D indicators. Chilean framework conditions continue to be a challenge: the ease of entrepreneurship index is below the OECD median (1[j]). Scarcity of human capital is also a major concern: all indicators are below the OECD median (1[s][t][u][v]). Over 2008-10, 55% of total scientific articles had international co-authors (1[q]) and 31% of total PCT patent applications were international co-inventions over 2007-09 (1[r]), both above the OECD median, owing in part to the small size of the national scientific and research community.

Recent changes in STI expenditures: Following a substantial increase in public spending, Chile's GERD was 0.42% of GDP in 2010, among the lowest of OECD countries with Mexico and Greece. The government's objective is to increase spending on R&D from 0.4% to 0.8% of GDP. In 2012 the public budget for science, technology and innovation rose to USD 500 million to help reach this objective.

Overall STI strategy: The National Innovation Strategy for Competitiveness, presented in 2008 by the previous government, has three main pillars: *i)* the development of human capital; *ii)* the strengthening of the science base to address socio-economic needs; and *iii)* the improvement of business R&D and innovation activities. The current government's 2010-14 Innovation Plan has eight major axes; these include greater emphasis on entrepreneurship and on technology transfer, global connection and dissemination.

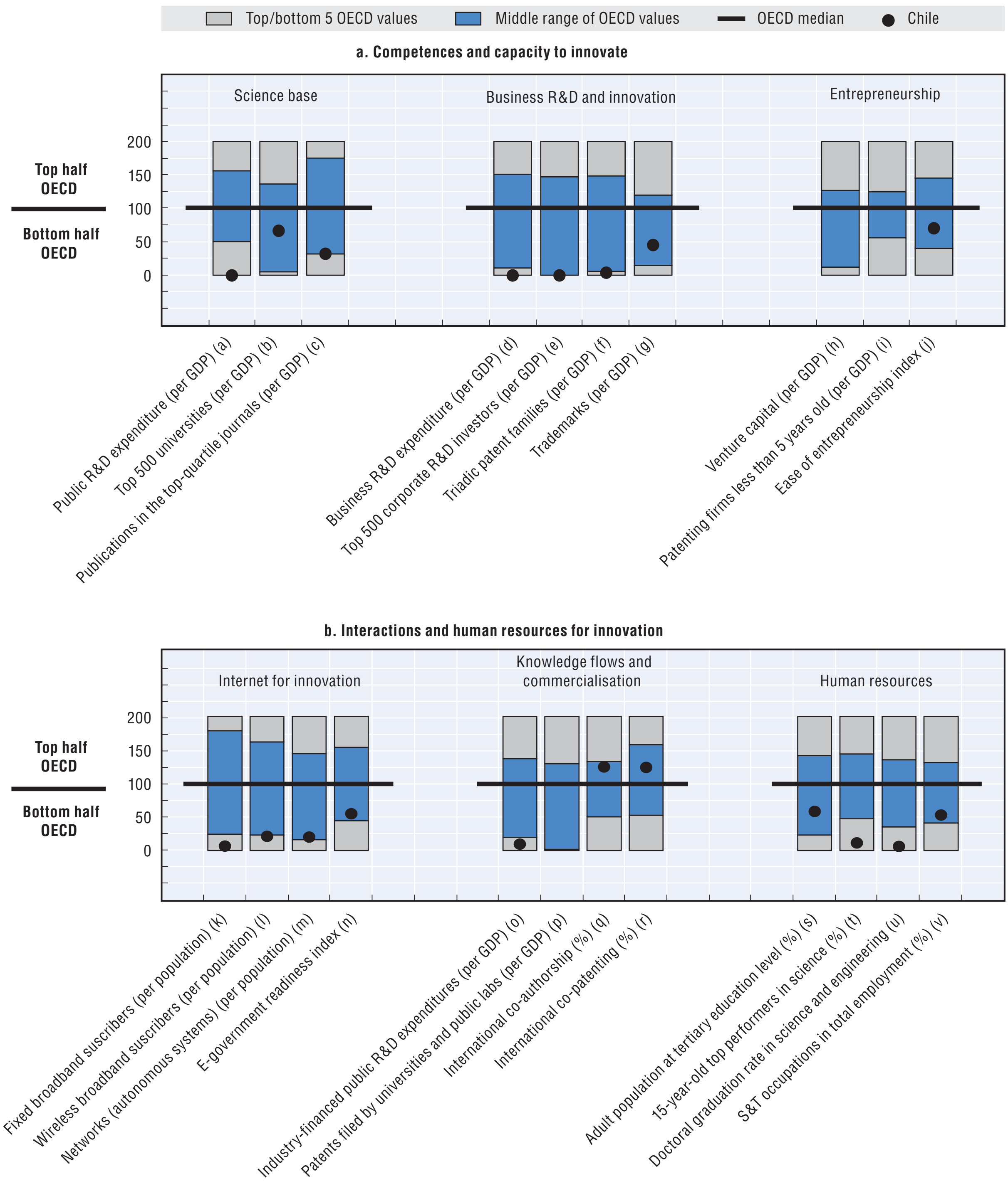
STI policy governance: Since the establishment of the National Innovation Council for Competitiveness (CNIC) in 2005 to advise the president on a national innovation strategy, there has been no major change in STI policy governance. An emerging debate in this respect concerns giving CNIC responsibility for monitoring the implementation of the strategy and evaluating its impacts.

Key figures

Labour productivity, GDP per hour worked in USD, 2010	**19.2**	**GERD, as % of GDP, 2010**	**0.42**
(annual growth rate, 2005-10)	(+2.7)	(annual growth rate, 2005-10)	n.a.
Environmental productivity, GDP per unit of CO_2 emitted in USD, 2009	**4.01**	**GERD publicly financed, as % of GDP, 2010**	**0.20**
(annual growth rate, 2005-09)	(+0.0)	(annual growth rate, 2005-10)	n.a.

Figure 10.7. **Science and innovation in Chile**

Panel 1. Comparative performance of national science and innovation systems, 2011



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

Science base: Chile's science base is weak. Public R&D expenditure was only 0.16% of GDP in 2010, the lowest among OECD countries (1[(a)]). The scientific community is small (1[(v)]) and quality research is concentrated in only a few universities. Public research does not do enough to meet the needs of the productive sector.

Entrepreneurship: Limited financial resources and administrative burdens have hampered start-up activities. In response, a law was passed in January 2011 to lower regulatory barriers for young companies and reduce the time to start up a business. Programmes such as Fondo Capital Abeja aim to ease access to credit for small enterprises and women, and the Support for Entrepreneurial Environment programme aims to foster entrepreneurship skills and competences.

ICT and scientific infrastructures: As part of the objective to strengthen the national science base, the government has increased funding for the modernisation and improvement of S&T infrastructures, notably through the recently established Fondequip, with a budget of over USD 10 million in 2012.

Knowledge flows and commercialisation: The Chilean Economic Development Agency (CORFO) promotes collaborative research by companies, researchers and PRIs in priority sectors (*e.g.* aquaculture, the food industry, mining). It offers a number of incentives to improve technology transfer (*e.g.* support for IPRs and programmes to strengthen universities' transfer and licensing offices). Go to Market, a programme launched in 2011, aims to facilitate the commercialisation and export of the results of applied R&D carried out by enterprises and researchers.

Globalisation: Start Up Chile, launched as a pilot programme in 2010, seeks to attract entrepreneurs from abroad by offering equity-free seed capital and a temporary one-year visa to develop innovative start-up activities. A programme to attract international centres of excellence for competitiveness aims to facilitate the installation in Chile of international centres of excellence in R&D. Collaboration has already been established with the Fraunhofer-Gesellschaft (Germany) in biotechnology, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) (Australia) in mining and mineral processing, Inria (France) in ICT, and Wageningen UR (Netherlands) in the food industry. It focuses specifically on generating capacity in priority sectors such as aquaculture and mining. The Global Connection programme supports the internationalisation of Chilean entrepreneurs.

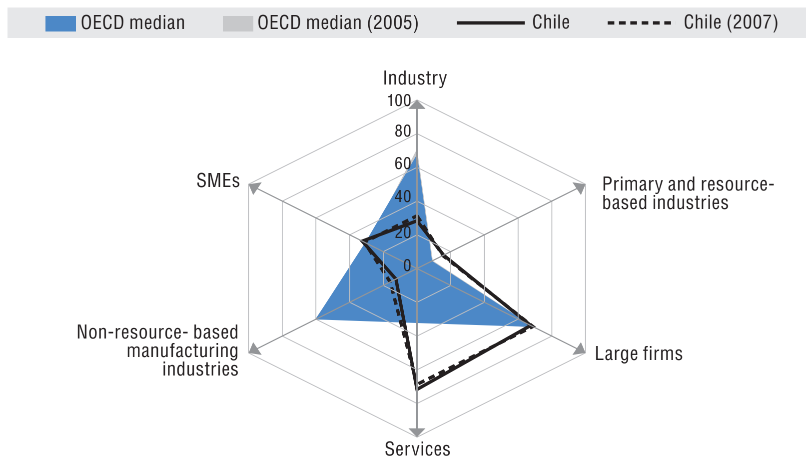
Human resources: The improvement of the quality of the national education system at all levels is a priority. The Teacher Vocation Scholarship, launched in 2010, encourages good students to become teachers, and a quality assurance system was introduced in 2011. Chile VA! (2011) is a programme to promote S&T vocations by organising science camps. These programmes are complemented by an increase in scholarships and a reduction in the interest rate on guaranteed student loans. A programme for placing researchers in enterprises has been implemented to enhance researchers' involvement in activities that support private innovation.

Emerging technologies: Through CORFO, Chile has developed a programme to strengthen strategic productive sectors in five fields: food, mining, global services, aquaculture and special interest tourism. With a budget of USD 1.1 million for 2012, the programme focuses on co-ordination of work between public and private institutions, companies, researchers and academics to promote the competitiveness of these sectors.

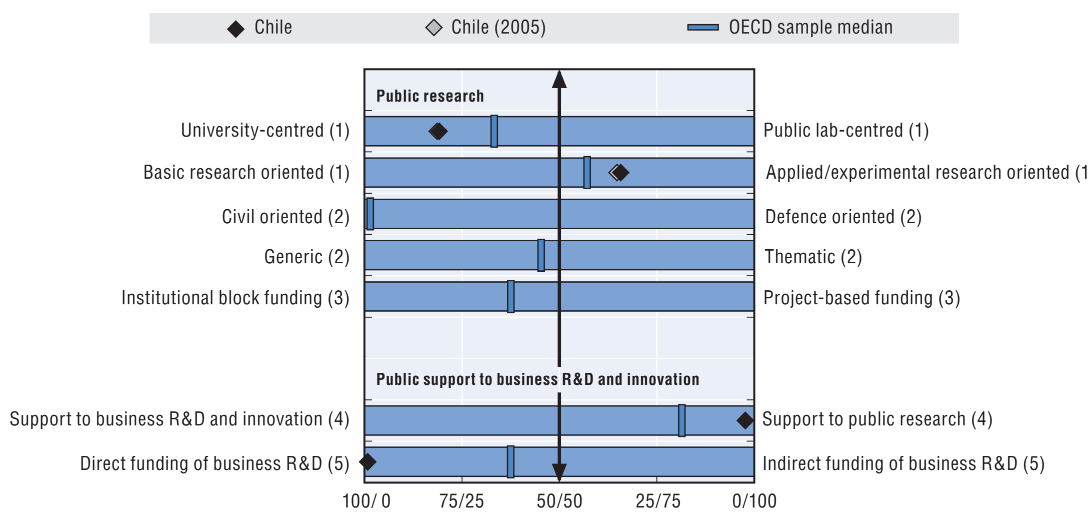
Green innovation: The Ministry of Environment, established in 2010, is in charge of implementing the National Plan on Climate Change 2008-12. In 2009 the Renewable Energy Centre was created to help build national capabilities to address related challenges.

Panel 2. Structural composition of BERD, 2009

As a % of total BERD



Panel 3. Overview of national innovation policy mix, 2010



1. Balance as a percentage of the sum of HERD and GOVERD.
2. Balance as a percentage of total GBAORD.
3. Balance as a percentage of total funding to national performers.
4. Balance as a percentage of the sum of HERD and GOVERD funded by government and higher education and components of (5).
5. Balance as a percentage of the sum of indirect funding of business R&D and innovation through R&D tax incentives and direct funding of BERD through grants, contracts and loans.

Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888932690263

CHINA

Hot STI issues

- Promoting indigenous innovation capability, especially among Chinese firms.
- Fostering scientific excellence and world-class talent for STI.
- Innovating for green growth and addressing social challenges.

General features of the STI system: China is the world's second largest economy in terms of GDP but its GDP per capita is USD 8 350 (PPP). The STI system has moved from a Soviet-type science-based R&D system to a firm-centred market-based innovation system. While China's "open door" policy has helped it to access foreign capital and technologies, create pockets of knowledge-intensive activities and move up global value chains, it has also increased its reliance on foreign technologies. The national innovation system features marked regional disparities. Beijing has a strong science base, with many PRIs, including the Chinese Academy of Sciences (CAS), and top universities; these are national R&D centres with global connections. Shanghai has a large-scale, R&D-intensive industry base. Guangdong province has a foreign (manufacturing) firm-based innovation system and accounts for more than half of China's PCT patent applications (almost two-thirds in ICT). In contrast, China's western regions lack the absorptive capacity needed to capture knowledge flows from coastal areas and abroad. Collaboration, as shown in patent data, is weak across regions. China's R&D output in terms of patents is low (Panel 1[f]) although Chinese firms are active both as R&D performers and contractors (1[d](o)). The business sector accounts for 72% of GERD (1.30% of GDP). Business funds 11% of academic research (0.06% of GDP). China's RTA has increased in ICT over the past decade but lost considerable ground in biotechnology and green technologies (Panel 3). Innovative entrepreneurial activities (1[i]) appear constrained by regulatory and administrative burdens (1[j]). The dominance of state-owned enterprises, especially in public facilities, tends to reduce pressures to innovate. China's ICT infrastructures have developed fast but, in per capita terms, ICT use and e-government readiness are still low compared to the OECD median (1[k](m)(n)). While China had the world's largest pool of FTE researchers in 2007, its workforce's tertiary education attainment is low (1[s]). This is changing quickly, as the tertiary attainment rate is twice as high for those aged 25-34 as for the 55-64 age group.

Recent changes in STI expenditures: China's GERD has more than doubled in just five years (2005-10) to USD 179 billion. Since 2009, China has the world's second largest R&D expenditure after the United States. GERD reached 1.77% of GDP in 2010. BERD as a share of GERD increased to the top level of OECD countries (Panel 2), and firm self-funded R&D reached 93%.

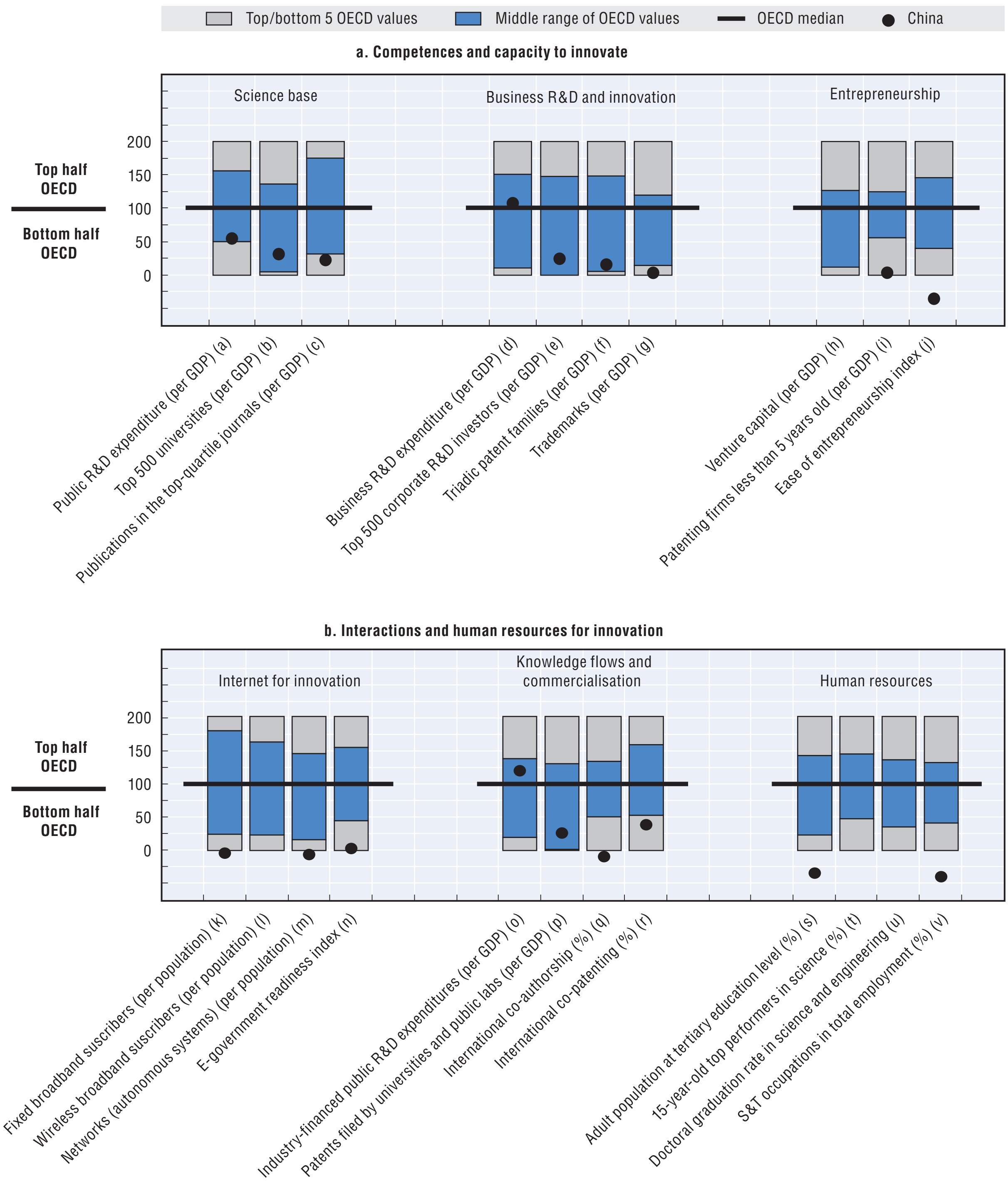
Overall STI strategy: The Medium- and Long-term Plan for S&T Development 2006-20 (MLP) provides a blueprint for China's transformation to an innovation-driven economy by 2020. R&D expenditures are meant to reach 2.5% of GDP. The present 12th Five-Year-Plan for S&T Development (2011-15) plays a central role in implementing the MLP and emphasises key technologies for strategic and emerging industries (manufacturing, agriculture, ICT), relieving the pressures on energy, resources and the environment, and accommodating

Key figures

Labour productivity, GDP per hour worked in USD, 2010	**n.a.**	**GERD, as % of GDP, 2010**	**1.77**
(annual growth rate, 2005-10)	n.a.	(annual growth rate, 2005-10)	(+17.9)
Environmental productivity, GDP per unit of CO_2 emitted in USD, 2009	**1.32**	**GERD publicly financed, as % of GDP, 2010**	**0.43**
(annual growth rate, 2005-09)	(+3.5)	(annual growth rate, 2005-10)	(+15.7)

Figure 10.8. **Science and innovation in China**

Panel 1. Comparative performance of national science and innovation systems, 2011



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

the needs of an ageing population (pharmaceuticals, medical equipment).

STI governance: China's STI governance features strong central government leadership in setting strategic directions, objectives and policy frameworks. Provincial governments can adapt the national STI strategy to regional conditions for implementation.

Science base: Public research is strongly oriented towards applied and experimental R&D (82.9% of public R&D expenditure) (Panel 4). In spite of a major reform that converted many PRIs to enterprises in the early 2000s, PRIs still dominate public research (68.2%). In 2010, the CAS launched Innovation 2020, an extension of the Knowledge Innovation Programme, designed to improve CAS's R&D capability and contribution to innovation by setting up a series of research centres in space, IT, energy and health sciences, as well as science parks in Beijing, Shanghai and Guangdong.

Business R&D and innovation: The government has adopted various policy instruments to foster enterprise-centred innovation emphasising indigenous innovation capacity. While direct public support to business R&D is limited (4.3% of BERD in 2009), new tax incentives promote China's technological development. Since 2010, firms have access to a new R&D tax credit, and investments in R&D equipment can benefit from accelerated depreciation.

Entrepreneurship: The corporate tax and the value-added tax (VAT) have been significantly reduced for high-technology enterprises, SMEs and ICT firms in order to support development and technology transfer in software industries. New regulations allowing foreign investors to purchase local currency for investment in private equity partnerships were adopted in early 2011, and the central government appropriated USD 25 billion to strengthen credit guarantees and support the expansion of domestic demand.

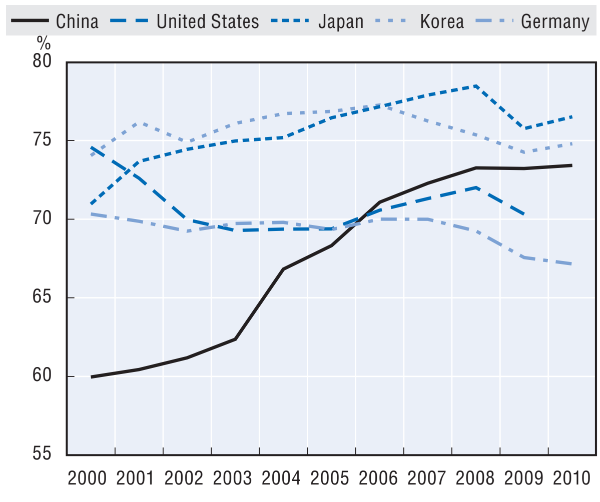
Clusters and regional policies: China has a tradition of special economic and high-technology zones. Recent policy initiatives aim to strengthen linkages among them. In 2008, USD 393 million was earmarked, under the stimulus plan, to strengthen transport infrastructures, in particular to accelerate the construction of a high-speed railway network between Beijing, Shanghai and the Pearl River Delta. The Framework for Development and Reform Planning for the Pearl River Delta Region (2008-20) has been adopted to make the region an innovative centre in the Asia-Pacific area.

Knowledge flows and commercialisation: Attention has been given to strengthening the regulatory framework for IPR protection and to facilitate the transfer and commercialisation of knowledge. A new National Intellectual Property Strategy, adopted in 2008, aims to achieve a relatively high level of producing, utilising, protecting and managing IP by 2020. A special fund was set up in 2009 to support international patenting, national interim provisions for intellectual property management of major projects were adopted in 2010, and an IP Protection Action Plan was launched in 2011.

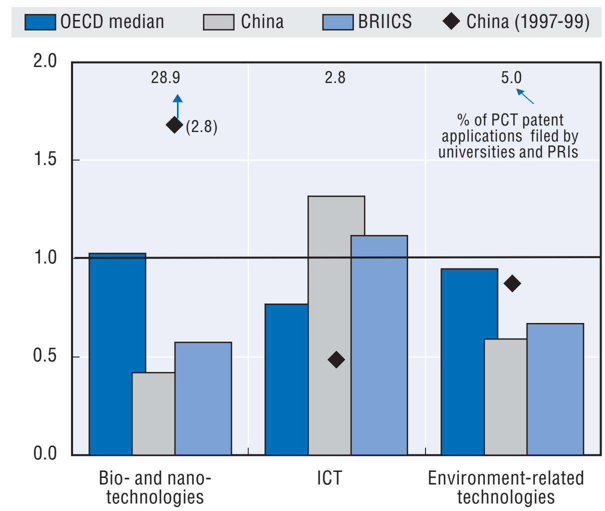
Human resources: The Medium- and Long-term National Plan for Science and Technology Talent Development (2010-20) was adopted to promote highly skilled mobility, to implement innovative platforms for S&T talent, and to establish national research centres for high-level R&D personnel. Living allowances and funding for postdoctoral research in enterprises are provided as well. Firms that invest in education and training programmes are granted tax incentives.

Green innovation: In 2009, the Ten Cities and Thousands Lightening Project aimed to promote the application of semiconductor lighting technology in 37 cities. In the same year, a demonstration programme involving 1 000 energy-saving or new-energy vehicles in 25 cities was launched to turn the automotive market towards new-energy vehicles and to have 500 000 of these vehicles in the market by 2015. The 12th Five-Year-Plan (FYP) has also devoted considerable attention to energy and climate change (*e.g.* gradual establishment of a carbon trade market) and has triggered a new wave of industrial policies in support of clean energy industries and related technologies.

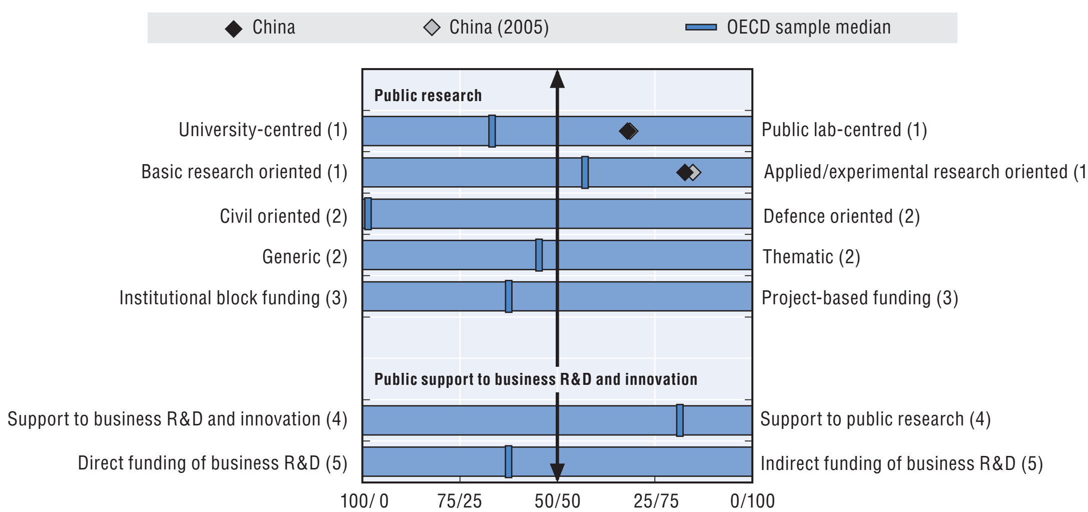
Panel 2. Share of R&D performed by the business sector, top 5 world performers, 2000-10
As a % of total GERD



Panel 3. Revealed technology advantage in selected fields, 2007-09
Index based on PCT patent applications



Panel 4. Overview of national innovation policy mix, 2010



1. Balance as a percentage of the sum of HERD and GOVERD.
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Source: OECD, Main Science and Technology Indicators (MSTI) Database, June 2012; see reader's guide and methodological annex.

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COLOMBIA

Hot STI issues

- Strengthening governance of STI.
- Doubling expenditure on R&D to 0.5% of GDP by 2014 by channelling revenue from primary resources.
- Promoting human capital.
- Expanding innovation to new regional areas.

General features of the STI system: Colombia is a middle-income country with large oil supplies. The economy has grown consistently over the past decade and withstood the global recession relatively well. It has a high level of FDI, notably in the oil sector; this provides potential leverage for international collaboration. Its research sector is small and it faces major societal challenges: low educational standards, low tertiary attainment, inadequate infrastructure, a high level of inequality, and suboptimal ICT and scientific infrastructures. These shortcomings have to be addressed if Colombia is to realise its ambitious STI objectives and become a knowledge-intensive economy. But the country has capitalised on its integration in international networks. In 2008-10, 50% of scientific articles were produced jointly with researchers abroad (Panel 1[(q)]). Human resource indicators are relatively weak: only 10% of persons employed are in S&T occupations (1[(v)]) and PISA science scores of 15-year-olds are well below the OECD median (1[(t)]). With 6 fixed broadband and 5 wireless subscribers per 100 inhabitants, there is room for improvement in ICT infrastructures (1[(k) (l)]). The e-government readiness index is relatively high compared to other Latin American countries and similar to levels in the Czech Republic (1[(n)]).

Recent changes in STI expenditures: Colombia has very low R&D intensity, with GERD at around 0.16% of GDP for the last five years to 2011. In 2009, the private sector funded 19% of GERD, the public sector 77%% and 4% was financed from abroad. Colombia aims to increase GERD to 0.5% of GDP by 2014.

Overall STI strategy: In 2010, the government identified innovation as one of the five drivers of future economic growth and social development. The Departamiento Nacional de Planeacion (DNP), together with the innovation agency, Colciencias, have formulated an ambitious STI strategy, presented in the Sectoral Strategic Plan for Science, Technology and Innovation, within the framework of the National Development Plan 2010-14: Prosperity for All. A national innovation strategy is currently being developed.

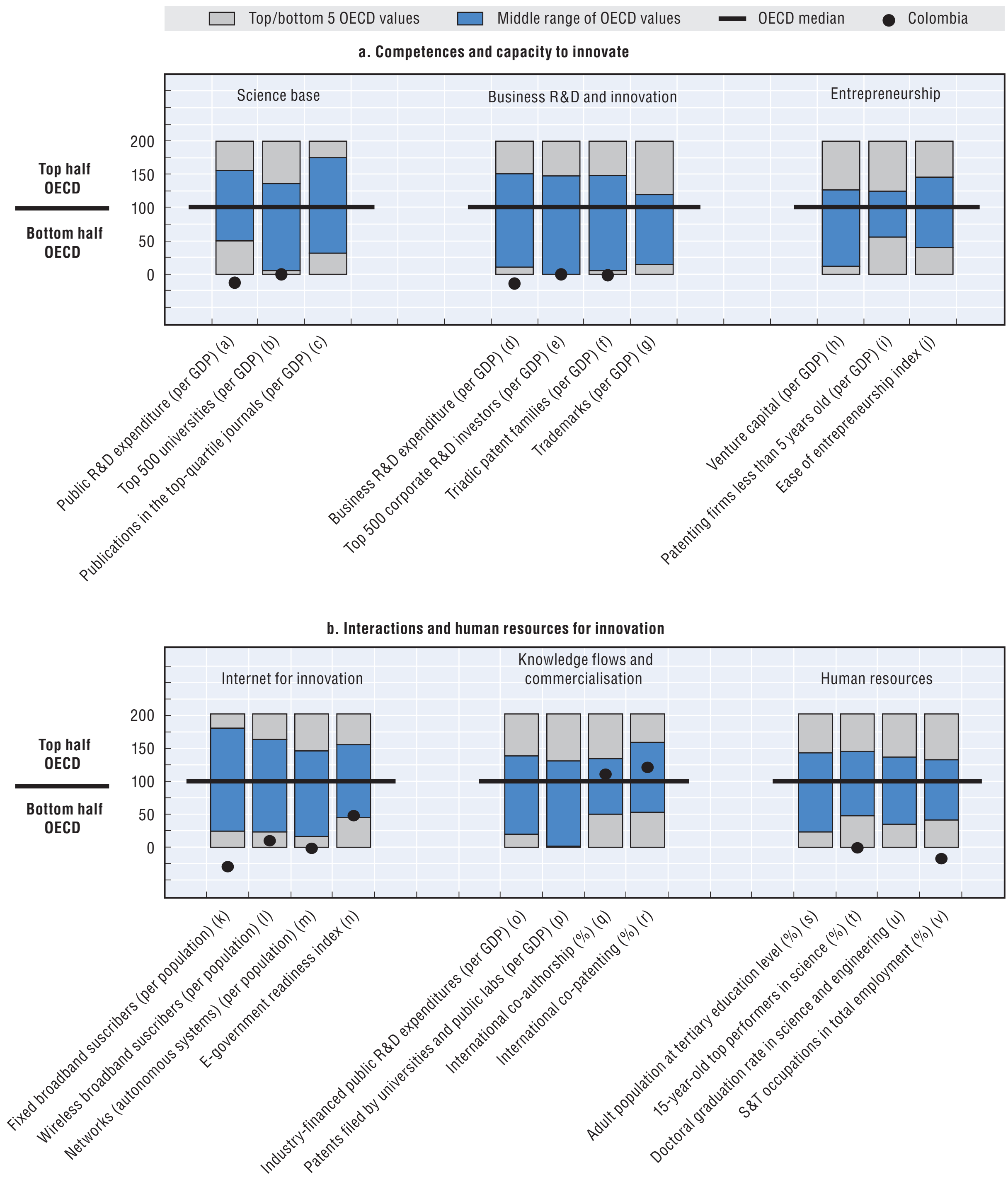
STI policy governance: DNP and Colciencias are the leading agencies of the National System for Science, Technology and Innovation (NSSTI). The World Bank (WB) and the Inter-American Development Bank (IDB) have provided a loan of USD 50 million for strengthening Colombia's STI governance structure.

Key figures

Labour productivity, GDP per hour worked in USD, 2010	**n.a.**	**GERD, as % of GDP, 2009**	**0.16**
(annual growth rate, 2005-10)	n.a.	(annual growth rate, 2005-09)	(+4.8)
Environmental productivity, GDP per unit of CO_2 emitted in USD, 2009	**6.85**	**GERD publicly financed, as % of GDP, 2009**	**n.a.**
(annual growth rate, 2005-09)	(+3.4)	(annual growth rate, 2005-09)	n.a.

Figure 10.9. **Science and innovation in Colombia**

Panel 1. Comparative performance of national science and innovation systems, 2011



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

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Science base: In 2010 Colciencias' budget for the creation and strengthening of research centres was about USD 14 million; it was increased to USD 22 million in 2011.

Business R&D and innovation: A mix of direct and indirect funding is used to fund business R&D and innovation. Colciencias, the Ministry of Agriculture and Bancóldex, the state-owned Colombian entrepreneurial development bank, subsidise and co-finance R&D and STI projects. The *Legislative Act* 5 of July 2009 modified the Constitution to create the General Royalties System (SGR) which invests 10% of total receipts from the exploitation of non-renewable natural resources in a fund to finance STI projects. The tax deduction for STI R&D and technological development projects was increased from 125% to 175% in 2011.

Entrepreneurship: The Modernisation and Innovation Fund for Micro, Small and Medium Enterprises (MSMEs) allocates co-financing for innovation programmes; these are managed through the newly created Development and Innovation Unit at Bancóldex, which also provides coaching and mentoring to high-technology entrepreneurs. Moreover, Colombia has programmes to provide equity financing and venture capital investments (USD 53 million in 2011), such as the Emprender Fund which provides access to seed capital for innovative entrepreneurs and Fontic-Colciencias which promotes and funds STI programmes in the ICT sector.

Clusters and regional policies: A 2011 Colciencias Consultancy Report identified a lack of implementation and decentralisation capabilities in most regions. *Law 1286 of 2009* strengthens and consolidates regional STI policies. Moreover, various projects have been implemented to strengthen regional clusters, such as the Technology District in Bolívar (the petrochemical and naval sectors) and the innovation nodes network in Risaralda (automation, robotics and biotechnology).

Globalisation: In order to tap into global knowledge Colciencias and the Ministry of Foreign Affairs actively support Colombian researchers and innovators engaged in international projects. A number of scientific and technical co-operation agreements with other countries are also in place. Bancóldex, Proexport and Colciencias provide subsidies to promote foreign STI investment. This has already attracted two international cutting-edge technology R&D centres.

Human resources: Colciencias has designed a strategy to support STI skills from early childhood to doctoral study. Government initiatives include increasing the number of highly qualified human resources in priority areas, achieving a higher percentage of full-time teachers in universities and strengthening regional scientific and technological capabilities. The development of regional capabilities particularly concerns higher education institutions, which have received over USD 4 million in recent years from the Ministry of National Education in order to strengthen their master's and doctoral programmes. Also, the Virginia Gutiérrez de Pineda, Francisco José de Caldas and Bicentennial Generation Programmes provide scholarships for doctoral and overseas study. Programmes such as *Pequeños cientificos* ("little scientists") promote critical thinking and scientific skills at an early age.

Emerging technologies: To develop emerging technologies, the national STI policy (CONPES 3582, 2009) proposed developing strategic sectors to produce high-value goods and services with high scientific and technological content. These sectors include energy and natural resources, biotechnology, materials and electronics, ICT, logistics and design. A genome sequencing centre and bioinformatics and computational biology centre are also being developed.

Green innovation: Green innovation is addressed in the CONPES 3700 document. Colciencias is designing strategic plans for green-related sectors, including water and forest resources, biodiversity, alternative energy, and biofuels.

CZECH REPUBLIC

Hot STI issues

- Increasing the efficiency and flexibility of R&D institutes and simplifying R&D support.
- Increasing the quality of human resources and improving tertiary graduation rates.
- Improving international co-operation and developing global networks.
- Becoming one of the world's 20 most competitive nations and developing a knowledge economy, with a focus on innovation, infrastructure and institutions.

General features of the STI system: The Czech Republic has an open economy and a strong focus on technical and engineering industries. Its strong automotive sector spurred the economic recovery after the global crisis. Its STI system is supply-driven. In spite of efforts to move to a knowledge-intensive economy, change has been gradual. BERD has grown by 6.8% annually since 2000 (in real terms), and jumped from 0.70% of GDP in 2000 to 0.97% of GDP in 2010 (Panel 1[(d)]). Links between industry and science are modest, with a small proportion of public research funded by industry (1[(o)]). Integration with global networks is near the OECD median (1[(q) (r)]). The rate of PCT patents filed by universities and public labs is low (1[(p)]). In 2007-09, the Czech Republic had an RTA in environment-related technologies but performed less well in ICT and emerging technologies. Human resource indicators show some weaknesses: only 17% of the adult population is tertiary-qualified (1[(s)]), although a relatively high 31% of persons employed are in S&T occupations (1[(v)]). The 5.6 researchers per 1 000 employment is below the median. PISA science scores of 15-year-olds rank 16th in the OECD (1[(t)]) and have deteriorated. ICT infrastructure indicators vary, with 15 fixed broadband and 55 wireless subscriptions per 100 inhabitants (1[(k) (l)]). The relative number of autonomous networks is among the highest in the OECD (1[(m)]), but the e-government readiness index is below the median, similar to levels in Poland and the Slovak Republic (1[(n)]).

Recent changes in STI expenditures: GERD increased from 1.35% of GDP in 2005 to 1.56% of GDP in 2010 and the government aims to reach 2.7% of GDP by 2020. In constant prices, GERD grew strongly by 5.7% a year since 2005 and publicly-funded GERD has increased by 5% a year. In 2010, industry funded 49% of GERD, and the government funded 40%. The share of GERD financed from abroad rose from 3% in 2000 to 10% in 2010.

Overall STI strategy: The National Research Development and Innovation (RDI) Policy 2009-15 was approved in 2009, with nine key objectives. It identified four thematic areas: sustainable energy/competitive industry; molecular biology; information society; the environment. The new Strategy for International Competitiveness (2012-20) aims to place the Czech Republic among the world's 20 most competitive nations. A new national innovation strategy focuses on infrastructure, institutions and innovation (the "3i's").

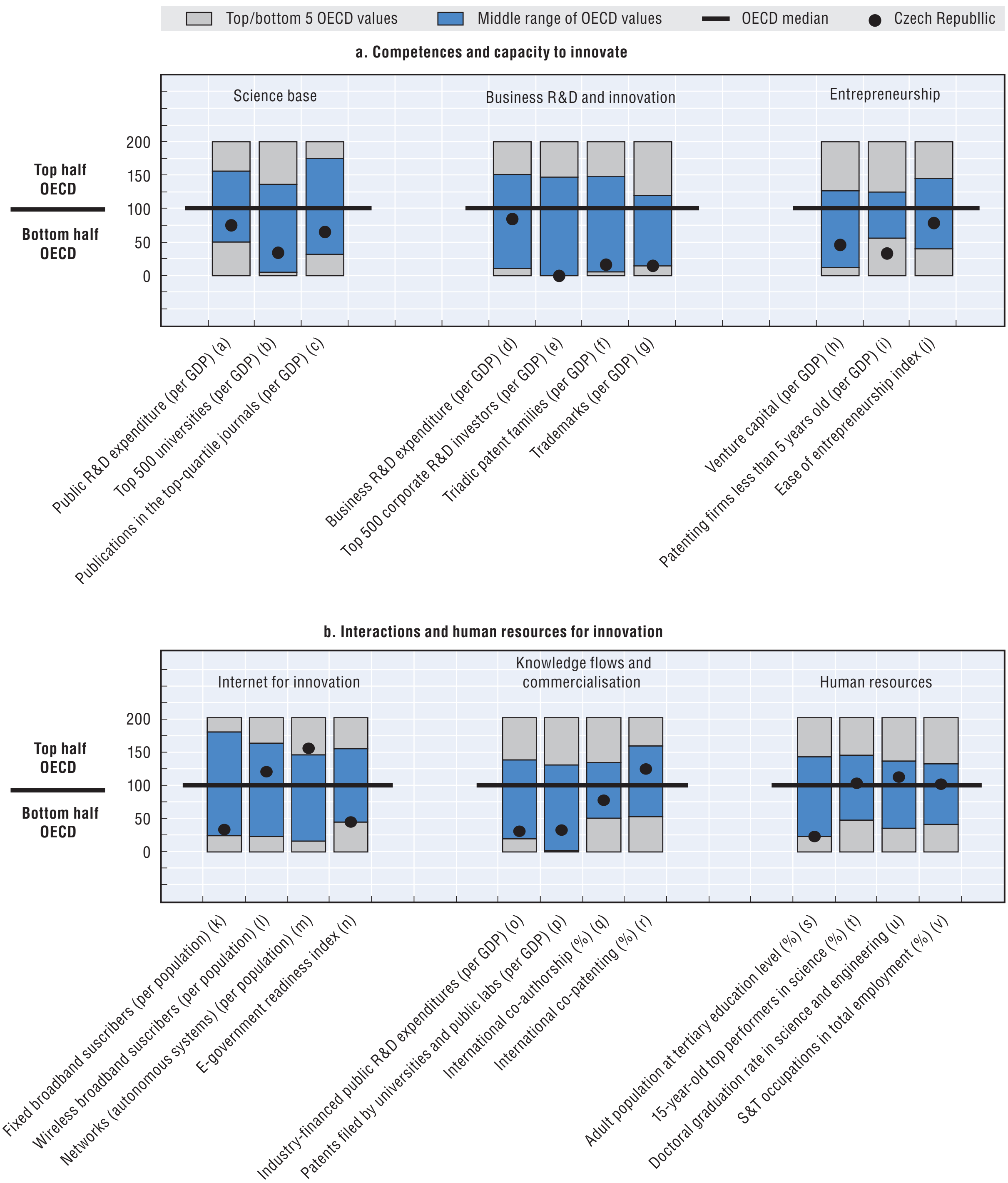
STI policy governance: STI governance has been largely unchanged since 2009. The Council for Research, Development and Innovation implements the National RDI Policy and plays an advisory role. The new Technology Agency has improved

Key figures

Labour productivity, GDP per hour worked in USD, 2010	**29.3**	**GERD, as % of GDP, 2010**	**1.56**
(annual growth rate, 2005-10)	(+2.5)	(annual growth rate, 2005-10)	(+5.7)
Environmental productivity, GDP per unit of CO_2 emitted in USD, 2009	**2.44**	**GERD publicly financed, as % of GDP, 2010**	**0.64**
(annual growth rate, 2005-09)	(+5.2)	(annual growth rate, 2005-10)	(+5.0)

Figure 10.10. **Science and innovation in the Czech Republic**

Panel 1. Comparative performance of national science and innovation systems, 2011



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

budgeting, funding and RDI procurement through the BETA Programme, and co-ordinates with ministries such as the Ministry of Education, Youth and Sports (MEYS), the Ministry of Industry and Trade (MIT), the Czech Science Foundation and CzechInvest.

Science base: The Czech Republic has a comparatively weak science base, although it has a strong engineering tradition. Public R&D and publications rank below the OECD median and universities rank in the bottom five of the OECD (1[(a)(b)(c)]).

Business R&D and innovation: The POTENCIAL Programme promotes technology centres and in-house R&D. The Enterprise Europe Network provides technology transfer services. A number of awards encourage innovators, such as Innovation of the Year, Czech Innovation and Best Co-operation of the Year. Czech Head, provides an annual prize for science achievements.

Entrepreneurship: Initiatives that foster entrepreneurship include START, GUARANTEE and PROGRESS that provide subsidised loans and guarantees to innovative start-ups.

ICT and scientific infrastructures: Research infrastructure is fragmented and concentrated in Prague and to a lesser extent in Brno. A lack of large research infrastructures is addressed through the European Strategy Forum on Research Infrastructures (ESFRI) and by the MEYS Operational Programme Research and Development for Innovation (USD 1.2 billion). An e-infrastructure within the GÉANT network (the CESNET – Czech NREN Operator) is under development. The ICT and Strategic Services Programme encourages innovation in ICT solutions, software, and high-technology repair and data centres.

Clusters and regional policies: The Co-operation Programme (2007-13) promotes clusters, poles of excellence and co-operative projects. In 2010, USD 42 million was invested in cluster collaboration platforms. MIT and CzechInvest oversee 30 science and technology parks which contribute to regional innovation strategies.

Knowledge flows and commercialisation: The National RDI Policy has increased the focus on collaboration initiatives. The Technology Agency's ALPHA Programme supports co-operation between business and research with a budget of USD 417 million. MIT's TANDEM and IMPULS Programmes support industrial R&D and public-private R&D collaboration and have already allocated USD 585 million to more than 700 projects. USD 314 million has been approved to create 35 centres of competence for public-private collaboration over 2012-19. CzechInvest's PROSPERITY Programme supports technology transfer. The INNOVATION and INOVACE programmes protect IPRs, patents, designs and trademarks.

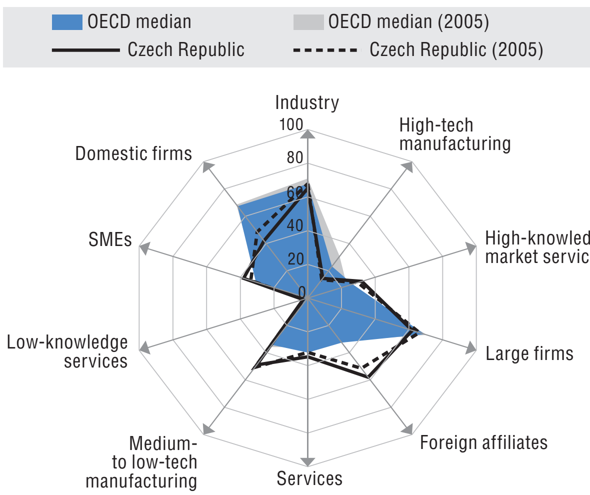
Globalisation: The Czech Republic has lagged behind other EU countries in terms of FDI. This led to a change in the *Act on Investment Incentives* in 2000. Furthermore, the National Trade Promotion Agency encourages internationalisation of Czech firms by facilitating global links. A number of CzechInvest incentives, such as tax deductions, training and requalification, promote foreign investment.

Human resources: Czech human capital is insufficient, although the number of researchers has recently increased. The Operational Programme Education for Competitiveness aims to increase academic standards, with USD 417 million budgeted for 2007-13. The Czech Little-Head and Open Science II programmes promote scientific education of school students and at universities. In 2008 a Working Group for Equal Opportunities for Women and Men was established in MEYS to achieve gender-equal education. The share of tertiary-qualified population among those 30-34 years old is forecast to increase to 34% by 2020.

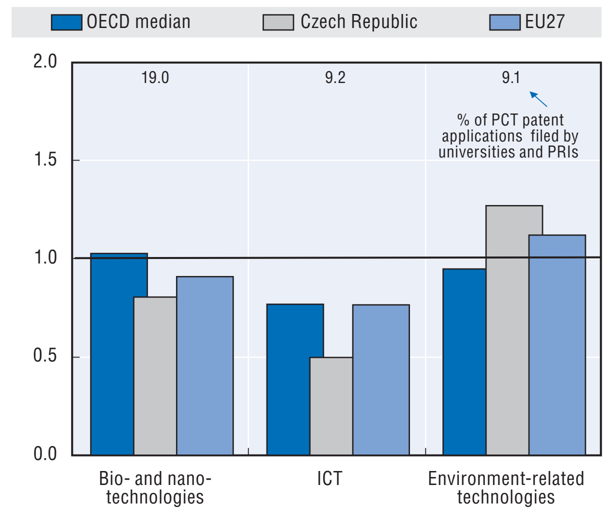
Emerging technologies: New long-term national priorities are being prepared and will address key emerging technologies. Current technological projects include the Extreme Light Infrastructure and the Prague Asterix Laser System at the Institute of Physics, and the COMPASS-D Programme at the Institute of Plasma Physics. The Programme for the Support of Environmental Technologies supports eco-technologies and the ALPHA programme supports enabling technologies in a range of industries.

Green innovation: The Ministry of Environment has updated the Programme of Support of Environmental Technologies approved by the government in July 2009. The update aims to increase energy efficiency and stresses the importance of renewables and eco-innovation.

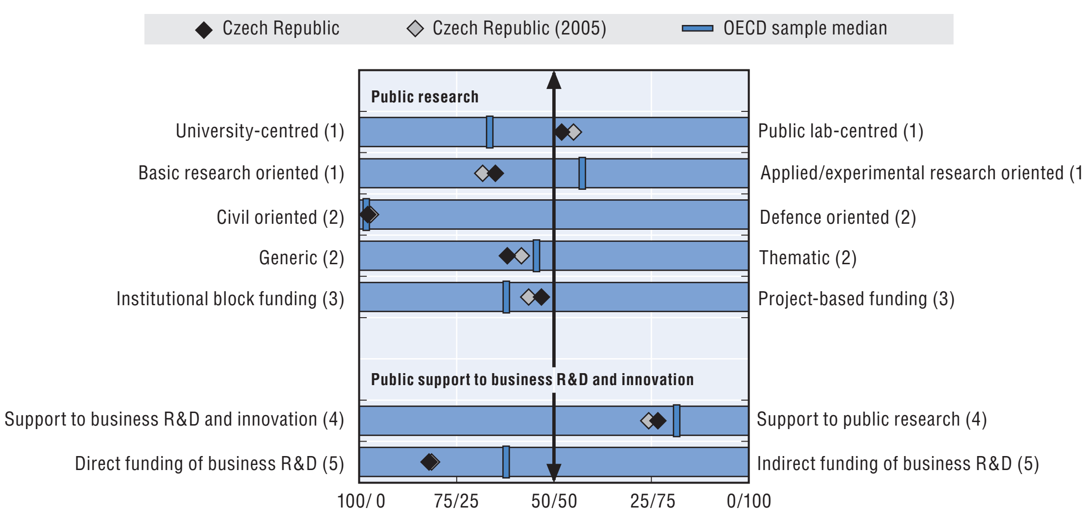
Panel 2. Structural composition of BERD, 2009
As a % of total BERD



Panel 3. Revealed technology advantage in selected fields, 2007-09
Index based on PCT patent applications



Panel 4. Overview of national innovation policy mix, 2010



1. Balance as a percentage of the sum of HERD and GOVERD.
2. Balance as a percentage of total GBAORD.
3. Balance as a percentage of total funding to national performers.
4. Balance as a percentage of the sum of HERD and GOVERD funded by government and higher education and components of (5).
5. Balance as a percentage of the sum of indirect funding of business R&D and innovation through R&D tax incentives and direct funding of BERD through grants, contracts and loans.

Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888932690320

DENMARK

Hot STI issues

- Reversing the trend in labour productivity decline by boosting innovation.
- Supporting innovation in high-growth sectors with new industrial policy measures.
- Improving industry and science linkages and the supply of high-level skills for STI.

General features of the STI system: Denmark is a highly developed economy with a relatively sound fiscal position. However, recent years have seen a decline in labour productivity (by 0.2% over 2005-10) and labour productivity only returned to its 2007 level in 2011. Denmark has strong business innovation, particularly in emerging and renewable energy technologies. BERD stands at 2.08% of GDP (Panel 1[d]) and triadic patenting (1[f]) is at the top of mid-range in the OECD area. The share of public R&D expenditures financed by industry (1[o]) is below the OECD median, whereas the rate of patents filed by universities and PRIs (1[p]) is above it. International co-operation in science and innovation is mixed as well: while Denmark is at the top of the mid-range performance in terms of international co-authorship of scientific publications (1[q]), international co-applications for PCT patents are below the OECD median (1[r]). ICT infrastructures are well developed, and Denmark ranks third in terms of fixed broadband subscribers per 100 inhabitants within the OECD area (1[k]). S&T occupations represent 41% of total employment (1[v]), but at 34%, the tertiary-qualified adult population is just above the OECD median (1(s)). The supply of the future skilled workforce needs strengthening, as performance in science by students aged 15 is currently weak (1[t]), and PhD graduation rates in S&E are rather low (1[u]). However, the yearly intake of PhD students has doubled since 2006.

Recent changes in STI expenditures: Danish GERD, at 3.06% of GDP in 2010, is at the top of the mid-range of OECD countries. During 2005-10, GERD increased annually by 4.4%. Further increases in R&D expenditure are expected to come from the business sector. The government aims to encourage private-sector investments in public research and innovation by strengthening the business sector's belief in R&D and innovation as drivers of future economic growth.

Overall STI strategy: A Denmark that Stands Together (October 2011) serves as the vision statement of the present government. It emphasises investment in research and education. A national innovation strategy is to be launched in 2012. Priority issues will include identification of the strengths of public research and business innovation as a basis for the establishment of new public-private partnerships; greater emphasis on higher education; and further internationalisation of the Danish STI system.

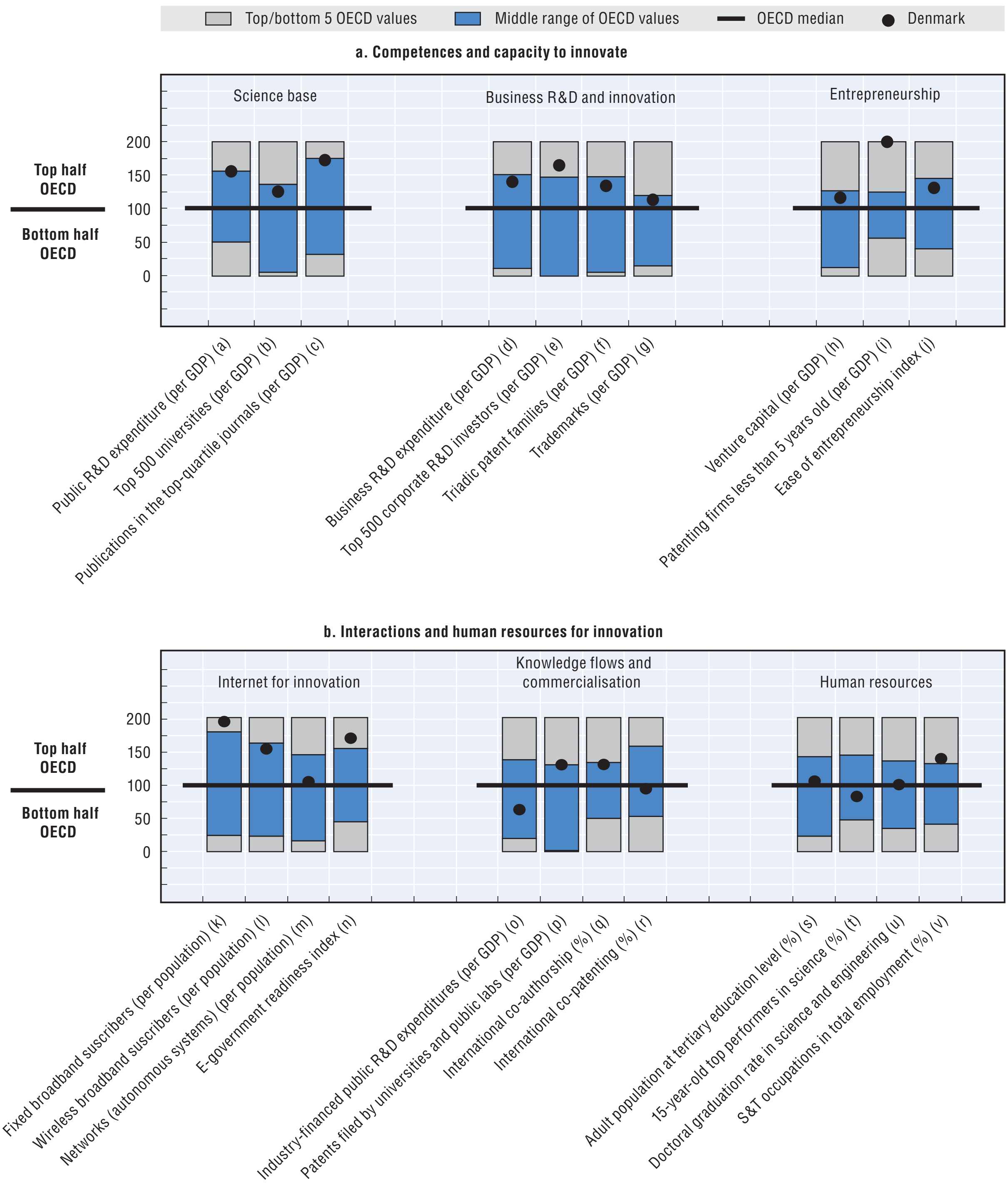
STI policy governance: When the present government took office in 2011, it implemented some changes in STI governance. To underline the central role of higher education in innovation, the Ministry of Science, Technology and Innovation took over all responsibilities for higher education and its name was changed to the Ministry of Science, Innovation and Higher Education. Also, the Ministry of Business and Growth has replaced the Ministry of Economics and Business Affairs. Over the last five years, greater emphasis has been placed on evaluation and impact assessment of innovation policy instruments. In 2011, an evaluation manual set the minimum requirements for data collection and evaluation methods.

Key figures

Labour productivity, GDP per hour worked in USD, 2010	**51.3**	**GERD, as % of GDP, 2010**	**3.06**
(annual growth rate, 2005-10)	(–0.2)	(annual growth rate, 2005-10)	(+4.4)
Environmental productivity, GDP per unit of CO_2 emitted in USD, 2009	**4.50**	**GERD publicly financed, as % of GDP, 2010**	**0.85**
(annual growth rate, 2005-09)	(+0.0)	(annual growth rate, 2005-10)	(+4.5)

Figure 10.11. **Science and innovation in Denmark**

Panel 1. Comparative performance of national science and innovation systems, 2011



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

Science base: Denmark has a strong science base which has been dominated by universities over the past five years (Panel 4). Public expenditures on R&D were 0.96% of GDP in 2010 (1[a]), among the top five OECD countries. Danish scientists perform respectably in terms of publication in top international scientific journals (1[c]). University funding is a balance of the traditional allocation of block funding and a performance-based allocation mechanism, which has been reformed through the progressive introduction of bibliometric indicators.

Business R&D and innovation: Existing schemes have received additional public funding to accelerate R&D and innovation in the business sector. The Business Innovation Fund, with a budget of USD 97 million for 2010-12, supports innovation and market maturity in green and welfare areas. The report, *Strengthened Innovation in Business*, presented in August 2010, identified barriers to business innovation and recommended measures, including easing of administrative burdens, to address them.

Entrepreneurship: Danish young patenting firms have the highest share per GDP among OECD countries (1[i]).The government has launched initiatives to improve the entrepreneurial climate: the USD 1.3 billion Danish Growth Capital aims to strengthen the market for equity and venture capital, and the Vækstfonden's loan guarantee scheme was boosted to USD 570 million. The government has also developed an entrepreneurship education strategy.

Public-sector innovation: *Strengthened Innovation in Business* also underlines the importance for private-sector innovation of innovation in public services. To further simplify administrative procedures for business, more public services have been digitised. In May 2011 a new public procurement scheme was launched to improve the efficiency and quality of public procurement with a view to encouraging innovation in the private sector.

ICT and scientific infrastructures: Within the general trend among EU countries towards greater emphasis on the development of research structures, the *Danish Roadmap for Research Infrastructures*, published in September 2011, includes 19 proposals for high-priority projects and initiatives. Denmark will also host the European Spallation Source (ESS) in the Dano-Swedish Øresund region.

Clusters and regional policies: In 2010, the Strategic Platforms for Innovation and Research were established as a new model of collaboration between public research and industry through which private actors can be more involved in the planning and performance of public research and innovation.

Knowledge flows and commercialisation: The National Reform Programme 2011 recommends accelerating the commercialisation of research outcomes. In addition to the promotion of collaborative research the government encourages the use and trade of IPRs.

Globalisation: The present Danish government emphasises the internationalisation of Danish STI systems. It has made the greater mobility of Danish students and the influx and retention of foreign investment and international talents a priority. As part of the objective to increase exports, especially to BRIICS countries, the export loan facility scheme under the official export credit agency EKF will be boosted to USD 4.5 billion.

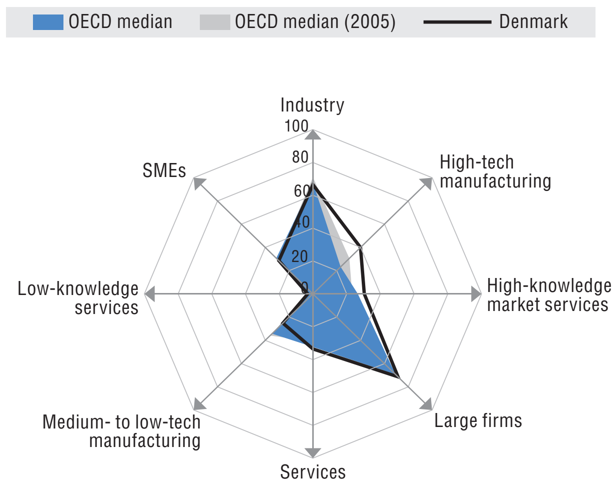
Human resources: Education is central in the present government platform for addressing the decline in labour productivity. Quantitative targets have been set to increase the share of youth with higher education attainment. The Globalisation Fund has allocated around USD 1.9 billion for 2007-12 to strengthen upper secondary education, higher education, and adult and lifelong learning, through a broad range of initiatives (*e.g.* the talent programme, quality enhancement, vocational education and training, and research infrastructure).

Emerging technologies: Denmark is the leading OECD country in terms of RTA in bio- and nano-technologies as well as in environmental technologies (Panel 3). A Denmark that Stands Together sets the vision for the transition towards a green economy, by developing new environmental and energy-related technologies as well as biotechnology.

Green innovation: A broad political agreement on energy was reached in 2012, including the target of a carbon-neutral economy in 2050, to be achieved by a continued high level of funding for related R&D and demonstration. A framework for the climate and energy policy to 2020 has since been adopted.

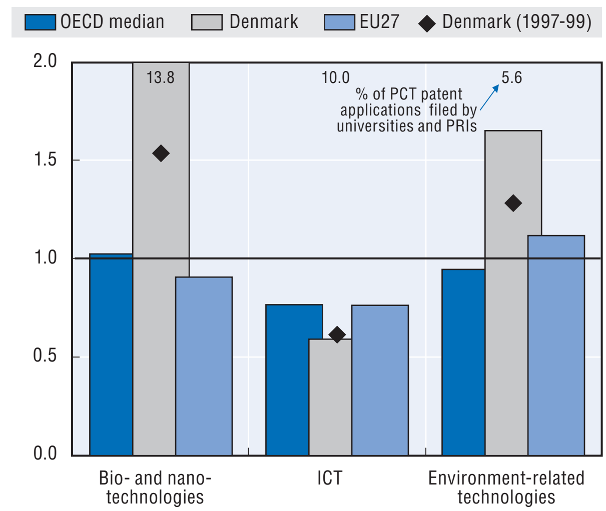
Panel 2. Structural composition of BERD, 2009

As a % of total BERD

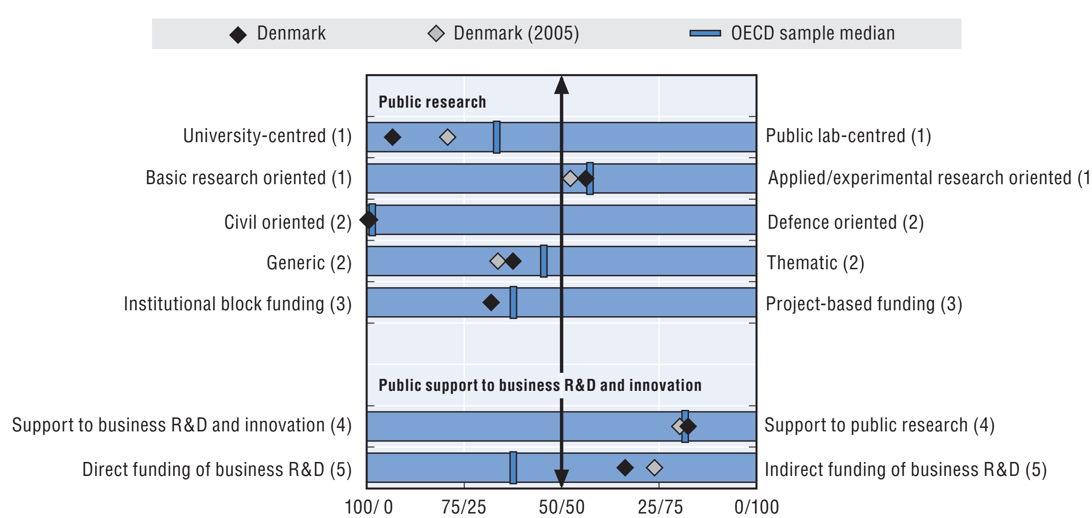


Panel 3. Revealed technology advantage in selected fields, 2007-09

Index based on PCT patent applications



Panel 4. Overview of national innovation policy mix, 2010



1. Balance as a percentage of the sum of HERD and GOVERD.
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Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888932690339

EGYPT

Hot STI issues

- Enhancing involvement of the business sector in R&D and innovation.
- Improving the supply of human capital in S&T through a better education system and increased attractiveness of research careers.

General features of the STI system: Egypt is a diversified middle-income economy and one of the most developed and dynamic economies in North Africa and the Middle East. It is richly endowed with natural resources (fertile plains of the Nile valley, coal deposits, oil and gas resources) and benefits from a central location for international traffic (Suez Canal). Although agriculture contributes significantly to GDP, economic growth has been driven by the expansion of industrial and services activities. Recent economic reforms have permitted growing inflows of FDI and strengthened the presence of multinationals. The ICT sector has particularly benefited from liberalisation. In 2010 revenues from telecommunications services accounted for 3.7% of GDP, on par with Japan and well ahead of the United States (Panel 2). The number of mobile cellular telephone subscribers exploded between 2005 and 2010 (Panel 3). In spite of an underdeveloped mortgage market, the banking system has expanded and opened up new funding opportunities. In 2011, Egypt ranked among the top five remittance recipient countries. The USD 14 billion in remittance inflows help to sustain more demand than national production capacities can meet. The country's R&D capabilities and infrastructures are poorly developed. Firms' contribution to R&D is negligible (and no reliable data are available). The relative number of patents is very low (Panel 1[f]). Firms tend to innovate by adapting imported technologies and absorbing foreign knowledge through international collaboration. Egypt produces 39% of its scientific articles and 24% of its PCT patent applications with foreign counterparts (1[q] [r]). Human resources in S&T are poorly developed: only 22% of persons in employment were in S&T jobs in 2007 (1[v]) and the researcher population is small and shrinking (from 49 000 to 36 000 FTE between 2007 and 2009).

Recent changes in STI expenditures: Egypt's GERD was a low 0.21% of GDP in 2009. After having increased in parallel to GDP from 2005, R&D expenditures decreased sharply in 2009 and GERD intensity felt below its 2005 level (0.24%). The global crisis and the Arab Spring events, which spread to Egypt from January 2011, have had profound political and economic consequences. However, the government has reinforced its commitment to S&T, increased the research budget significantly, and sets a target for GERD of 1% of GDP.

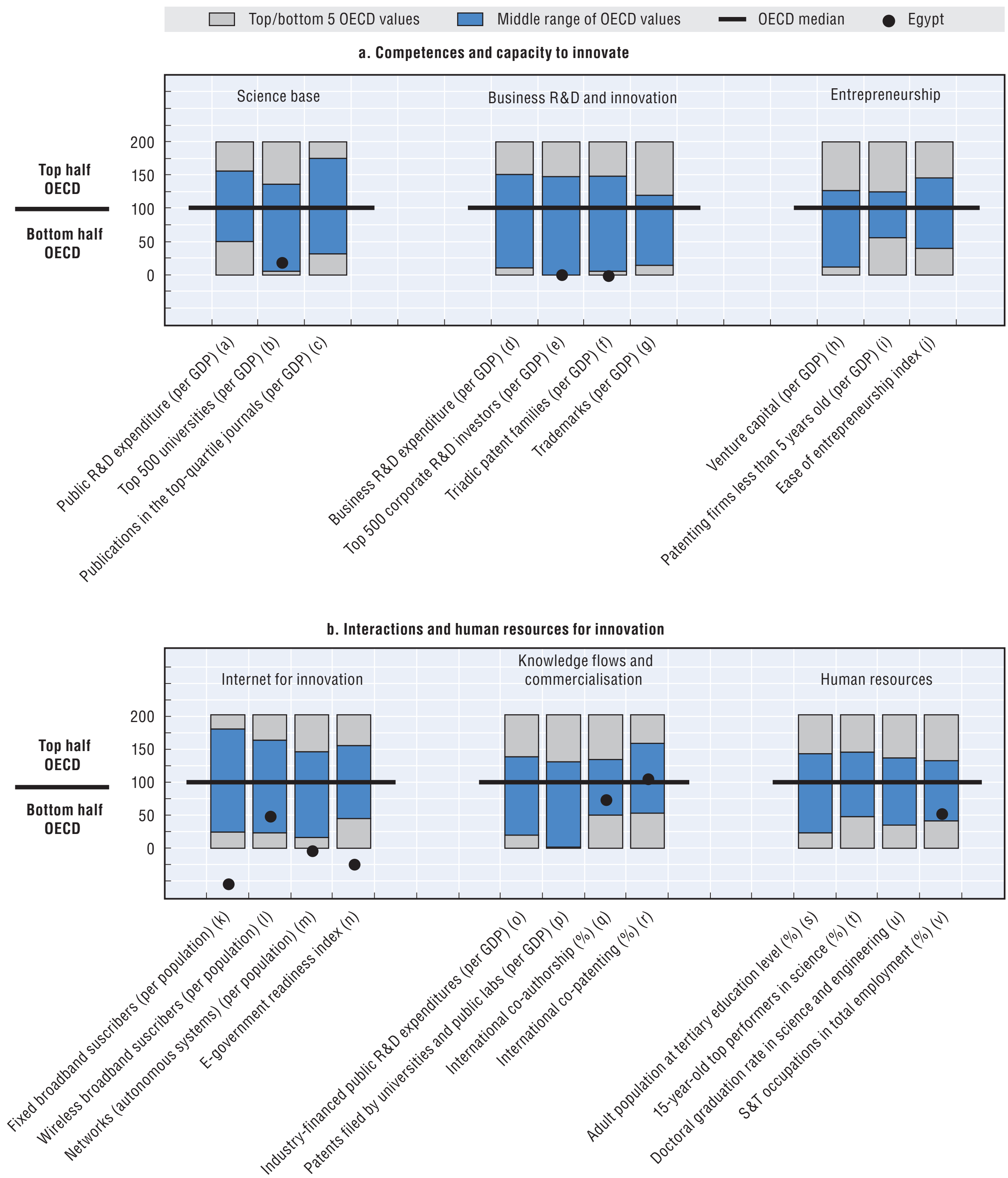
Overall STI strategy: Following an overall evaluation of the national S&T system (2006), Egypt launched the Decade for Science and Technology 2007-16 in order to foster co-operation with developed economies and to strengthen national S&T capabilities. The Developing Scientific Research Plan 2007-16 was introduced to restructure S&T governance, to improve national S&T capabilities (investments and human resources), to develop a complete value chain from research to commercialisation, and to disseminate S&T culture across society. The Plan

Key figures

Labour productivity, GDP per hour worked in USD, 2010	**n.a.**	**GERD, as % of GDP, 2009**	**0.21**
(annual growth rate, 2005-10)	n.a.	(annual growth rate, 2005-09)	(+3.5)
Environmental productivity, GDP per unit of CO_2 emitted in USD	**2.68**	**GERD publicly financed, as % of GDP, 2009**	**n.a.**
(annual growth rate, 2005-09)	(+3.0)	(annual growth rate, 2005-09)	n.a.

Figure 10.12. **Science and innovation in Egypt**

Panel 1. Comparative performance of national science and innovation systems, 2011



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

Source: See reader's guide and methodological annex.

adopted a sector- and technology-oriented approach. In February 2012, a new strategy was announced, primarily to foster the commercialisation of research.

STI policy governance: STI policy governance has undergone major changes since 2007: creation of the Ministry of Higher Education and Scientific Research which designs research policies; creation of the Higher Council for Science and Technology (HCST), a consultative body for setting S&T strategy and priorities; restructuration of the Academy of Scientific Research and Technology (ASRT), as policy advisor in charge of assessment and evaluation; and transfer of ASRT funding competences to the newly established Science and Technology Development Fund (STDF), which provides financial support on a competitive basis.

Science base: The bulk of research activities are carried out within universities, most of which have been established recently. Over-regulated and heavily centralised governance, as well as the lack of a clearly defined strategy, remain major obstacles to the formation of an efficient public research system. In addition few researchers in universities and PRIs are young, and many are absorbed by teaching assignments and heavy administrative duties to the detriment of research activities.

Business R&D and innovation: The contribution of the business sector to R&D and innovation is essentially insignificant. There is now greater policy emphasis on the involvement of the private sector and the commercialisation of research outcomes geared towards economic and social needs.

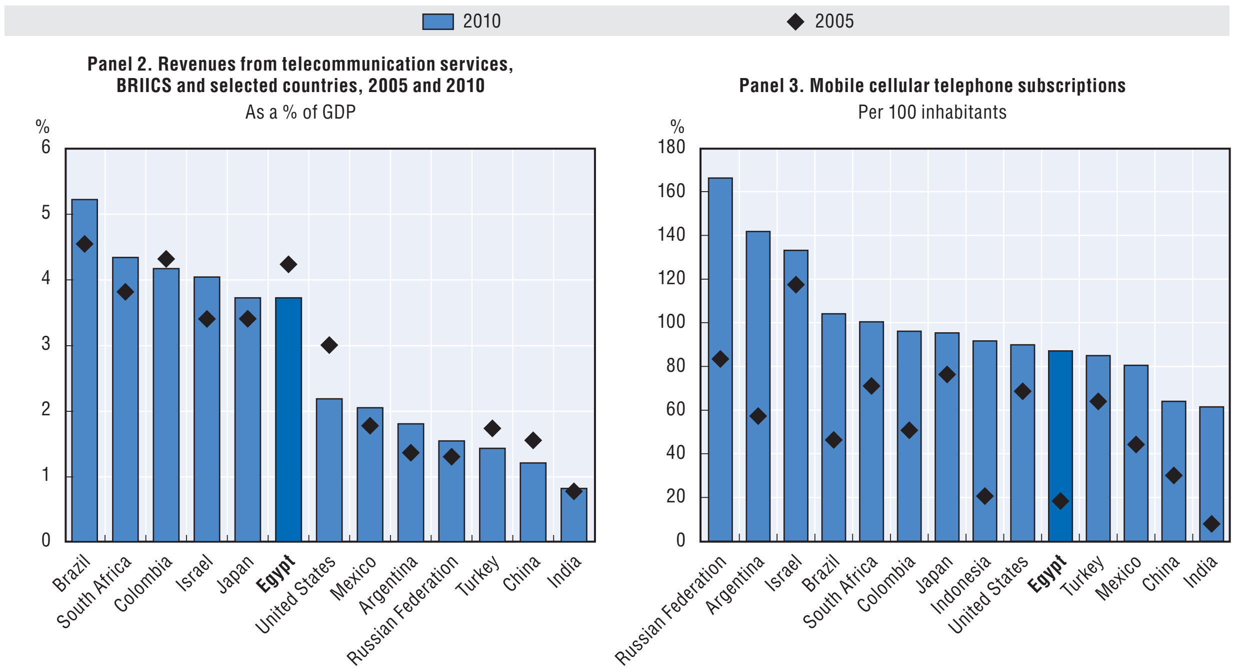
Knowledge flows and commercialisation: Promotion of academia-industry collaboration has been the main policy instrument for increasing the business sector's contribution to R&D and innovation. Many STDF programmes and grant schemes under the Research, Development and Innovation (RDI) Programme encourage proposals by consortia of companies, universities and PRIs. Various infrastructures have been established to support public-private partnerships, such as the Zewail City of Science and Technology, inaugurated in 2011, which encompasses a university, research centres and a technology park. The Faculty for Every Factory Programme also aims to accelerate knowledge flows between academia and industry by supporting the hiring of researchers by companies.

Globalisation: The expansion of scientific and research collaboration with developed economies is one of the priorities of Egypt's current STI strategy. The RDI programme was launched in 2007 with a USD 13.4 million grant from the European Union to foster linkages between academia and industry, but also to ease Egypt's integration in the European Research Area through participation in the Seventh Framework Programme. Egypt has also signed bilateral agreements for the funding of joint research projects and mobility programmes (*e.g.* the German Egyptian Research Fund GERF or the US-Egypt Science and Technology Joint Fund). As part of the objective to improve the quality of the national research system, programmes such as the Road to Nobel and the Reintegration grants have been introduced to attract highly qualified foreign and national expatriate researchers.

Human resources: The government's efforts have focused on improving the quality of the education system. A National Strategic Plan for Pre-University Education Reform (2007/08-2011/12) was introduced to develop a system that would be more responsive to the requirements of a knowledge-based economy. The Higher Education Reform Strategy (2002-17) aims to improve the quality and efficiency of the higher education system, notably through the Higher Education Enhancement Programme Fund and the development of more efficient higher education funding mechanisms and the establishment of a National Quality Assurance and Accreditation Agency.

Green innovation: Egypt suffers from serious water scarcity and is threatened by desertification and permanent soil damage. The development of new and renewable energies and the shift away from current oil dependency have been identified as a national STI policy priority. A strategy adopted in 2008 aimed to diversify the production of energy and increase consumption of renewable energy produced especially from wind power.

ICT sector in Egypt, BRIICS and selected countries, 2005-10



Note: BRIICS=Brazil, Russian Federation, India, Indonesia, People's Republic of China, South Africa.

Source: ITU (International Telecommunication Union), World Telecommunication/ICT Indicators, 2011.

StatLink http://dx.doi.org/10.1787/888932690358

ESTONIA

Hot STI issues

Improving Estonia's long-term growth through:

- Increasing the quality and efficiency of public research and reforming the public R&D funding system.
- Strengthening the private sector's R&D investment and innovation capability and the business environment for innovation.
- Strengthening the future supply of PhDs in S&E.

General features of the STI system: Estonia is a small OECD economy and its government's priorities include R&D and innovation. Over the past decade, Estonia has strengthened its R&D and innovation system through market-oriented reform of the former Soviet system. Estonia has one of the highest GERD growth rates in the OECD area, at 11.8% a year during 2005-10. BERD increased significantly from 0.42% to 0.82% of GDP over the same period. In 2010, the business sector performed 50% of GERD, up from 45% in 2005. Nonetheless, business innovation remains below the OECD median in terms of R&D expenditure (Panel 1[(d)]), top firms (1[(e)]), patents (1[(f)]) and trademarks (1[(g)]), and it is concentrated in a limited number of high-technology sectors, such as ICT, biotechnology, and financial and telecom services. Estonia has a relatively strong public and university research system (1[(a)(c)]), a solid human capital base (1[(s)(t)(u)(v)]), good connections to global knowledge networks (1[(q)(r)]) and Internet infrastructure and use is at the OECD median (1[(k)(l)(m)(n)]).

Recent changes in STI expenditures: In spite of the economic crisis, GERD rose from 1.28% of GDP in 2008 to 1.63% of GDP in 2010. The government funds 44% of GERD, the business sector 44%, and foreign sources 11%. For 2007-10, government-financed GERD and industry-financed GERD increased from 0.45% to 0.71% and from 0.49% to 0.72% of GDP, respectively. Forecasts suggest public R&D budgets are likely to increase in the coming years.

Overall STI strategy: The Knowledge-Based Estonia II Research and Development and Innovation Strategy 2007-13 sets the key objectives and technological priorities for R&D. The main objectives are to increase the quality of both public research and private-sector innovation and the potential for long-term growth. These objectives are to be achieved by developing human capital (*e.g.* increasing the attractiveness of researcher careers); increasing enterprises' innovation capacity; developing policies for long-term growth; and reorganising public-sector R&D and innovation to increase efficiency (*e.g.* modernising R&D infrastructures). The key technologies identified in the strategy are ICTs, biotechnology and material technologies. The strategy for 2014-20 will be formulated during 2012.

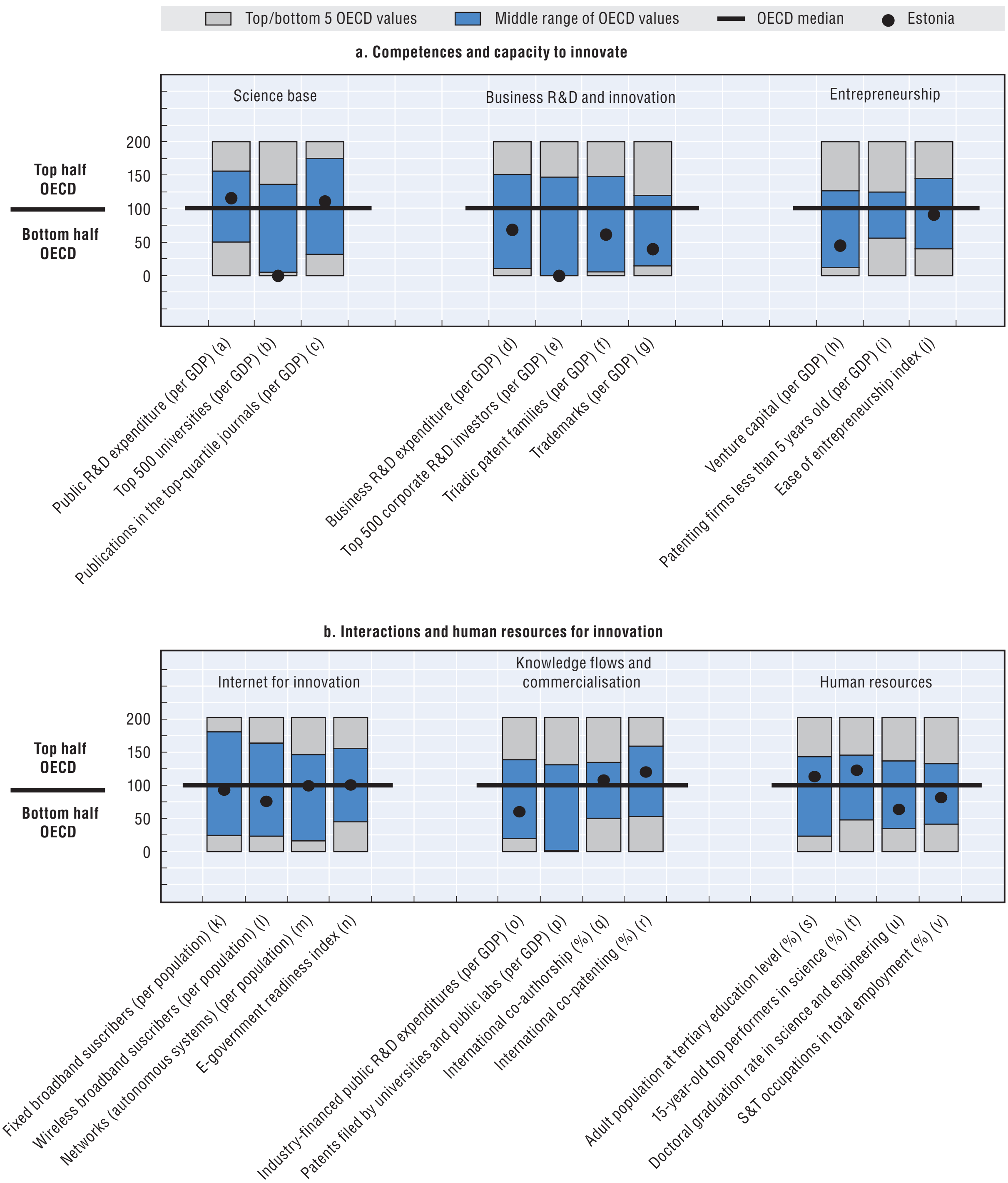
STI policy governance: The Estonian Research Council was created by the 2011 amendment of the *Organisation of Research and Development Act* to serve as a funding agency; it has absorbed the previous Estonian Science Foundation and Archimedes Foundation. Its missions are to: foster basic and applied R&D, support researchers, encourage international co-operation and co-ordinate and implement national and international training and educational and research programmes.

Key figures

Labour productivity, GDP per hour worked in USD, 2010	**26.4**	**GERD, as % of GDP, 2010**	**1.63**
(annual growth rate, 2005-10)	(+3.2)	(annual growth rate, 2005-10)	(+11.8)
Environmental productivity, GDP per unit of CO_2 emitted in USD, 2009	**1.77**	**GERD publicly financed, as % of GDP, 2010**	**0.73**
(annual growth rate, 2005-09)	(+2.5)	(annual growth rate, 2005-10)	(+12.1)

Figure 10.13. **Science and innovation in Estonia**

Panel 1. Comparative performance of national science and innovation systems, 2011



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

Science base: Over the last decade, Estonian public research has improved significantly. The four public universities play an important role in R&D and stand slightly above the OECD median in terms of international scientific publications (1[c]). However, university-performed GERD fell from 52% in 2000 to 38% in 2010. The Estonian government has adopted several programmes to support knowledge production and to increase universities' excellence, competitiveness and internationalisation. The amendment of the *Organisation of Research and Development Act* introduced two new types of R&D evaluation: regular evaluations to assess R&D quality against internationally recognised criteria and targeted evaluations designed to improve research in specific fields.

Business R&D and innovation: During 2001-10 BERD grew faster than in other OECD countries. Yet, as a share of GDP and of patenting by firms, BERD remains well below the OECD median. Moreover, just 58 firms account for 75% of BERD. The Estonian government intends to stimulate business R&D and innovation with direct funding (*e.g.* innovation vouchers) and non-financial measures (*e.g.* the Innovation and Entrepreneurship Awareness and Competence Raising Programme 2009-13).

Entrepreneurship: The conditions for entrepreneurship and innovation are below the OECD median (1[h][j]). Efforts are under way to promote entrepreneurship (*e.g.* Innovation and Entrepreneurship Awareness and Competence Raising Programme 2009-13; Start-up Estonia). In addition, fostering entrepreneurship in HEIs is part of the Government Action Plan 2011-15.

ICT and scientific infrastructures: Investments in R&D infrastructures are largely funded by EU structural funds. The total budget for 2007-13 is USD 320 million, split between investment in buildings (USD 165 million) and in research equipment (USD 157 million). In 2010, the government adopted a Research Infrastructures Roadmap outlining the need to upgrade existing research infrastructures and create new research facilities. It lists 20 research infrastructures of national importance and serves to guide public investments in R&D infrastructures over the next 10-20 years.

Knowledge flows and commercialisation: Efforts are being made to strengthen interactions between the scientific and business communities (*e.g.* the University of Tartu has adopted a new governance structure which involves external partners in the university's work and the government has a programme for training doctoral students in co-operation with business).

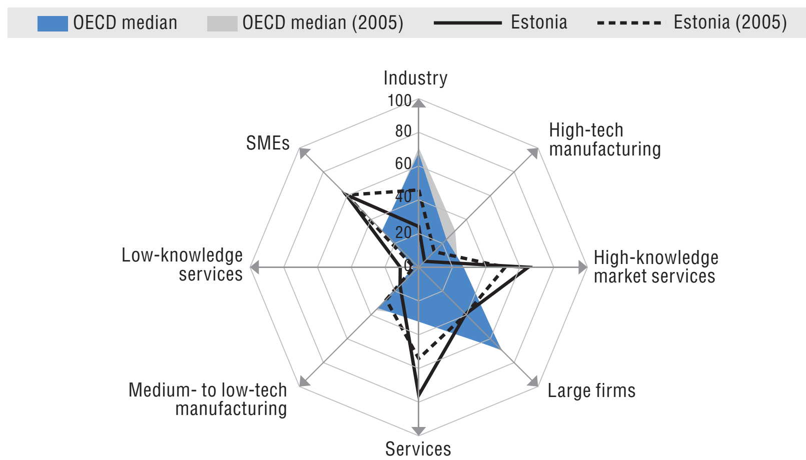
Human resources: The Estonian population's tertiary education level is above the OECD median (1[s]). In view of the low rate of S&T doctoral graduates, the Archimedes Foundation created in 2010 a Unit for Science Communication to co-ordinate several publicly funded initiatives and to manage a programme to raise young people's interest in S&T careers (budget of USD 6.5 million for 2009-13). Also, the Higher Education Strategy and the R&D and Innovation Strategy have as an objective 300 PhD graduates a year by 2015.

Emerging technologies: The Estonian government has launched six national R&D programmes in support of R&D in energy technology, ICT, biotechnology, health, environment technology and material technology. The Centres of Excellence and Competence Centres programmes also clearly target ICTs, environment and new materials, health care and medicine.

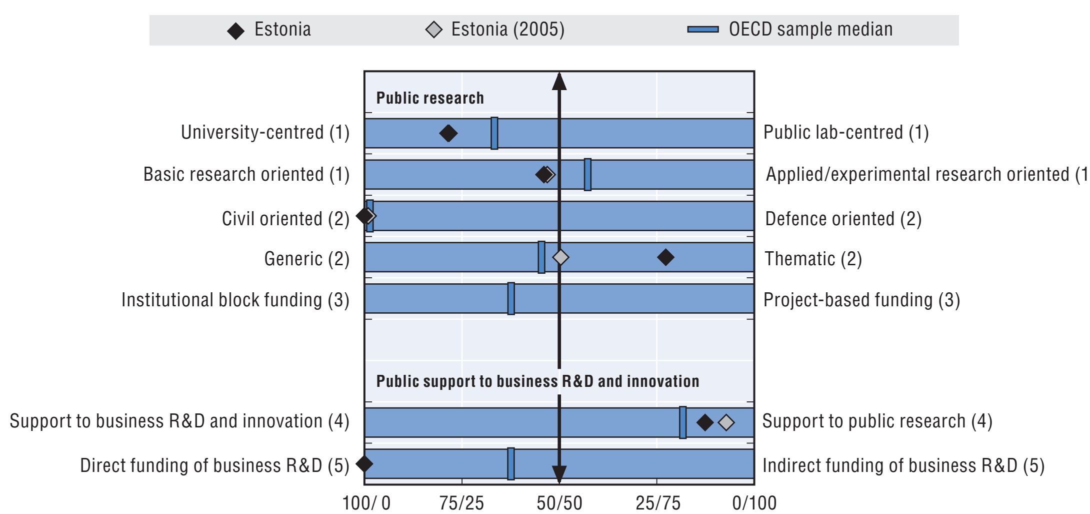
Green innovation: Energy, sustainable development and environmental issues are increasingly important government priorities. This is reflected, for example, in the Estonian Energy Technology Programme, a co-operation programme involving research, business and the state, to develop oil shale technologies and new, mainly renewable, energies.

Panel 2. Structural composition of BERD, 2009

As a % of total BERD



Panel 3. Overview of national innovation policy mix, 2010



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5. Balance as a percentage of the sum of indirect funding of business R&D and innovation through R&D tax incentives and direct funding of BERD through grants, contracts and loans.

Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888932690377

FINLAND

Hot STI issues

- Internationalising education, research and innovation and reforming PRIs.
- Broadening the scope of R&D and creating new growth enterprises in all sectors with a focus on SMEs.
- Addressing green growth through radical system changes.

General features of the STI system: For the past two decades, Finland's STI system has been highly ranked in international comparisons. Its economy is open and its businesses have good international links, although its research system is largely domestic (Panel 2). At 2.70% of GDP in 2010, BERD is well above the OECD median (Panel 1[d]). Finland has a strong and sustained RTA in ICT, and has improved its RTA in emerging and environmental technologies over the past decade, though these are still below the OECD medians (Panel 3). There are strong links between industry and science, and much public research is funded by industry (1[o]). International co-operation in science and innovation is mixed: 50% of scientific articles, slightly above the OECD median, but 19% of PCT patents, below the OECD median, are produced with foreign counterparts (1[q](r)). The rate of patents filed by universities and PRIs is well below the OECD median (1[p]). Human capital indicators are sound, with 38% of the adult population tertiary-qualified (1[s]) and 37% of persons employed in S&T occupations (1[v]). Finland leads the OECD with 23 researchers per thousand employees, and ranks at the top of OECD-area PISA scores in science for 15-year-olds (1[t]). ICT infrastructures are well developed, with 29 fixed broadband and 79 wireless subscribers per 100 inhabitants (1[k](l)). The e-government readiness is well above the OECD median and similar to that of Canada and Sweden (1[n]).

Recent changes in STI expenditures: GERD stood at 3.88% of GDP in 2010, the second highest in the OECD area. Between 2005 and 2010 it has increased regularly by 3.2% annually and is targeted to reach 4% of GDP by 2015. GOVERD is expected to fall in 2012, and public R&D is targeted to be 1% of GDP. Industry funded 66% of GERD in 2010 and government 26%, while 7% was funded from abroad. Given its high R&D intensity, the Finnish stimulus package of 2009 only moderately boosted STI spending with an additional USD 159 million.

Overall STI strategy: Finland's innovation system is currently undertaking a new round of reforms and refocusing its strategy. It was last evaluated in 2009. Recommendations included simplifying a complex and overlapping system, reviewing organisations and programmes, and reducing the number of R&D-related organisations and universities. The Demand and User-Driven Action Plan 2010-13 has meant a shift away from a supply-driven system. Areas to be addressed include the concentration of R&D and innovation in a few sectors, the low level of internationalisation of research, and fragmentation of education, research and innovation. Finland aims to have one of the world's best STI system by 2015.

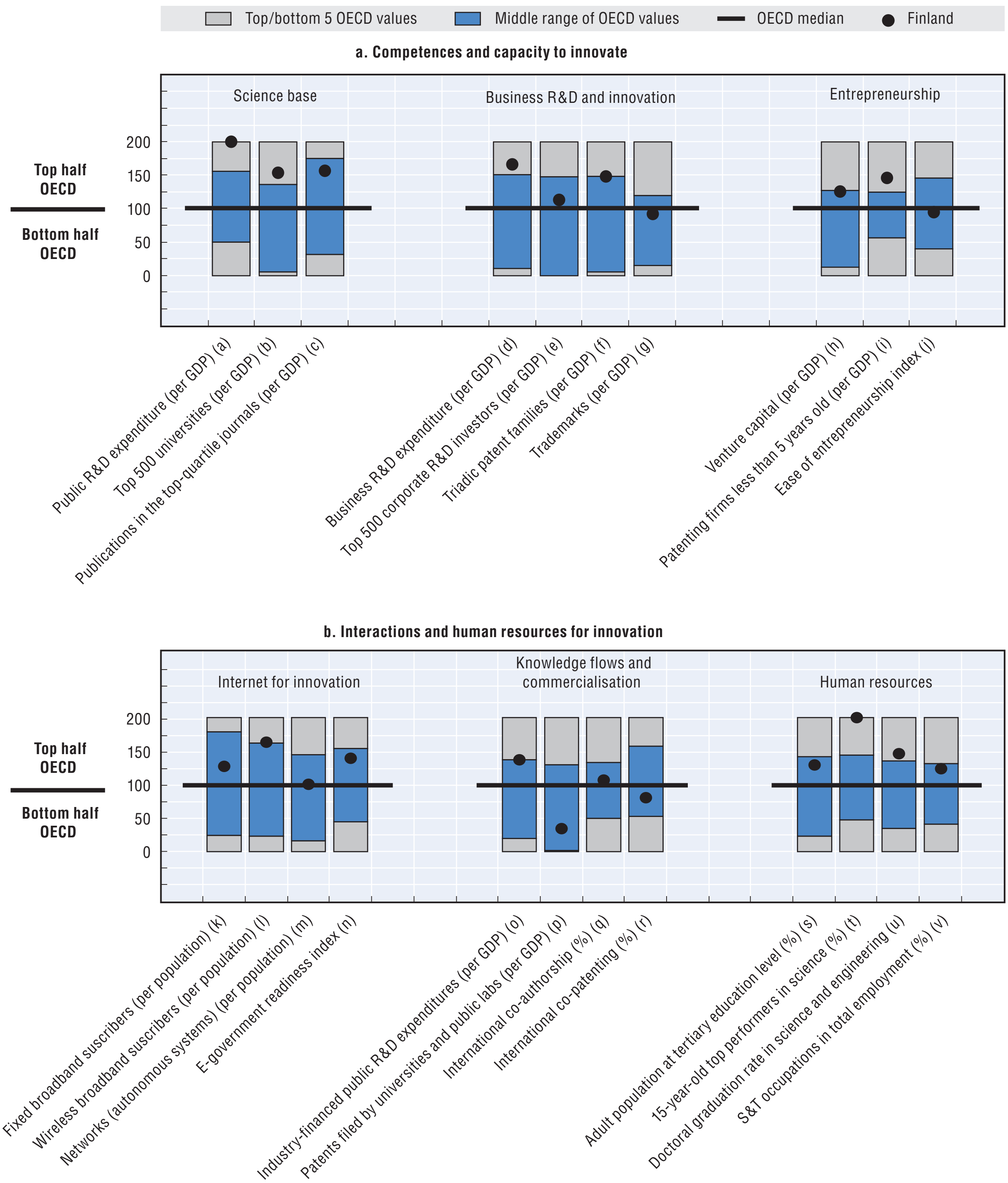
STI policy governance: The Ministry of Employment and Economy (MEE) was reorganised in September 2011 and is responsible for innovation policy planning and budgeting. The Ministry of Education and Culture (MEC) is responsible for higher education and science policy related matters. The Research and Innovation Council (RIC) is the main STI

Key figures

Labour productivity, GDP per hour worked in USD, 2010	**47.9**	**GERD, as % of GDP, 2010**	**3.88**
(annual growth rate, 2005-10)	(+1.1)	(annual growth rate, 2005-10)	(+3.2)
Environmental productivity, GDP per unit of CO_2 emitted in USD, 2009	**3.46**	**GERD publicly financed, as % of GDP, 2010**	**1.00**
(annual growth rate, 2005-09)	(+0.7)	(annual growth rate, 2005-10)	(+3.2)

Figure 10.14. **Science and innovation in Finland**

Panel 1. Comparative performance of national science and innovation systems, 2011



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

advisory body. MEE, MEC and RIC together will draft a new Science and Innovation Policy Action Plan by early 2013. The plan will be a part of the Government's mid-term review. The Government Programme 2011-15 has outlined guidelines to improve innovation in the current economic climate. The single most important policy document is the Research and Innovation Policy Guidelines 2011-15. A new Government Working Group for the Co-ordination of Research, Foresight and Assessment started work in 2011. Several evaluations of programmes and projects are in progress and will report in 2012-13. RIC work to reform PRIs also started in 2011.

Science base: Finland has a strong science base, high public-sector expenditure on R&D, highly ranked universities and a relatively high rate of scientific publications relative to GDP (1[(a)(b)(c)]).

Business R&D and innovation: The Finnish Funding Agency for Technology and Innovation (Tekes) has been shifting funding emphasis away from industrial and technological R&D-driven projects towards services firms, non-technical innovation and SMEs. A new R&D tax incentive scheme has been decided to be introduced probably in 2013 and is directed at companies and private venture capital. Tekes' new guiding principle for overall R&D funding is that the private sector should represent no less than two-thirds of GERD.

Entrepreneurship: Finland has a growing entrepreneurship culture, a robust venture capital industry (1[(h)]), and a very high relative number of young patenting firms (1[(i)]). The policy shift towards SMEs should improve the ease of entrepreneurship index (1[(j)]). Enterprise Finland is an online advisory service for SMEs. The Vigo Accelerator programme has raised capital of some USD 80 million for promising start-up firms in clean technology, ICT, mobile and life sciences.

Public-sector innovation: To optimise public services the Innovative Forerunner Cities Initiative targeted a group of ten innovative cities. Managing Innovations is a joint ministerial effort to increase policy co-ordination. In 2011, it was decided in principle to make public-sector data, archives and information available at no charge.

ICT and scientific infrastructures: ICT enjoys high priority. The National Digital Library, the IT Centre of Science, the Finnish Social Science Data Archive and Apps4Finland are digital information management programmes. Tekes supports a range of technology-targeted programmes, such as Value-added Mobile Solutions (VAMOS), a wireless technology project, and ubicom technology.

Globalisation: To address the moderate level of international research collaboration, Finland adopted the Strategy for the Internationalisation of Education, Research and Innovation (2010-15) prepared by the RIC. The Strategic Centres for Science, Technology and Innovation (SHOKs) and the Centre of Expertise Programme (OSKE) support cluster development. Finnvera, the state-owned finance company, offers loans and guarantees to exporting firms, while Groove (2010-14), with Tekes funding of USD 173 million, helps SMEs expand globally. International enterprises with R&D activities in Finland are eligible for Tekes funding..

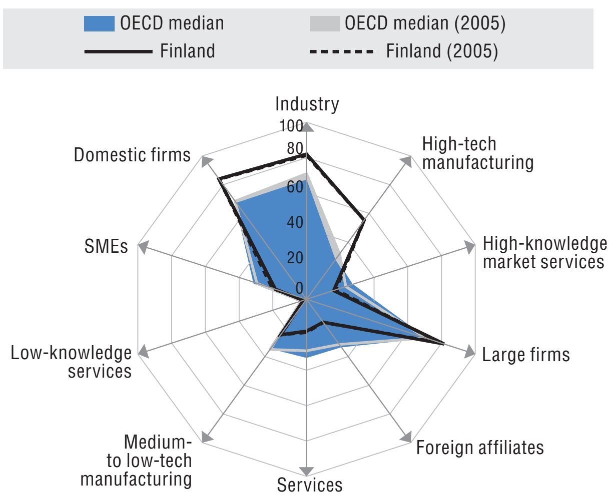
Human resources: Educational reforms have been implemented recently to ensure a well-functioning educational system and competitive labour market. The *Universities Act* changed the status of universities, increased their autonomy and merged a number of universities and HEIs into the University of Eastern Finland, the University of Turku and Aalto University. The Distinguished Professor Programme (FiDiPro) is a joint programme of Tekes and the Academy of Finland to attract leading international researchers. The LUMA Centre promotes science and mathematics studies. As part of its Europe 2020 Strategy, Finland seeks to increase tertiary attainment to 42%. Universities compile doctoral programmes in graduate schools focusing on research career's development.

Emerging technology fields: Tekes supports innovation in a number of emerging technology fields: services sector, pharmaceuticals, boating, tourism, food and water, biotechnology, ICT and digital, and safety and security. Tekes also funds infrastructure to support the use of electric vehicles.

Green innovation: R&D investments in energy technology have been increasing since the mid-2000s and rose by USD 324 million in 2010. A government strategic programme was launched in 2012 to promote growth, business activity, innovation and internationalisation of the environment business sector. Tekes recently launched a new programme, Towards Sustainable Growth and Green Economy. The Centre of Expertise Programme includes clusters in clean technology, energy and forestry. Four SHOKs will specialise in green growth research. The ICOS project monitors greenhouse gases, and the Fuel Cell Programme 2007-13 has a budget of USD 185 million to develop alternative energy solutions. The Finnish Environment Institute (SYKE), the VTT Technical Research Centre and the LYNET Consortium of several PRIs conduct environmental research.

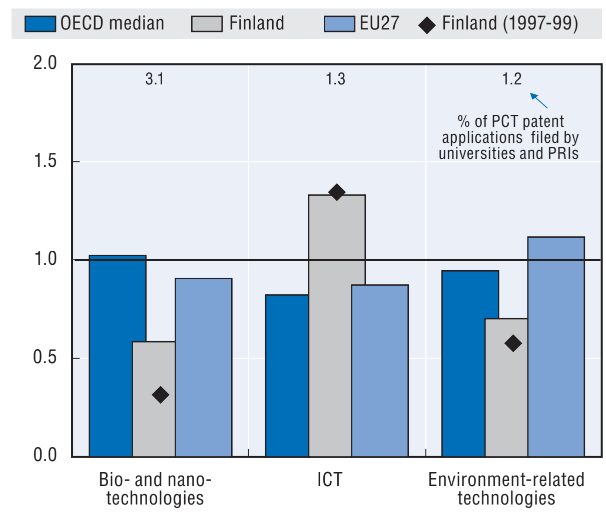
Panel 2. Structural composition of BERD, 2009

As a % of total BERD

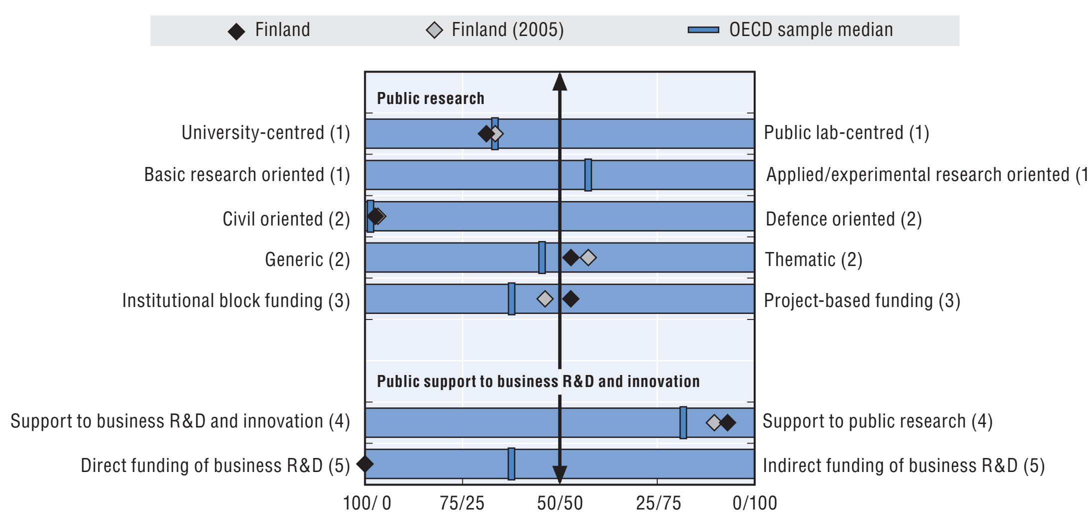


Panel 3. Revealed technology advantage in selected fields, 2007-09

Index based on PCT patent applications



Panel 4. Overview of national innovation policy mix, 2010



1. Balance as a percentage of the sum of HERD and GOVERD.
2. Balance as a percentage of total GBAORD.
3. Balance as a percentage of total funding to national performers.
4. Balance as a percentage of the sum of HERD and GOVERD funded by government and higher education and components of (5).
5. Balance as a percentage of the sum of indirect funding of business R&D and innovation through R&D tax incentives and direct funding of BERD through grants, contracts and loans.

Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888932690396

FRANCE

Hot STI issues

- Pooling research resources and activities to strengthen the system's international visibility.
- Accelerating leverage of public research and strengthening presence in IP markets.
- Supporting re-industrialisation and structuring industrial sectors through a public investment programme (PIA) and geographical clusters.
- Expanding and improving the assessment of public initiatives, including the PIA.

General features of the STI system: France is one of the world's top five economies as measured by GDP, owing to several knowledge-intensive sectors (high- and medium-high-technology manufactures, defence and financial services), the agri-food industry and tourism. The French innovation system is the second largest in Europe after Germany's with about 5% of OECD GERD, patents and publications. It is marked by the industrial policy of the 1960s-1970s, which gave certain industries (aviation, rail, nuclear) a lasting technological advantage. Some of its pharmaceutical, aeronautical and nuclear industries are among the world's largest private investors in R&D (Panel 1[e]). Nevertheless, the intensity of BERD, which returned in 2010 to its 2001 level (1.38% of GDP) after several years of decline, remains weak. Growth of BERD is constrained by: the shrinking share of manufacturing in value added and low spending on R&D by services (12% of BERD in 2007); the concentration of R&D activities in medium-high-technology sectors (29%), in particular the automotive industry (14%); and a broad base of SMEs that play a minor role in the research system (21%) (Panel 2). The funding of public research by industry is limited (1[o]), a sign of weak ties between these sectors. Furthermore, innovative entrepreneurship is fragile: France is below the OECD median for patents filed by young companies (1[i]). The French government maintains a strong influence over large segments of network industries, and regulatory barriers restrict competition in the retail sector and setting up of new stores. In the public sector, universities and PRIs are active in terms of PCT patent applications (1[p]) and patents filed in emerging technologies (Panel 3). The inflow of new doctoral graduates in science and engineering is steady (1[u]).

Recent changes in STI expenditures: With the adoption of the *Research Law* and the allocation of extra funding, GERD exceeded USD 40 billion in 2006. The Investments for the Future Programme (PIA), implemented as part of the stimulus plan, accelerated the roll-out of new STI capacities by injecting USD 40 billion over ten years to promote research, higher education, innovation and sustainable development.

Overall STI strategy: The priorities of the National Strategy for Research and Innovation (SNRI, 2009-12) are the strengthening of research capacity, scientific performance and the conditions of development for new companies, as well as knowledge transfer between public research bodies and business (in particular SMEs).

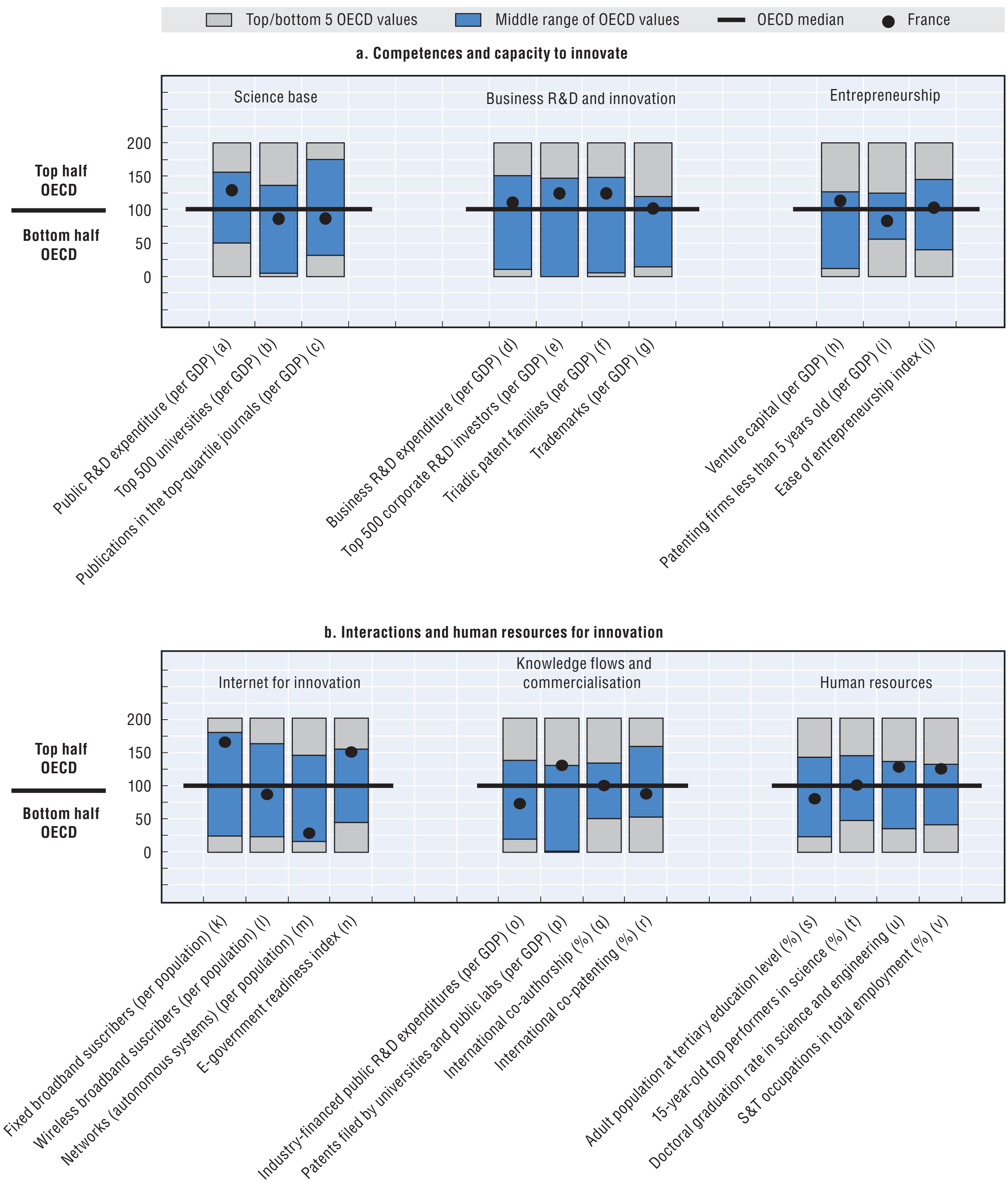
STI policy governance: The research and higher education system has recently undergone far-reaching reforms, including ministerial re-organisation, establishment of agencies for research funding (ANR) and for higher education and research

Key figures

Labour productivity, GDP per hour worked in USD, 2010	**57.7**	**GERD, as % of GDP, 2010**	**2.25**
(annual growth rate, 2005-10)	(+0.6)	(annual growth rate, 2005-10)	(+2.0)
Environmental productivity, GDP per unit of CO_2 emitted in USD, 2009	**6.13**	**GERD publicly financed, as % of GDP, 2010**	**0.92**
(annual growth rate, 2005-09)	(+2.3)	(annual growth rate, 2005-10)	(+2.5)

Figure 10.15. **Science and innovation in France**

Panel 1. Comparative performance of national science and innovation systems, 2011



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

evaluation (AERES), greater autonomy for universities (*LRU Act*), mutualisation of activities (PRES) and introduction of contract-based relations between the state and research bodies. The establishment in 2009-10 of thematic alliances (energy, health, ICTs, the environment, and human and social sciences) is a further step towards better co-ordination and programming.

Science base: France has a dual public research system: PRIs carry out almost half of public R&D, but the share is shifting towards universities (Panel 4). In spite of substantial public R&D expenditure (0.85% of GDP in 2010), the science base has few articles in leading scientific journals (1[(a)(c)]). The French university system is fragmented; it has only recently strengthened its research profile and relatively few institutes feature in university rankings (1[(b)]). Recent reforms in STI policy governance have resulted in a move towards more thematic research and competitive project-based funding and a larger role for universities (Panel 4).

Business R&D and innovation: Business R&D is a key priority of the SNRI and has drawn much policy attention in recent years. Government funding in this area has increased significantly. Indirect funding through the research tax credit (CIR) was reinforced by a major revision of the scheme in 2008 (at a budgetary cost of nearly USD 6 billion in 2010), while direct funding through the innovation agency (OSEO) and the ANR was maintained. The share of indirect funding rose from one-third to two-thirds of total government funding between 2005 and 2010, with a turnaround in the policy mix over the period (Panel 4). To consolidate corporate cash flows during the crisis, an immediate refund of research tax claims was introduced for 2009 and 2010. For SMEs immediate repayment was made permanent in 2011.

Entrepreneurship: The Estates General of Industry (EGI), an industry roundtable, has been the opportunity to draw up a new industrial policy focused on the structuring of industrial sectors, on re-industrialisation and on identification of strategic sectors (digital, eco-industries, energy, transport, chemicals, innovative materials). Under the PIA, OSEO funding to support industry and SMEs was increased by USD 2.8 billion. The PIA has enabled the establishment of two special venture capital funds: the National Seed Fund (2011) with USD 460 million, and the National Fund for Digital Society (2010), with USD 2.6 billion to support innovative digital services, applications and content.

ICT and scientific infrastructures: Under the PIA, France has invested massively in upgrading its research sites (laboratories and facilities of excellence). The Plan Campus sets aside USD 6.9 billion for renovating university buildings, including over USD 1 billion for the Plateau de Saclay.

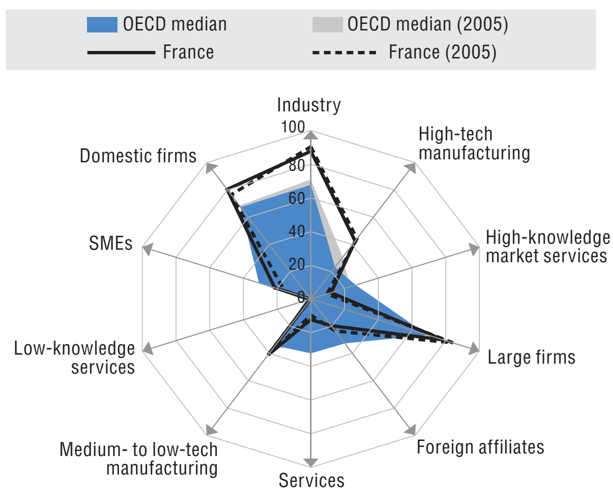
Clusters: The Competitiveness Cluster policy, introduced in 2004 to strengthen technological and industrial partnerships, has come to the end of its second phase (2009-11). It has received USD 575 million as part of the PIA (in addition to the initial USD 1.7 billion endowment). Efforts during the second phase focused on inter-cluster co-ordination and greater international visibility.

Knowledge flows and commercialisation: STI policy has sought to reinforce collaborative research and technology transfer. Under the PIA, interdisciplinary technological research institutes can be set up as public-private partnerships (USD 2.3 billion), with a view to becoming world-class campuses for technological innovation and enhancing cluster ecosystems. In addition to its funding for collaborative research, the ANR introduced in 2011 an Industrial Chairs programme to support collaborative research on strategic issues for French industry. The PIA has also funded the creation of a USD 1.2 billion National Fund for Research Promotion (2010) to support the deployment of accelerated technology transfer societies (SATT) and the professionalisation of research promotion. France Brevets, an IP investment fund, was set up in 2011.

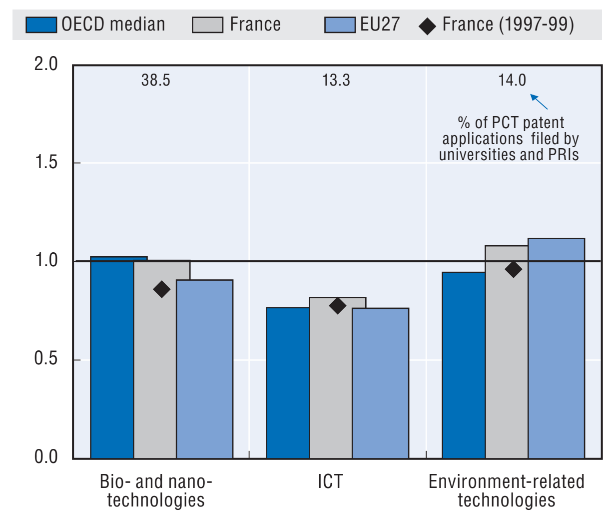
Green innovation: The Grenelle de l'environnement (2007) led to the introduction of measures targeting sectors with high environmental impact (tax incentives, eco-labels, green procurement, etc.). Nearly USD 7 billion has been invested for the research and pre-industrialisation phases of green industries of the future (*e.g.* technology platforms, clean vehicles, smart grids and circular economy). Public research has shifted towards environmental issues, an area in which France has acquired a slight RTA (Panel 3). The

Ambition Ecotech 2012 programme also aims at fostering the growth of eco-industries by providing funding to promote innovation and exports and by advising green SMEs.

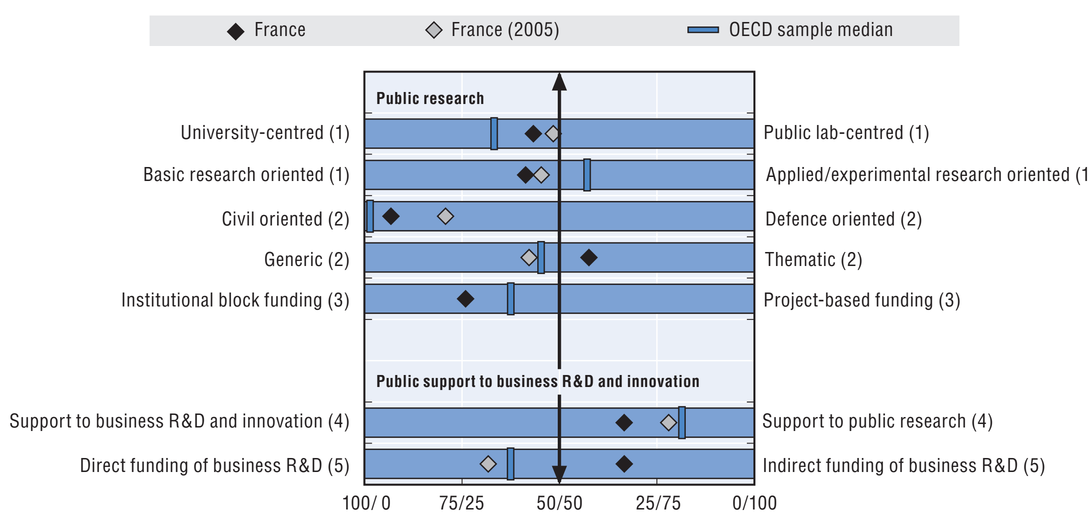
Panel 2. Structural composition of BERD, 2009
As a % of total BERD



Panel 3. Revealed technology advantage in selected fields, 2007-09
Index based on PCT patent applications



Panel 4. Overview of national innovation policy mix, 2010



1. Balance as a percentage of the sum of HERD and GOVERD.
2. Balance as a percentage of total GBAORD.
3. Balance as a percentage of total funding to national performers.
4. Balance as a percentage of the sum of HERD and GOVERD funded by government and higher education and components of (5).
5. Balance as a percentage of the sum of indirect funding of business R&D and innovation through R&D tax incentives and direct funding of BERD through grants, contracts and loans.

Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888932690415

GERMANY

Hot STI issues

- Maintaining a lead in eco-innovation, addressing demographic change and ageing.
- Further improving access to funding for start-ups and innovative SMEs, fostering innovation in services.
- Improving the policy mix, including through a combined system of direct support and tax incentives.

General features of the STI system: Germany has the EU's largest innovation system. It supports an export-oriented economy with a thick layer of internationally competitive firms, notably in manufacturing. Germany represents 9% of OECD-area GERD, 8% of scientific publications, and 12% of triadic patent families. In 2011, BERD was 1.92% of GDP, well above the OECD average (Panel 1[d]). It is leveraged by strong links between industry and science, with a comparatively high proportion of public research funded by industry (1[o]). The relative number of patents filed by universities and public labs is on a par with the OECD median (1[p]), and industry patenting is strong. In terms of RTA, Germany is not specialised in ICTs and emerging technologies but has strengthened in the latter (Panel 2). While it has lost some of its RTA in environment-related technologies, it remains very strong. Only 27% of the adult population is tertiary-qualified (1[s]), but 37% of persons employed are in S&T occupations (1[v]). It has 8.1 researchers per thousand total employment, close to the OECD median. Researchers are well integrated in international networks: 47% of scientific articles and 17% of PCT patent applications are produced with international collaboration (1[q][r]). ICT infrastructures are well developed with 33 fixed broadband and 29 wireless suscribers per 100 inhabitants (1[k][l]). The e-government readiness index is slightly above the OECD median (1[n]).

Recent changes in STI expenditures: GERD was 2.82% of GDP in 2010, and has been growing by 3.7% a year for the past five years. It is targeted to be 3% of GDP by 2015. In 2009 industry funded 66% of GERD, government funded 30% and 4% was funded from abroad. Public funding in particular has grown over the past five years. The federal government and states (Länders) target spending 10% of GDP on education and research by 2015.

Overall STI strategy: Overall policy priorities have not fundamentally changed. The new High-Tech Strategy 2020 has identified five societal and global challenges: climate, nutrition/health, mobility/transport, security, and communication. Individual technology fields are intended to contribute to major social policy aims or to drive innovation in key technology areas. The Strategy aims to create lead markets and identified wide-ranging "forward-looking projects" over the next 10-15 years that will affect society. The Higher Education Pact, the Initiative for Excellence and the *Academic Freedom Act* are complementary. Key policy priorities are to keep pace with global trends, fund private and public R&D, reform the education system, and improve industry-science links. New policy measures include Validation of Innovation Potentials of Scientific Research, Go Innovative and Research Campus, a scheme that funds complex technologies with potentially radical impact.

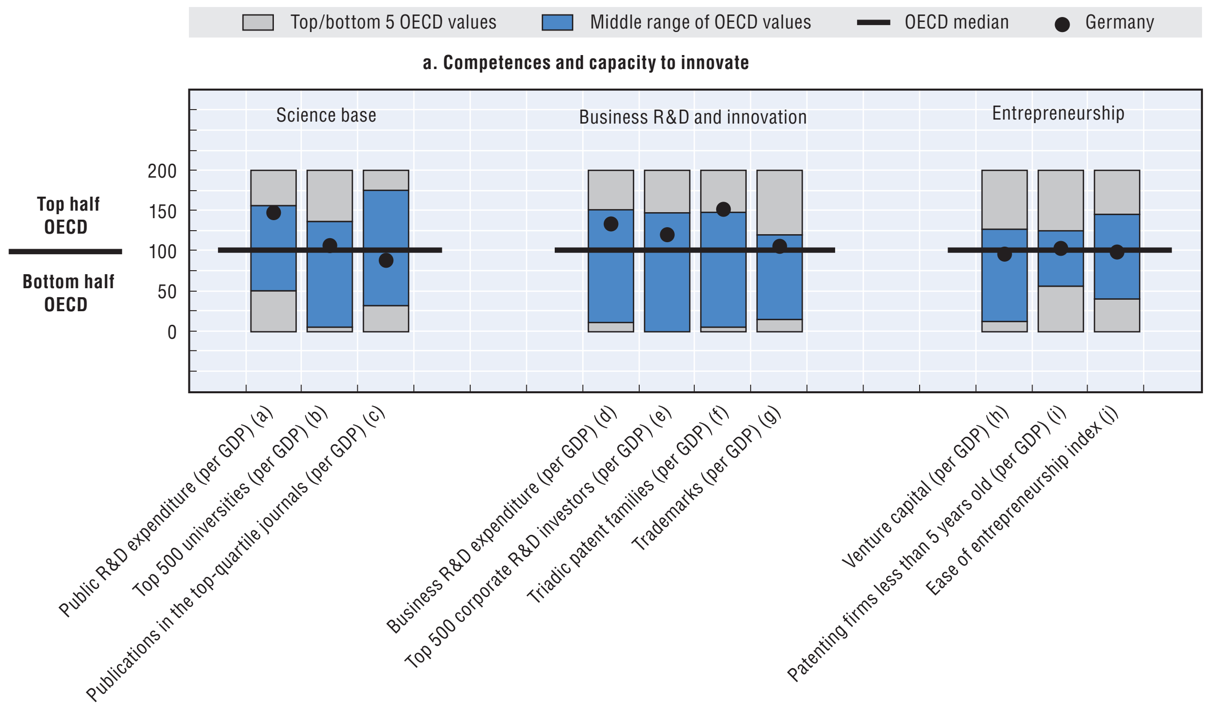
Key figures

Labour productivity, GDP per hour worked in USD, 2010	**53.6**	**GERD, as % of GDP, 2010**	**2.82**
(annual growth rate, 2005-10)	(+0.8)	(annual growth rate, 2005-10)	(+3.7)
Environmental productivity, GDP per unit of CO_2 emitted in USD, 2009	**3.94**	**GERD publicly financed, as % of GDP, 2009**	**0.84**
(annual growth rate, 2005-09)	(+2.9)	(annual growth rate, 2005-09)	(+4.9)

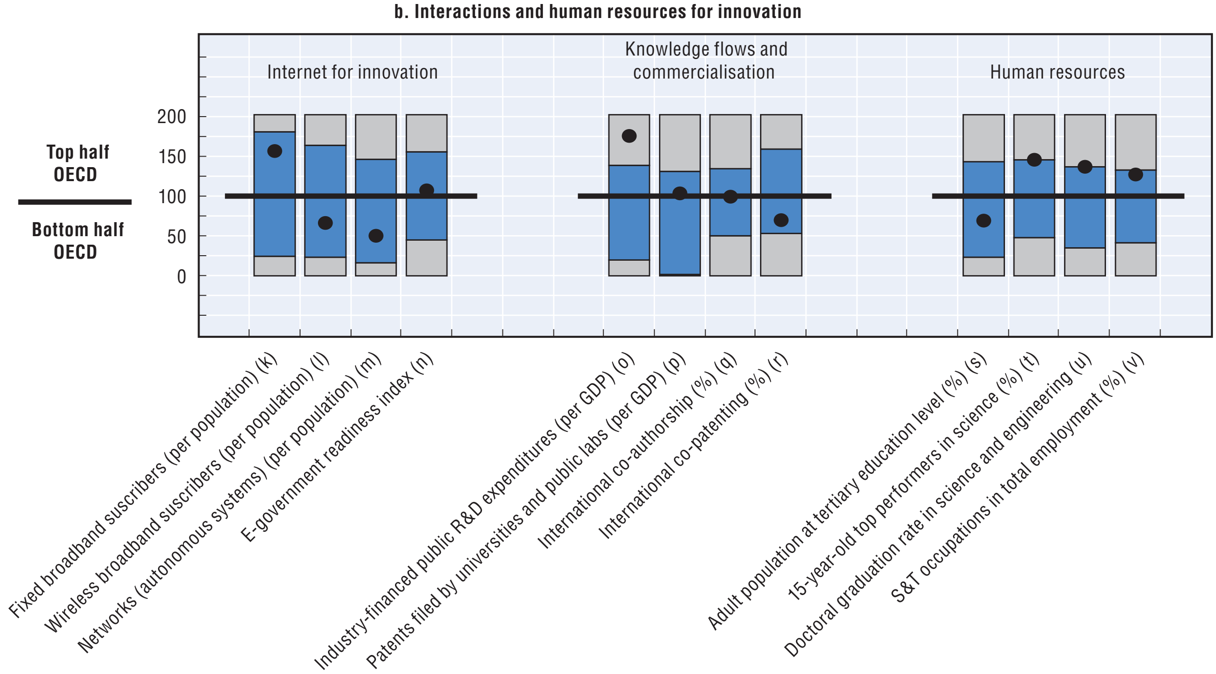
Figure 10.16. **Science and innovation in Germany**

Panel 1. Comparative performance of national science and innovation systems, 2011

a. Competences and capacity to innovate



b. Interactions and human resources for innovation



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

STI policy governance: STI governance has also been stable in recent years. Both the federal government and the states are important players. The Federal Ministry of Education and Research (BMBF) directs public and private R&D activities towards targeted fields of technology. The Federal Ministry of Economics and Technology (BMWi), and the KfW Banking Group have innovation programmes. The states fund universities and R&D linkages programmes.

Science base: Germany has a strong science base, with high public-sector spending on research, highly rated universities and research publication outputs (1[(a)(b)(c)]). GOVERD has increased by 4.7% a year in constant prices between 2005 and 2010, despite the recession and fiscal consolidation. Recent efforts to strengthen the science base include increases of up to 20% in the funding mechanisms for university research by both the German Research Foundation (DFG) and BMBF. The 2010 Pact for Research and Innovation is a joint effort of the government and the states to increase R&D funding to the Fraunhofer Society, the Helmholtz Association, the German Research Laboratories, the Leibnitz Association, the Max-Planck Society and the German Research Foundation from 3% to 5% a year.

Business R&D and innovation: Germany does not spend a high proportion of GDP on subsidies for R&D, and relies on direct support rather than tax incentives. It provides support to innovation in various ways.

Entrepreneurship: Limited access to finance for start-ups and SME innovation projects is an obstacle to innovation. The Central Innovation Programme for SMEs (ZIM) is a support measure open to all technologies and sectors. Its budget was increased by USD 1.1 billion for 2010-11 and it was voted the best innovation promotion measure in 2011. Venture capital (VC) access is being improved through tax relief for holding companies that invest in young technology companies. The High-Tech Gründerfonds invests in VC, as does the High-tech Startup Fund, ERP Startup Fund and EXIST, an entrepreneurship grant to universities.

Knowledge flows and commercialisation: Germany performs well in terms of knowledge flows and commercialisation. Initiatives to further improve collaboration between business and science are the Leading Edge Cluster Competition (with a budget of USD 1.5 billion), Excellence Clusters, Research Campus and Research Bonus; the German Centres for Health Research Initiative aims to improve laboratory-to-clinic knowledge transfer. The Strategy for the Internationalisation of Science and Research is meant to help German companies enter into partnerships with the world's most innovative centres. The EUROSTARS and Research in Germany programmes foster international links. The *Act on Better Enforcement of Intellectual Property Rights* and SIGNO protect and commercialise innovative ideas.

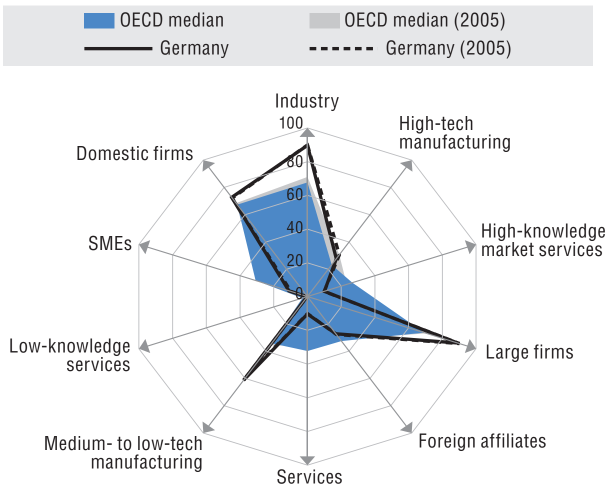
Human resources: A lack of skilled personnel is perceived as an emerging constraint. MINToring, School Curricula and Education Chains are programmes designed to improve secondary schooling, increase tertiary attainment rates and avoid a lack of expertise in maths, information technology, natural sciences and technology. The Quality of Teaching Pact has a budget of USD 2.5 billion to improve the quality of teaching from 2011 to 2020.

Emerging technologies: Technological competences need to be maintained and extended. The Initiative for Excellence promotes cutting-edge research at universities. Programmes such as Leading Edge Cluster and Innovation Alliances focus on breakthrough technologies. The 2012 BMBF Foresight Process will emphasise seven new fields, including production/consumption 2.0, life sciences, demography and sustainable energy solutions. Other areas include the Action Plan Nanotechnology 2015 and USD 1.5 billion a year for civil space programmes.

Green innovation: Green innovation remains a major German strength. The Framework Programme Research for Sustainable Development (FONA) (2010-15) was launched in 2010 and focuses among others on climate, energy and sustainable resource management. The CLIENT project helps to establish international partnerships in environmental and climate protection technologies and to trigger the development of lead markets.

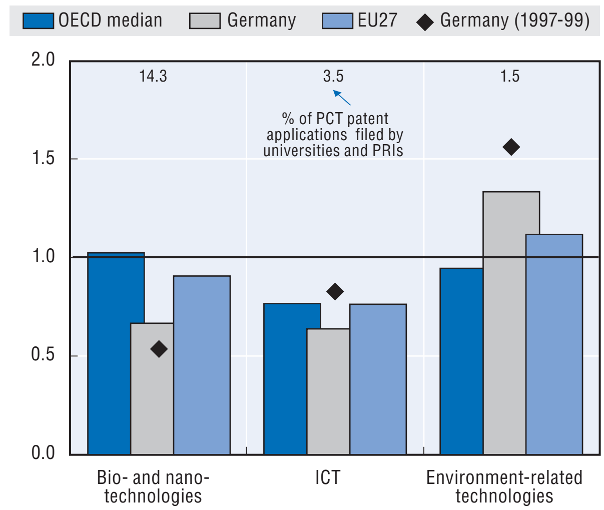
Panel 2. Structural composition of BERD, 2009

As a % of total BERD

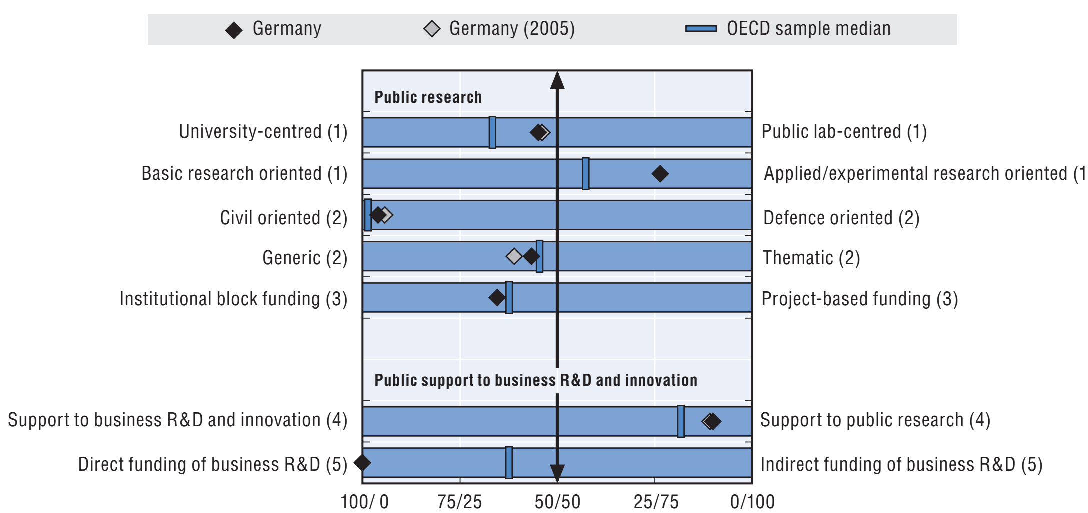


Panel 3. Revealed technology advantage in selected fields, 2007-09

Index based on PCT patent applications



Panel 4. Overview of national innovation policy mix, 2010



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Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888932690434

GREECE

Hot STI issues

- Improving framework conditions for innovation.
- Making innovation a centrepiece of a competitive economy.
- Moving from brain drain to brain circulation.

General features of the STI system: Greece is in a deep and protracted economic recession. In response the Greek government has embarked on fiscal consolidation and structural reforms. Improving framework conditions for innovation and overcoming serious weaknesses in the innovation system are critical for regaining competitiveness and sustainable growth. GERD has stagnated at 0.60% of GDP and is dominated by public expenditure which is far below the OECD median (Panel 1[(a)]). The share of BERD in GDP was the second lowest among OECD countries in 2007 (1[(d)]). Greece lacks large corporate investors in R&D (1[(e)]) and BERD is largely accounted for by SMEs (Panel 2). Links between academia and industry are weak; there is little demand from industry for R&D and innovation and the corresponding supply from universities and PRIs is small, as shown by the relative number of patents filed by universities and public labs to GDP (1[(p)]). Indicators of human resources fall short of the OECD median: Only 24% of the adult population has attained tertiary level education (1[(s)]), and S&T occupations accounted for a similar share of total employment in 2010 (1[(v)]). Greece also lags in terms of quality of universities (1[(b)]). Brain drain has been a recurrent issue and appears to be increasing in the wake of the crisis.

Recent changes in STI expenditures: Although GERD is already very near the bottom of OECD countries, the crisis is exerting a dampening effect on public and business investment, including in R&D. EU structural funds remain the most important source of funding for R&D and innovation. The challenge is to absorb these funds and put them to efficient use.

Overall STI strategy: The National Strategic Plan for Research and Development 2007-13 defined as the main STI policy priorities the improvement of R&D capabilities (investment, human capital, infrastructures) and the promotion of links between research and industry to accelerate the dissemination of innovation. It also aimed at increasing participation in international (especially European) programmes.

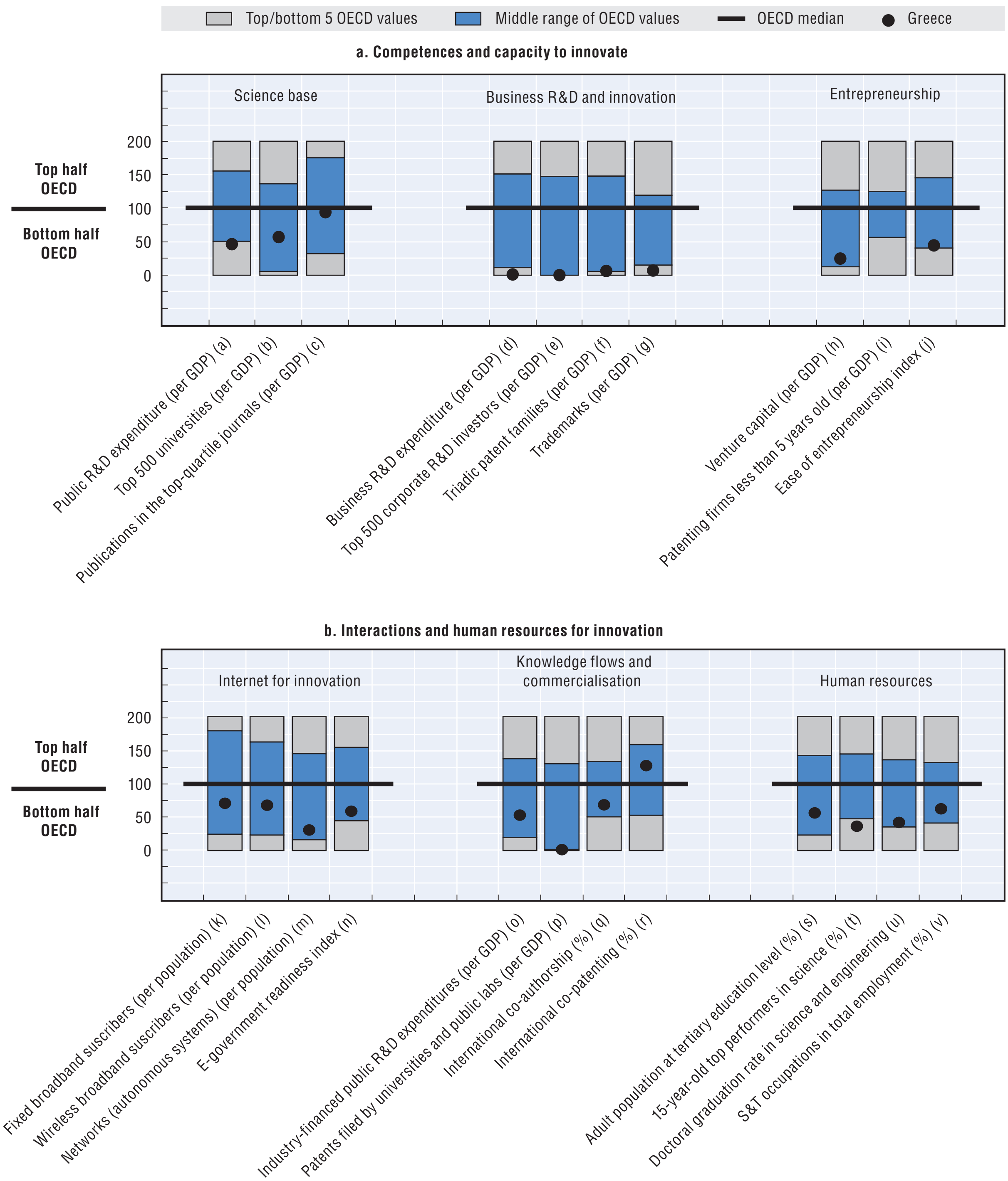
STI policy governance: The Greek governance system shows weaknesses in policy co-ordination and evaluation. Institutional changes in 2009 include the move of the General Secretariat for Research and Technology (GSRT) to the Ministry of Education, Lifelong Learning and Religious Affairs, with a view to building a unified area for education and research, and the establishment of the Ministry of Development, Competitiveness and Shipping, which manages the National Strategic Reference Framework, the reference document for programming of EU funds at national level, including structural funds.

Key figures

Labour productivity, GDP per hour worked in USD, 2010	**33.6**	**GERD, as % of GDP, 2007**	**0.60**
(annual growth rate, 2005-10)	(+0.6)	(annual growth rate, 2005-07)	(+4.7)
Environmental productivity, GDP per unit of CO_2 emitted in USD, 2009	**3.68**	**GERD publicly financed, as % of GDP, 2005**	**0.29**
(annual growth rate, 2005-09)	(+3.5)	(annual growth rate, 2001-05)	(+4.6)

Figure 10.17. **Science and innovation in Greece**

Panel 1. Comparative performance of national science and innovation systems, 2011



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

Science base: Greece's current research system is weak and largely decoupled from the domestic economy. Against the backdrop of fiscal consolidation, increased public R&D expenditure is not considered realistic. Greece has forsaken the GERD target of 1.5% of GDP by 2020; the government emphasises more efficient use of available resources. *Law 4009/2011* is moving universities towards greater autonomy and introduces a new funding mechanism based on quality indicators.

Business R&D and innovation: Structural reforms are being undertaken in the competition framework, the labour market and the tax system. The *Investment Law 3908/2011* shifted public support for business R&D and innovation from grants towards subsidised loans, guarantees and tax incentives.

Clusters and regional policies: Cluster policy contributes to strengthening links between academia and industry through initiatives such as A Greek Product, a Single Market: The Planet. This scheme was launched in 2011 to invite existing networks to submit proposals that would demonstrate the possibility of developing innovation clusters in areas in which Greece has a comparative advantage.

Knowledge flows and commercialisation: The promotion of commercialisation, through the creation of a framework more conducive to entrepreneurship, is the main instrument for developing links between academia and industry. In addition to Innovation Vouchers for SMEs (2009) and calls for the creation of spin-offs, the Co-operation programme encourages partnerships between the private sector and research institutions in specific sectors. In 2011, a scheme for recruiting high-level scientific personnel to support business R&D was announced, and an Entrepreneurship Fund (ETEAN SA) was established with an expected budget of USD 1.7 billion to provide flexible funding (venture capital, start-up and seed capital, business angels). One-stop shops for start-ups became operational in 2011 and licensing procedures were simplified.

Globalisation: Strengthening the internationalisation of Greece's STI system is one of the objectives of the Strategic Plan. Therefore, GSRT has developed bilateral collaborations, and schemes have been launched to encourage further participation by PRIs and businesses in international (especially European) programmes such as the Joint Technology Initiatives (ENIAC, ARTEMIS) or ERA-NET.

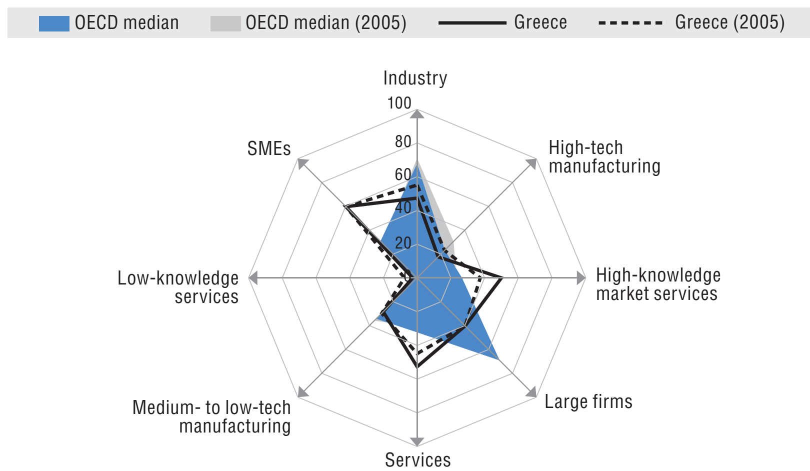
Human resources: To reform the education system, *Law 4009/2011* introduced major changes in the governance of universities in order to improve the quality of teaching and services delivered to students. The New School policy, introduced in 2010, targets improvement of primary and secondary schools through curriculum modernisation, reform of teacher training and implementation of a digital school strategy. These policies attempt to achieve the targets set out in the National Reform Programme 2011-14: under 10% of early school leavers and at least 32% of the younger generation tertiary-qualified. To alleviate mismatches between demand for and supply of skills, a National Network for Lifelong Learning was established.

Emerging technologies: Micro- and nano-electronics and embedded systems have recently emerged on Greece's R&D landscape. They are developed through domestic measures (the Corallia cluster for microelectronics) and participation in international programmes such as joint technology initiatives (the European Nanoelectronics Initiative Advisory Council and the Advanced Research and Technology for Embedded Intelligence and Systems).

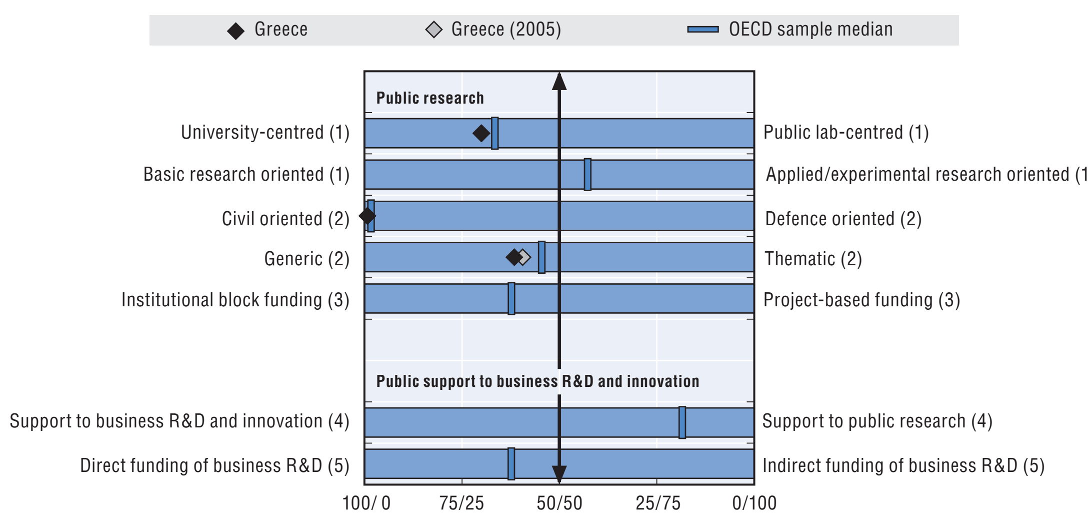
Green innovation: A Ministry of Environment, Energy and Climate was established in 2009. A set of measures has been introduced to achieve better alignment of environmental and energy policy with domestic technological development. These include green infrastructures (to make the environment and environmental protection an area of entrepreneurial activity), including the Green Island – Ai Stratis project for the development of mature renewable energy and energy-saving technologies to cover the island's needs; and the Energy Efficiency in Household Building Initiative (to improve the energy efficiency of existing dwellings and to achieve a 20% reduction in energy consumption).

Panel 2. Structural composition of BERD, 2009

As a % of total BERD



Panel 3. Overview of national innovation policy mix, 2010



1. Balance as a percentage of the sum of HERD and GOVERD.
2. Balance as a percentage of total GBAORD.
3. Balance as a percentage of total funding to national performers.
4. Balance as a percentage of the sum of HERD and GOVERD funded by government and higher education and components of (5).
5. Balance as a percentage of the sum of indirect funding of business R&D and innovation through R&D tax incentives and direct funding of BERD through grants, contracts and loans.

Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888932690453

HUNGARY

Hot STI issues

- Increasing innovative domestic firms.
- Reforming education to improve human capital and tertiary attainment.
- Building a competitive R&D environment that contributes to economic growth.

General features of the STI system: Hungary has a very open economy with quite a large manufacturing sector, much of which is foreign-owned. BERD has grown by a strong 9% a year in constant prices since 2000, almost doubling from 0.36% of GDP in 2000 to 0.69% of GDP in 2010. A high proportion of BERD is carried out in foreign affiliates engaged in high-technology manufacturing (Panel 2); much domestically owned industry performs little innovation. Industry-science linkages are sound, with the share of public research funded by industry (Panel 1(o)) above the OECD median. Integration with global networks is also good: 48% of scientific articles and 32% of PCT patent applications were produced with international collaboration (1(q)(r)). However, the number of PCT patents filed by universities and public research labs per GDP is below the OECD median (1(p)). Hungary has an RTA in environment-related technologies; ICT and bio- and nano-technologies are close to the OECD median. Human resource indicators are weak: only 20% of the adult population is tertiary-qualified (1(s)), and PISA science scores of 15-year-olds rank Hungary 27th in the OECD (1(t)). ICT infrastructures are under-developed: Hungary has 20 fixed broadband and 10 wireless subscribers per 100 inhabitants (1(k)(l)). The e-government readiness index is below the OECD median, similar to Slovenia and the Czech Republic (1(n)).

Recent changes in STI expenditures: Hungary's GERD was 1.16% of GDP in 2010, well below the Barcelona target of 3%. However, GERD grew by a robust 4% a year between 2005 and 2010, one of the highest growth rates in the EU. As part of its Europe 2020 Strategy, Hungary has targeted GERD to increase to 1.8% of GDP by 2020. In 2010, a relatively high 47% of GERD was funded by industry, 39% by government, and 12% from abroad.

Overall STI strategy: Hungary's innovation policy has undergone regular changes over the past decade. The New Széchenyi Plan (ÚSzT) revised and updated the official S&T Innovation Policy Strategy in early 2011 and is currently the main strategy document. It focuses on selected key technology areas and has as its overriding objectives to increase R&D intensity and to increase innovation by firms.

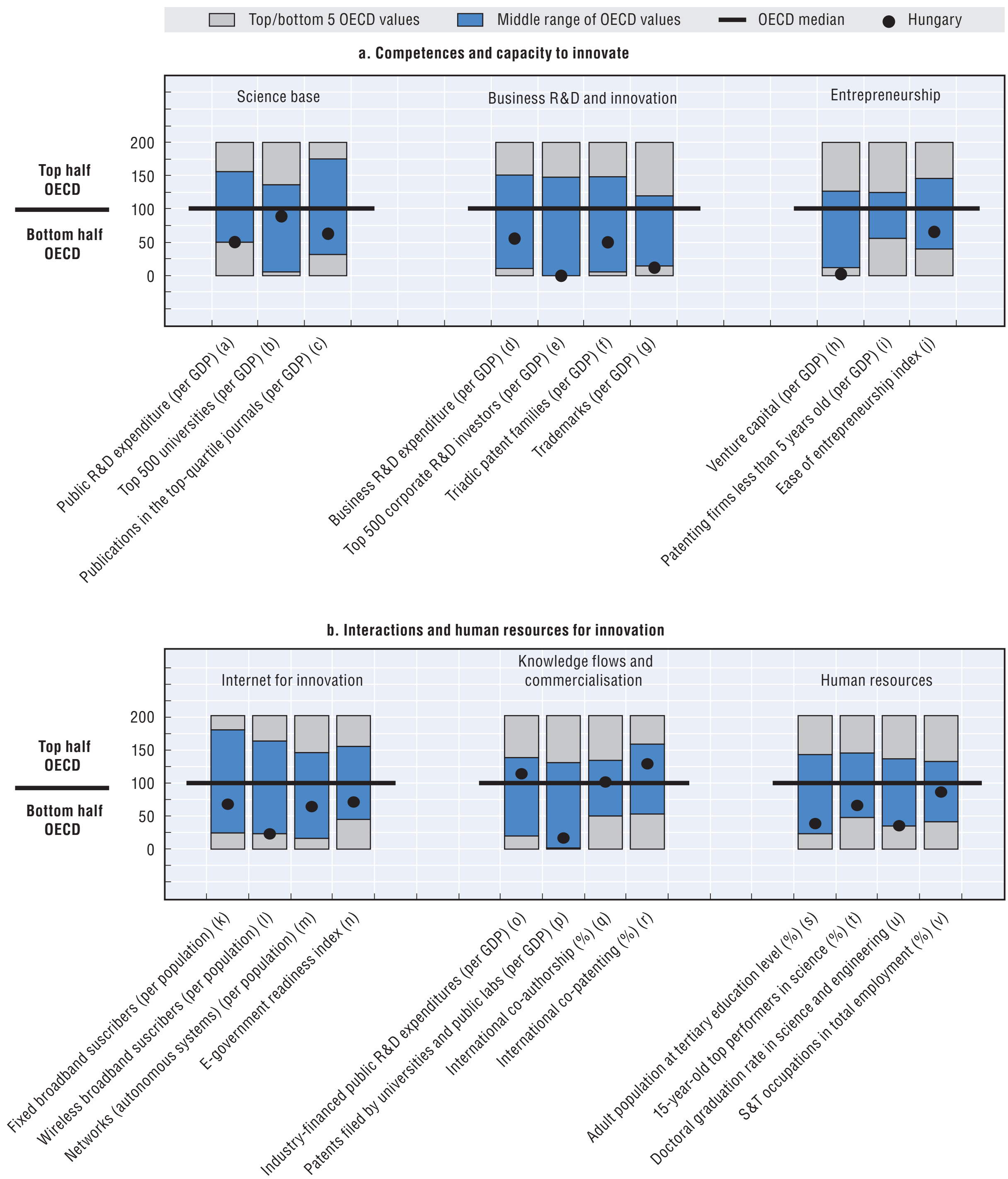
STI policy governance: STI policy governance arrangements have also changed regularly over the last two decades, and have even been modified twice since 2009. Currently, the National Research, Innovation and Science Policy Council (NKITT) provides long-term strategic advice to government. Four ministries (National Economy, National Development, National Resources and Public Administration and Justice) are represented on the NKITT. The National Innovation Office (NIH) is a key policy organisation. The Hungarian Academy of Sciences (HAS), with its network of scientific research institutes, oversees the Hungarian Scientific Research Fund (OTKA).

Key figures

Labour productivity, GDP per hour worked in USD, 2010	**26.1**	**GERD, as % of GDP, 2010**	**1.16**
(annual growth rate, 2005-10)	(+0.8)	(annual growth rate, 2005-10)	(+4.0)
Environmental productivity, GDP per unit of CO_2 emitted in USD, 2009	**4.21**	**GERD publicly financed, as % of GDP, 2010**	**0.46**
(annual growth rate, 2005-09)	(+3.6)	(annual growth rate, 2005-10)	(–0.6)

Figure 10.18. **Science and innovation in Hungary**

Panel 1. Comparative performance of national science and innovation systems, 2011



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

Science base: Hungary has a relatively small science base which is equally distributed between higher education and the institutes of the Hungarian Academy of Sciences (Panel 4). Public expenditures on R&D are low (1[(a)]); this is reflected in university rankings and international publications, both of which are below the OECD median (1[(b)(c)]).

Business R&D and innovation: The global financial crisis has significantly affected Hungary's R&D and innovation policy. In 2010, around USD 77 million (almost 37% of the STI budget) of the Research and Technological Innovation Fund (KTI) were blocked and some schemes were suspended. Business R&D instruments include direct funding such as competitive grants, equity financing and venture capital, and innovation vouchers, as well as a tax credit for R&D.

Entrepreneurship: The technological level of a large proportion of Hungarian firms, especially SMEs, is obsolete and underdeveloped. Increasing the share of innovative domestic firms is one of the main objectives of Hungary's STI policy. The Complex Enterprise Technology Development Initiative targets this area with a budget of USD 278 million.

ICT and scientific infrastructures: Spending on Hungary's research infrastructure was weak during the transition period. More recently, initiatives have been put in place to improve the quality of public research laboratories, including the Social Infrastructure Operational Programme (SOIP) and the National Research Infrastructure Survey and Roadmap (NEKIFUT). The National Information Infrastructure Development Institute (NIIF) is a supercomputer grid dedicated to research, and the Electronic Information Service (EISZ) facilitates access to data for higher education and scientific research institutions.

Clusters and regional policies: Cluster policy initiatives are a key pillar of regional policy. The Pole Programme supports clusters of firms with export potential in the main cities. The Economic Development Operational Programme (EDOP) and the Central Hungary Operational Programme (CHOP) also support cluster activity. There is also support for innovation and technology parks.

Knowledge flows and commercialisation: Initiatives that improve research and technology commercialisation include the Corvinus First Innovation Venture Capital Fund (CELIN), which assists start-up SMEs, and the Start Equity Guarantee Fund. The Hungarian Intellectual Property Office (HIPO) oversees intellectual property protection and has prepared the Action Plan Promoting Industrial Property Competitiveness of Entrepreneurs (Vivace) to address the country's weak IPR and innovation culture.

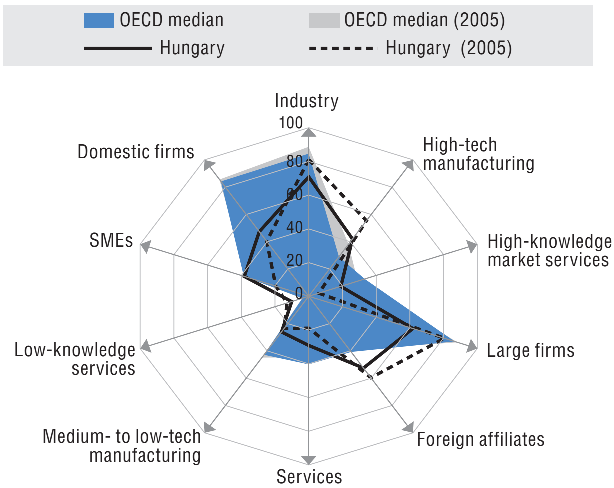
Human resources: Hungary's skills levels and human resource indicators are low. The New Széchenyi Plan aims to improve the quality of human resources in the academic sector. The government has increased support for PhD study, corporate scholarships, and post-doctoral job opportunities. Other initiatives to improve the education system include funding for Momentum: "From Brain Drain to Brain Gain" directed at talented young researchers, while the Campus Hungary Programme supports international student mobility.

Emerging technologies: Hungary has taken steps to improve nanotechnology research (the NAP Nano Scheme) through an International Research and Development Agreement in 2005 with the Russian Federation. The National Technology Programmes and Platforms are further measures to support the state-of-the-art technologies that are expected to play a decisive role in Hungary's economic development.

Green innovation: Green economic development is one of the seven focus areas of the New Széchenyi Plan. Hungary's National Sustainable Development Strategy (2007) encourages R&D in future energy sources. Other green initiatives include the Hungarian National Renewable Energy Action Plan, the National Environmental Technology Innovation Strategy (2011-20) and the National Energy Strategy (2030).

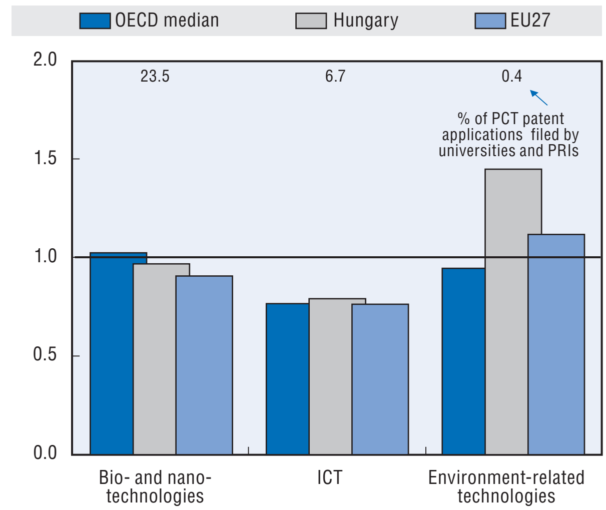
Panel 2. Structural composition of BERD, 2009

As a % of total BERD

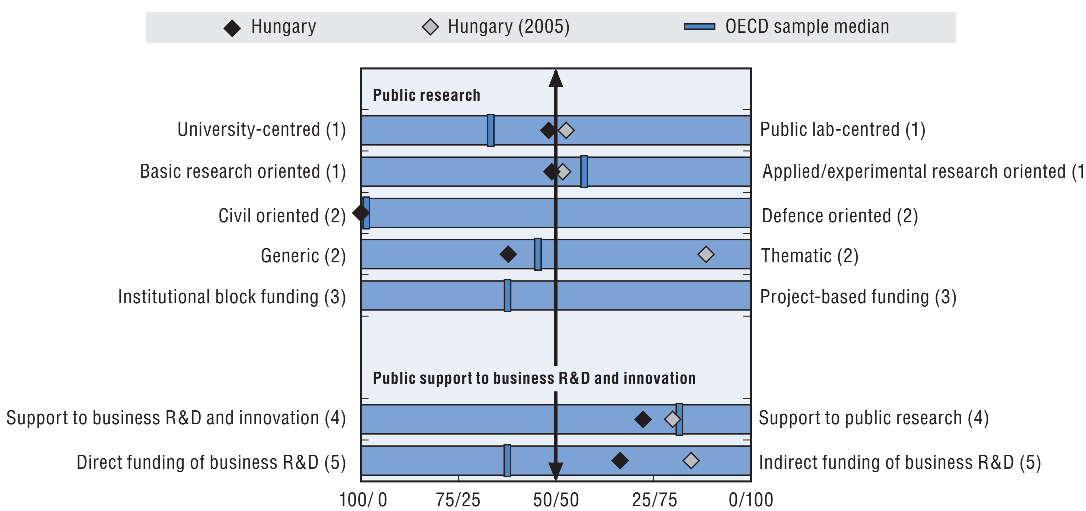


Panel 3. Revealed technology advantage in selected fields, 2007-09

Index based on PCT patent applications



Panel 4. Overview of national innovation policy mix, 2010



1. Balance as a percentage of the sum of HERD and GOVERD.
2. Balance as a percentage of total GBAORD.
3. Balance as a percentage of total funding to national performers.
4. Balance as a percentage of the sum of HERD and GOVERD funded by government and higher education and components of (5).
5. Balance as a percentage of the sum of indirect funding of business R&D and innovation through R&D tax incentives and direct funding of BERD through grants, contracts and loans.

Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888932690472

ICELAND

Hot STI issues

- Restoring and rebuilding capacity in STI and increasing industry R&D.
- Improving co-ordination of research funding among responsible ministries.
- Targeting green industries as the fastest-growing sector in the next decade.
- Continuing educational reforms and increasing the number of graduates in science and engineering.

General features of the STI system: Iceland's economy has diversified into high-knowledge services over the last decade to complement the traditionally strong fishing sector and aluminium production. Geothermal and hydropower industries have attracted investment from high-technology green firms. However, the global financial crisis severely affected Iceland and has put several investment projects on hold. Firms are moderately involved in the research system and most business R&D activities are concentrated in high-knowledge services and high-technology manufacturing (Panel 2). BERD as a percentage of GDP was 1.4% in 2008, down from 1.5% in 2000. BERD intensity and research output in terms of patents are close to the OECD median (Panel 1[(d)(f)]). Iceland's performance in terms of non-technological innovation is good, as reflected in trademark counts (1[(g)]). The regulatory and administrative environment is not very conducive to entrepreneurship (1[(j)]) owing to bureaucratic hurdles, foreign ownership restrictions in various sectors (electricity, fisheries) and entry barriers in network industries. In addition, universities and public labs do not actively patent the results of their research activities (1[(p)]). Because of its small size and remote location, Iceland lacks world-class universities and large corporate investors (1[(b)(e)]). Links between industry and science are strong, and industry funds 18% of public research (1[(o)]). Iceland is strongly integrated in global networks: 72% of scientific articles and 42% of PCT patent applications are produced with international collaboration (1[(q)(r)]). ICT infrastructures are well developed, with 34 fixed broadband and 54 wireless subscriptions per 100 inhabitants (1[(k)(l)]). The government's e-readiness index is around the OECD median (1[(n)]), similar to that of Austria, Ireland and Luxembourg. Human capital indicators vary: a third of the adult population has attained tertiary education (1[(s)]) and 39% of the workforce is employed in S&T jobs (1[(v)]). Iceland has a relatively high 17 researchers per thousand total employment, but PISA science scores of 15-year-olds are middling (1[(t)]) and doctoral graduation rates in science and engineering are low.

Recent changes in STI expenditures: Iceland's GERD was 2.64% of GDP (USD 334 million) in 2008 and is targeted to reach 4% in 2020. It grew by 2.3% during 2005-08. Industry remains the main funder of GERD (50%) and government's contribution (39%) is relatively large, but decreasing compared to OECD countries. Overseas funding accounts for a notable 10% of total GERD.

Overall STI strategy: Current government priorities focus on achieving macroeconomic stability. Since the global crisis the national STI strategy has been refocused. The New Science and Innovation Strategy 2010-20 has placed greater emphasis on competitive and performance-based funding, better quality assessment, and creative and design industries. To consolidate funding, the Icelandic Centre for Research (Rannís) has merged research

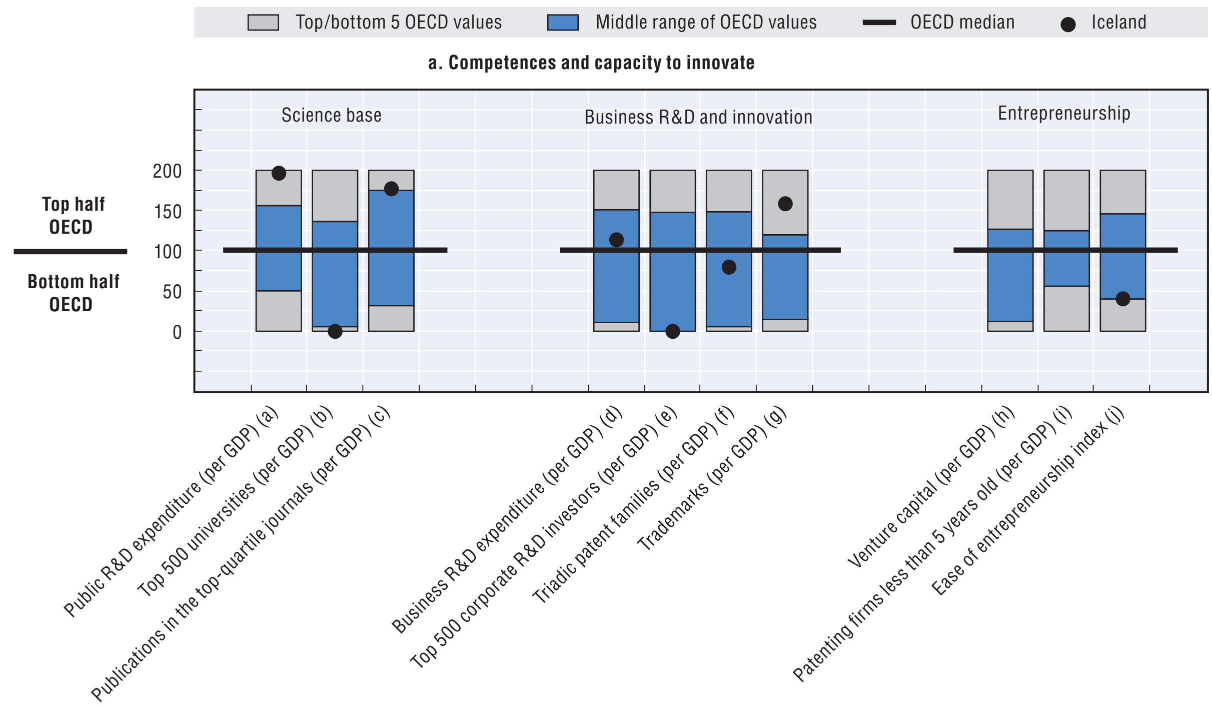
Key figures

Labour productivity, GDP per hour worked in USD, 2010	**40.1**	**GERD, as % of GDP, 2008**	**2.64**
(annual growth rate, 2005-10)	(+0.6)	(annual growth rate, 2005-08)	(+2.3)
Environmental productivity, GDP per unit of CO_2 emitted in USD, 2009	**5.86**	**GERD publicly financed, as % of GDP, 2008**	**1.03**
(annual growth rate, 2005-09)	(+3.7)	(annual growth rate, 2005-08)	(+0.9)

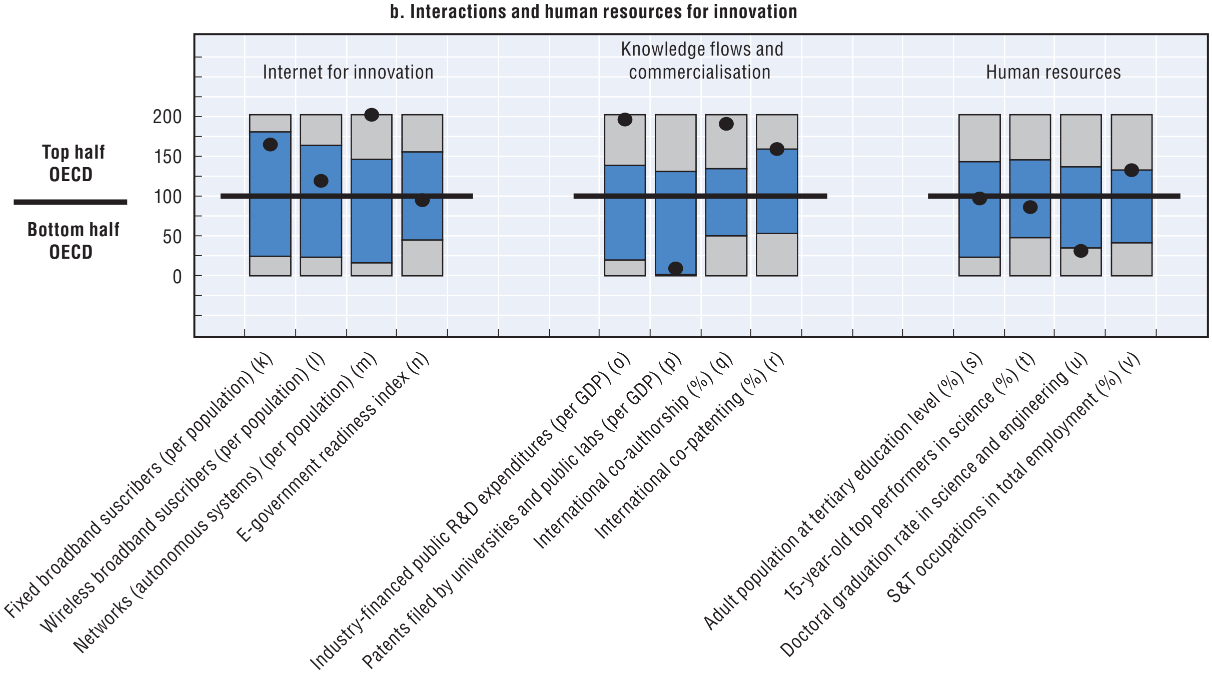
Figure 10.19. **Science and innovation in Iceland**

Panel 1. Comparative performance of national science and innovation systems, 2011

a. Competences and capacity to innovate



b. Interactions and human resources for innovation



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

and technology funds. In 2011, a series of open forums were conducted to shape STI policy and provide a sharper focus.

STI policy governance: In 2009, the Minister of Science, Education and Culture (MSEC) established a national task force and a panel of international experts to review STI policy. Rannís and Innovation Centre Iceland (ICI) are two key funding agencies. The Science and Technology Council (STPC) is responsible for innovation policy and has reinforced Rannís's capacity for evaluation of research and innovation.

Science base: Iceland has a strong science base and, along with Finland, the highest intensity of public R&D expenditures (at 1.14% of GDP) in the OECD area (1[a]) and a strong international publication record (1[c]). Although universities have gained in importance in the past five years, the public research system is traditionally centred in public labs. Public research is also very much oriented towards thematic issues and applied and experimental activities (Panel 3).

Business R&D and innovation: In 2009, Iceland introduced a tax reduction scheme for R&D to stimulate business R&D, with effect from 2011. Uptake has been good. All industries are eligible for tax deductions of up to 20% of research costs, with an annual maximum of USD 733 000 per company. The Technology Development Fund (TDF) received additional funding for 2011.

Entrepreneurship: Immediately after the crisis, grassroots initiatives were launched, such as creativity centres, idea generation houses, and entrepreneurship centres to boost entrepreneurship. The IMPRA unit at ICI helps entrepreneurs evaluate business ideas and provides counselling on start-up, growth and management. It also targets groups such as women, young entrepreneurs and managers. The Step Ahead initiative provides guidance to smaller firms. The Frumtak Investment Fund invests in start-up and innovation companies at home and abroad.

ICT and scientific infrastructures: In 2009, an STPC committee developed a research infrastructures roadmap to identify investment priorities. The MSEC has conducted an Information and Environment Research Programme on IT and eco-technology.

Clusters and regional policies: Through its centres of excellence and research clusters, STPC funds clusters in promising areas of comparative strength, such as geothermal activity. Grants of up to USD 22 000 are offered for the development of a service or product in an existing business or cluster in rural and regional areas. IMPRA also operates as an incubation centre.

Knowledge flows and commercialisation: The Off the Shelf project of the University of Iceland, in collaboration with the Patent Office and the Technology Court, provides students and researchers with incentives to exploit knowledge. The Iceland Living Lab (LL) at the ICI increases collaboration between users and producers and IMPRA promotes non-technological innovation. The Rannís Company and Institution (CI) grants also encourage collaboration.

Globalisation: The STPC, through Rannís, promotes international collaboration and networking as a top priority to compensate for a small domestic R&D market. The Nordic Innovation Council and the European Free Trade Agreement also facilitate Nordic co-operation. The TDF's support of companies seeking to globalise is highly rated.

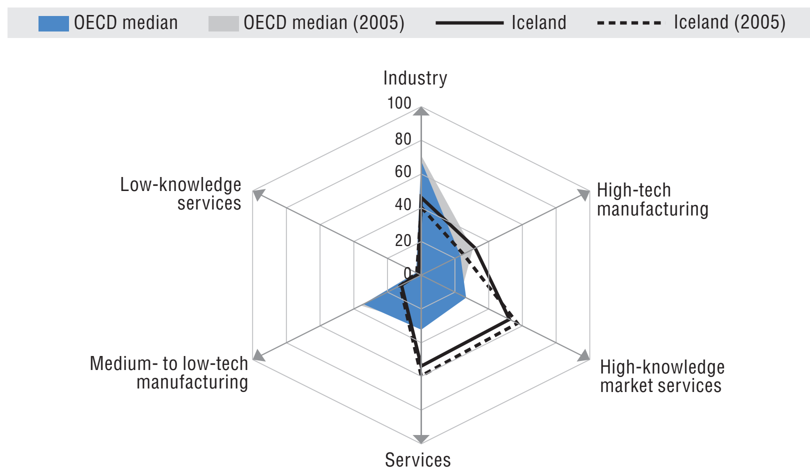
Human resources: Rannís participates in the EURAXESS service network which supports researchers. As part of its effort to prevent an outflow of researchers after the crisis, it offers grants to skilled overseas researchers. Secondary school education reforms passed in 2009 are expected to reduce drop-out rates and to increase formal education rates by 10% by 2020. The *New Act on Public Universities* in 2008 is an important higher education reform.

Emerging technologies: Iceland is home to DeCODE, a large genetics company that conducts extensive cutting-edge R&D. The TDF supports emerging technologies in geothermal research, genetics, artificial intelligence and eco-technologies. Recently, STPC launched a number of strategic research programmes at its centres of excellence, among others the Nano-science and Nanotechnology and Post-genomic Biomedicine Programmes, the Added Value for Seafood Programme, the Icelandic Institute for Intelligent Machines.

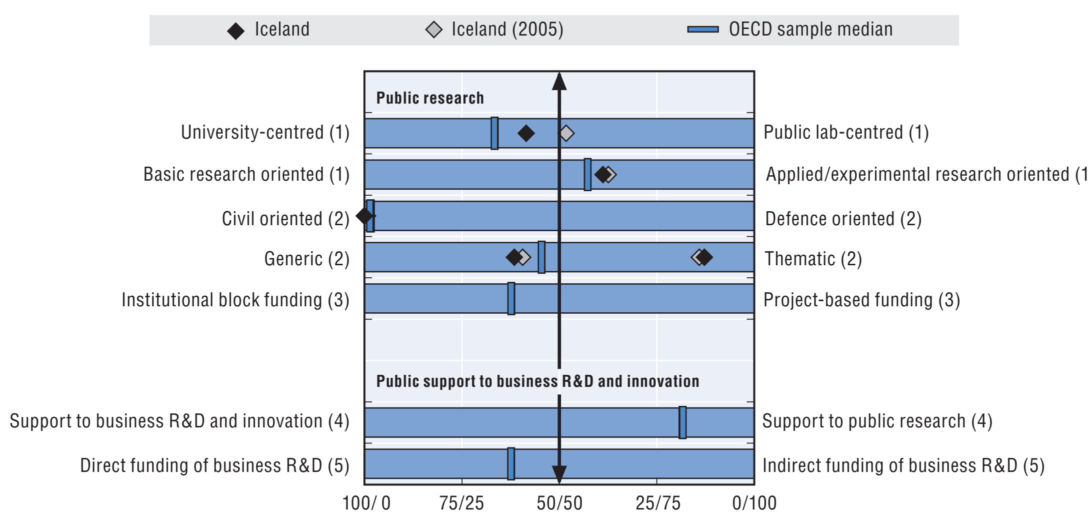
Green innovation: The Iceland 2020 strategy targets eco-innovation as the main growth sector in the next decade, and aims to double growth in turnover between 2011 and 2015. Green public procurement also enjoys high priority.

Panel 2. Structural composition of BERD, 2009

As a % of total BERD



Panel 3. Overview of national innovation policy mix, 2010



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Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888932690491

INDIA

Hot STI issues

- Developing clean and green technologies to combat climate change.
- Designing an innovation system to stimulate industry R&D.
- Implementing Inclusive Innovation initiatives to enhance productivity in agriculture and the informal sector.

General features of the STI system: India is an open market economy and the world's second most populous country. GDP increased by 8.4% a year during 2005-10 and the country weathered the global crisis remarkably. India has a large domestic market and a large and young labour force. An emerging middle class ensures strong demand for consumer goods. Local manufacturing industries (*e.g.* electronics) complement traditional labour-intensive industries (*e.g.* textiles). A pool of low-cost, highly skilled, English-speaking workers has attracted massive inflows of FDI. The outsourcing of knowledge-intensive activities to India has contributed to make the services sector the largest contributor to GDP (55%) and the presence of multinationals' R&D centres has accelerated India's integration in the global research system (Panel 1[r]). India hosts several top corporate R&D investors in automotive, industrial machinery and IT industries (1[e]). The contribution of Indian firms to R&D is small but expanding rapidly: they accounted for 34% of GERD in 2007 and 0.26% of GDP (1[d]) (up from 19% and 0.14% five years earlier). Research output (patents) and non-technological innovation (trademark counts) are still limited (1[f](g)). India's RTA in biotechnologies compares advantageously with that of other BRIICS (Panel 2). Framework conditions for entrepreneurship are weak (1[j]). Trade and FDI restrictions, along with administrative red tape, hinder investments. The financial sector is insufficiently developed to meet the needs for capital. ICT infrastructures are limited (1[k](m)). Low graduation rates and poor quality of education hamper the development of human resources for innovation. HRST account for only 7% of employment (1[v]) and the researcher population is relatively small (fewer than one researcher per 1 000 employment in 2005).

Recent changes in STI expenditures: India's GERD was 0.76% of GDP in 2007, essentially unchanged since 2000. But R&D expenditure grew by 8% a year in constant prices, rising from USD 13.8 billion to USD 22.9 billion, a level similar to that of the Netherlands and Sweden. At 66%, government remains the main R&D funder although the public contribution has decreased in relative terms from 82% since 2000. Forecasts of economic growth suggest that further growth in S&T can be expected.

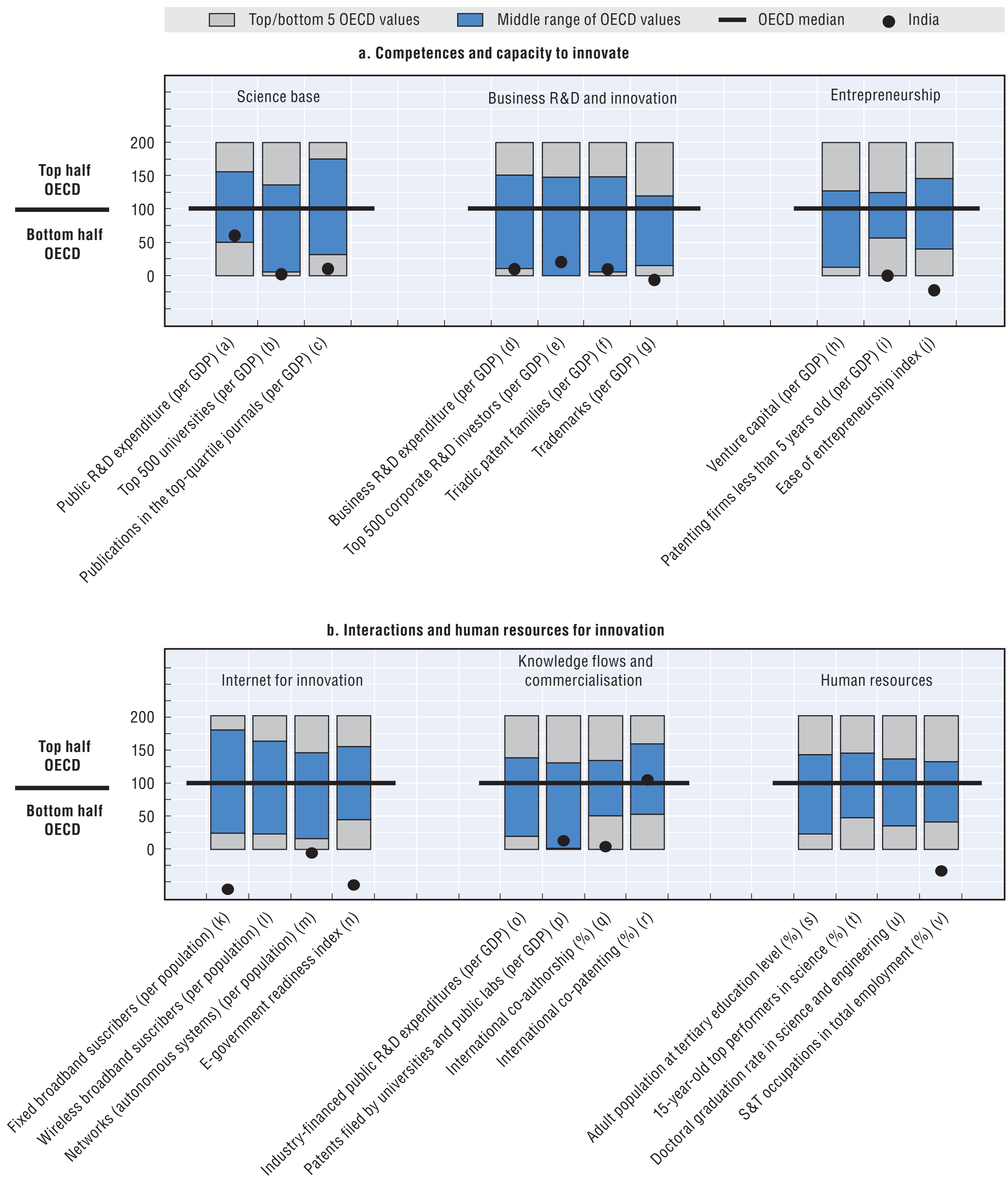
Overall STI strategy: India has adopted an indigeneous development model that features "inclusive growth" and low-cost frugal innovation. The government announced a Decade of Innovations 2010-20 and committed to strengthen S&T capacities, with GERD to reach 2% of GDP and the contribution of business to double. Priorities are space, nuclear and defence, ICT software, biotechnology and pharmaceuticals.

Key figures

Labour productivity, GDP per hour worked in USD, 2010	**n.a.**	**GERD, as % of GDP, 2007**	**0.76**
(annual growth rate, 2005-10)	n.a.	(annual growth rate, 2005-07)	(+8.0)
Environmental productivity, GDP per unit of CO_2 emitted in USD, 2009	**2.29**	**GERD publicly financed, as % of GDP, 2007**	**n.a.**
(annual growth rate, 2005-09)	(+0.0)	(annual growth rate, 2005-07)	n.a.

Figure 10.20. **Science and innovation in India**

Panel 1. Comparative performance of national science and innovation systems, 2011



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

STI policy governance: The National Innovation Council (NInC) was created in 2010 to define a new roadmap for research and innovation. State and sector innovation councils were set up. The capacities of the recently established Science and Engineering Research Board, a funding agency, were reinforced.

Science base: India's innovation system is dominated by universities and PRIs. Government R&D expenditures accounted for 0.47% of GDP in 2007 (1[a]). India has one world-class university (1[b]) and a weak publication record in top academic journals (1[c]). The volume of scientific publications has doubled over five years. Some 73% of public research is funded by block grants which are allocated on the basis of national research priorities.

Business R&D and innovation: With 95% of business R&D activities funded by firms themselves, public financial support is negligible.

Entrepreneurship: The government plans to strengthen the S&T potential of micro enterprises and SMEs in semi-urban and rural areas. Various awards and incentives are offered by the Ministry of Small-Scale Industries and the Council for Scientific and Industrial Research to encourage entrepreneurship and in-house R&D or to support target groups (*e.g.* National Award for Performance). The Ministry of Finance will launch the India Inclusive Innovation Fund in 2012-13 to focus on the needs of those in the lower echelons of society. The Science and Technology Entrepreneurs Park Programme stimulates networking.

ICT and scientific infrastructures: The Promotion of University and Scientific Excellence (PURSE), the Consolidation of University Research Innovation and Excellence (CURIE) for universities for women, and the Fund for Improvement of S&T Infrastructure in Higher Educational Institutions (FIST) all aim to develop S&T infrastructure. In 2011, the government approved a rural broadband plan and the NInC project to connect self-governing villages through optic fibre.

Clusters and regional policies: The NInC drives cluster development throughout the country through cluster innovation centres. The Network of ICT Entrepreneurs and Enterprises provides mentoring and advice. A number of technology business incubators, biotechnology and software technology parks, and a bio-IT park are operational.

Knowledge flows and commercialisation: The latest 12th Five-Year-Plan gives renewed attention to public-private partnerships. The Global Technology and Innovation Alliance and the Small Business Innovation and Research Initiative support commercialisation through strategic and public-private partnerships. The National Innovation Foundation (a private non-profit initiative) promotes the commercialisation of grassroots innovations. The Property and Utilisation of Public Funded Intellectual Property Bill 2008 governs IPR.

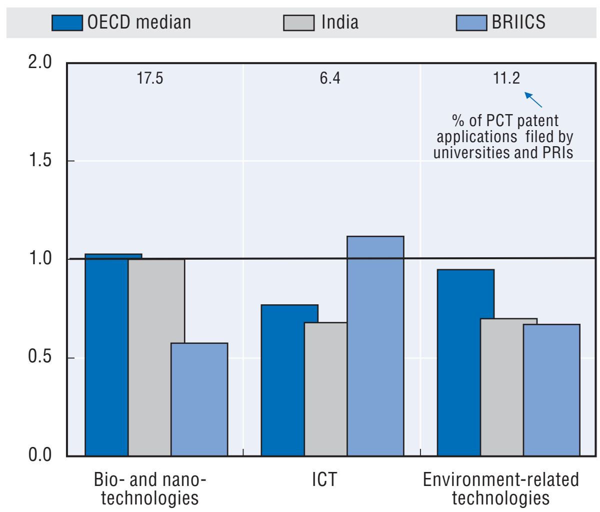
Globalisation: India is increasingly part of global knowledge flows. It has a number of bilateral R&D agreements, *e.g.* with the United States (clean energy research), the United Kingdom (next-generation telecommunication), the EU (energy and water technologies), and Australia (strategic research).

Human resources: The 11th Plan (2007-12) gave top priority to elementary, school and higher education by significantly raising education budgets. The Higher Education and Research Bill 2011 proposes a National Commission to improve regulation of university education and vocational and technical training. The Innovation in Science Pursuit for Inspired Research Programme (INSPIRE) promotes science, while the Assured Opportunity for Research Careers supports researchers. The Scholarship for Higher Education targets the study of science in the 17-22 age group. The national Fast Track Scheme for Young Scientists stimulates excellence in science.

Green innovation: India's demographic and economic growth, new modern lifestyles and higher electrification rates put energy supply security at risk since India depends heavily on imported coal to meet its needs. Current trends will drive up imports of fossil fuels, local pollution and greenhouse gas emissions. India experiences also recurring droughts that have serious impact on food security and population settlement. In 2008 India developed a National Plan on Climate Change to address solar energy, energy efficiency, water and strategic knowledge on climate change. The new Renewable Energy for Urban Industrial and Commercial Applications Programme emphasises green innovation. The Winning Augmentation and Renovation Programme aims to solve India's water problems through R&D solutions.

Panel 2. Revealed technology advantage in selected fields, 2007-09

Index based on PCT patent applications



Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888932690510

INDONESIA

Hot STI issues

- Accelerating the implementation of investment policy reforms.
- Increasing R&D capabilities (human resources, investments, infrastructures).

General features of the STI system: Indonesia is an emerging market economy and the largest economic player in Southeast Asia. After the dramatic collapse of its economy during the 1997-98 Asian crisis and years of political and social instability, Indonesia has started to grow. It was one of the rare countries with positive growth in 2008 and 2009. Reforms undertaken since the mid-2000s have helped to rebuild foreign investors' confidence and foster capital market development. Significant natural resources have supported the development of primary-resource-based and export-oriented manufacturing (refining, rubber and textile). The ICT sector has recently expanded rapidly (Panel 2). 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]). Research output (patents) and non-technological innovation (trademark counts) are almost nonexistent (1[f][g]). Indonesia has a complex regulatory environment in which government and state-owned companies continue to play a prominent role. Strict administrative procedures for establishing new firms, regulatory barriers to private investment, constraints on FDI (especially in telecommunications and transport), corruption, and restrictive labour regulations all hamper entrepreneurship and business development. The Indonesian archipelago encompasses thousands of islands and has serious and persistent problems in terms of basic infrastructures. Fixed broadband infrastructures are also undeveloped (1(k)). The very small Indonesian research community is well integrated in global knowledge networks: 70% of scientific articles and 50% of PCT patent applications are produced with international collaboration (1[q] [r]). International students who pursue tertiary-level studies abroad, especially in Australia, Japan and the United States (Panel 3) help to develop and reinforce academic networks. The education system is inefficient. Only 4% of the adult population was tertiary-qualified in 2007 (1[s]). Very few 15-year-olds have good PISA scores in science (1[t]). Indonesia has few professionals and technicians (1[v]) and very few researchers. The researcher population in fact decreased in relative terms from 0.46 to 0.19 per 1 000 employment between 2001 and 2009.

Recent changes in STI expenditures: Indonesia's GERD was only 0.08% of GDP in 2009 but has increased by a rapid 11.4% a year since the beginning of the 2000s. The policy emphasis on S&T for national economic development may encourage further R&D investments in the future.

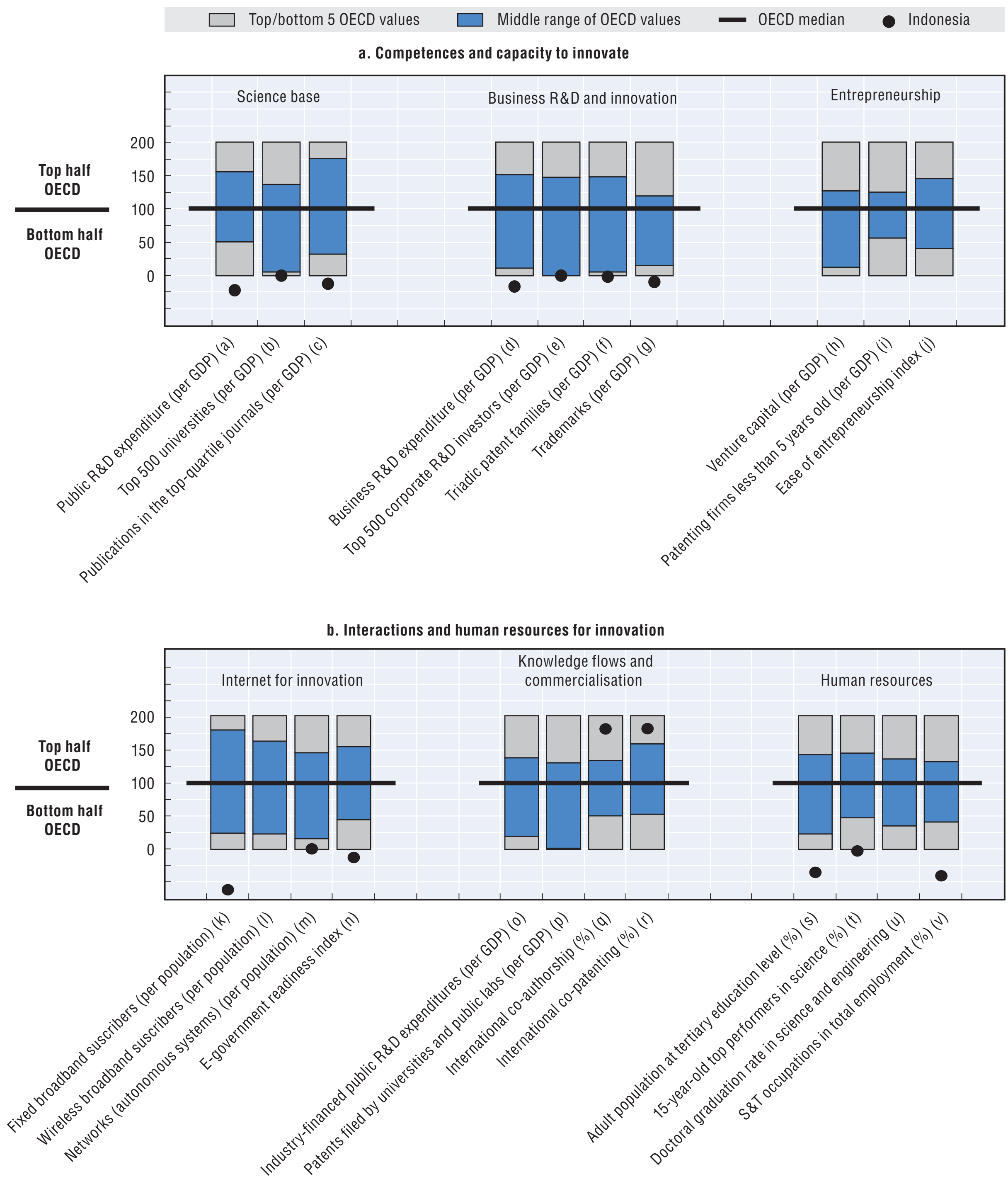
Overall STI strategy: Indonesia has a long-term development plan, Vision and Mission of Indonesian S&T Statement 2005-25, and has issued a series of five-year-plans to refine development priorities. The current plan (2010-14) focuses on quality of human resources, development of S&T through improved R&D capabilities (institutions, resources and domestic and international networks), and economic competitiveness. It also aims to improve the application and commercialisation of R&D results in order to address current national socioeconomic needs.

Key figures

Labour productivity, GDP per hour worked in USD, 2010	**n.a**	**GERD, as % of GDP, 2009**	**0.08**
(annual growth rate, 2005-10)	n.a	(annual growth rate, 2000-09)	(+11.4)
Environmental productivity, GDP per unit of CO_2 emitted in USD, 2009	**2.56**	**GERD publicly financed, as % of GDP**	**n.a**
(annual growth rate, 2005-09)	(+3.0)	(annual growth rate, 2000-09)	n.a

Figure 10.21. **Science and innovation in Indonesia**

Panel 1. Comparative performance of national science and innovation systems, 2011



Note: Normalised index of performance relative to the median values in the OECD area (Index median = 100).
Source: See reader's guide and methodological annex.

STI policy governance: Indonesia's STI governance is complex and involves many bodies. The independent National Innovation Committee (KIN) established in 2010 is in charge of oversight, steering and co-ordination of national innovation.

Science base: The public sector is the major performer of R&D, but the intensity of public investment in R&D is low (1[(a)]) and the public sector performs relatively poorly. Indonesia has no world-class university able to attract foreign talent and has few publications in the best scholarly journals (1[(b)(c)]).

Business R&D and innovation: R&D-performing companies are mostly concentrated in the manufacturing sector, which is largely composed of medium-low- and low-technology SMEs. The industrial structure and the lack of large firms and investment by multinationals seriously limit prospects for the development of business R&D.

Entrepreneurship: Indonesia has weak framework conditions for entrepreneurship. However, the *Investment Law 2007* led to a noticeable change in the entrepreneurial climate by clarifying various issues for investors and by revising the "negative list" of sectors in which domestic and foreign investments are prohibited or restricted. Indonesia has also actively reformed regulations and lowered costs to start up a business. An Innovation Centre for Micro, Small and Medium Enterprises was established to create synergies between the different support schemes to SMEs.

Knowledge flows and commercialisation: Links between R&D and innovation actors are historically weak. Major constraints on academia-industry collaboration are the rules concerning the research budget (return of all unspent allocations at the end of every fiscal year) and the accumulation of additional funds (transfer to the Ministry of Finance of incomes generated from industry projects). As regards commercialisation, Indonesia has made significant progress in the area of IPR protection. The application process has been streamlined, and enforcement has been improved through the establishment, in March 2006, of a National Task Force for IPR Violation Prevention and the transfer of legal competence to handle civil cases on IPRs to commercial courts. Nevertheless, corruption, lack of transparency and structural constraints impede the implementation of the reforms.

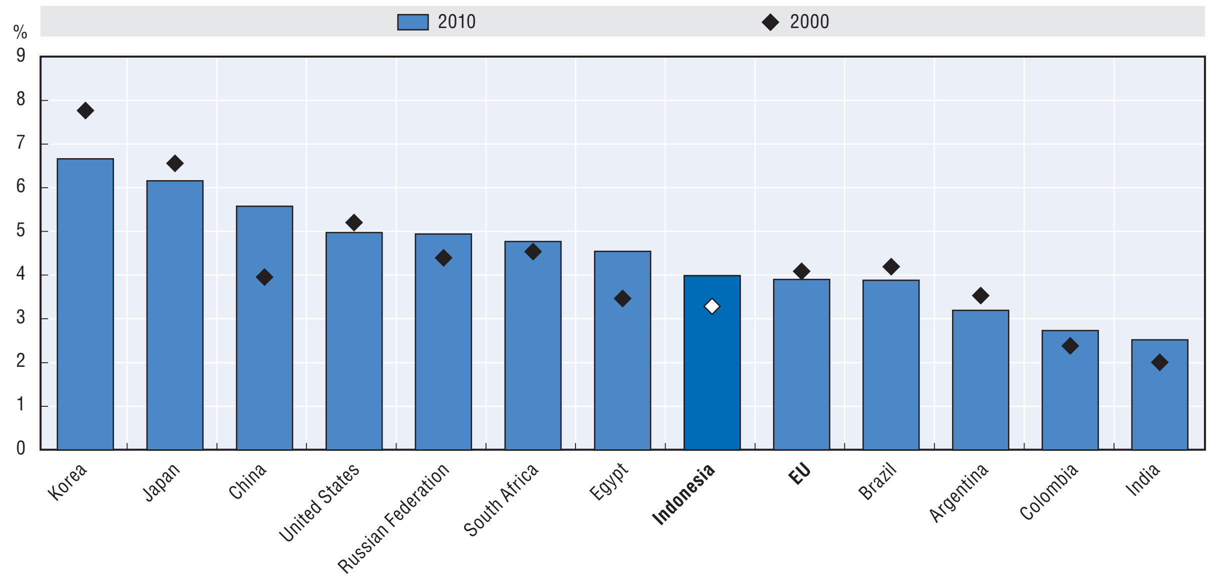
Globalisation: Although investment policy reforms since the 1980s have helped to open Indonesia's economy to foreign interests, the level of FDI is below that in other Southeast Asian countries. The 2007 *Investment Law* established national treatment for foreign investors, and make restrictions on foreign equity more transparent.

Human resources: Human resources are a major weakness of Indonesia's STI system. However, expenditures on education have increased over the past two decades, and must amount to 20% of the government budget since a 2005 amendment to the Constitution. The expansion of technical and vocational education and training has become a priority, and a National Education Strategy was adopted to reduce disparities in access to education, to enhance teaching quality, and to improve the management and accountability of schools.

Green innovation: Indonesia faces serious energy and environmental challenges. While national oil and gas production is declining, domestic energy demand is rising fast under the combined effects of the world's fourth largest population growth, a rapid economic transition and poverty reduction. Electricity generation which is still mostly based on conventional sources, urbanisation, population concentration (Java-Madura-Bali), large-scale deforestation and over-exploitation of natural resources are sources of environmental degradation. The National Council on Climate Change aims to build capacities for reducing carbon emissions and the Indonesia Climate Change Trust Fund attracts investments to finance climate change adaptation and mitigation programmes.

Panel 2. Value added in ICT industries, BRIICS and selected countries, 2000 and 2010

As a % of GDP

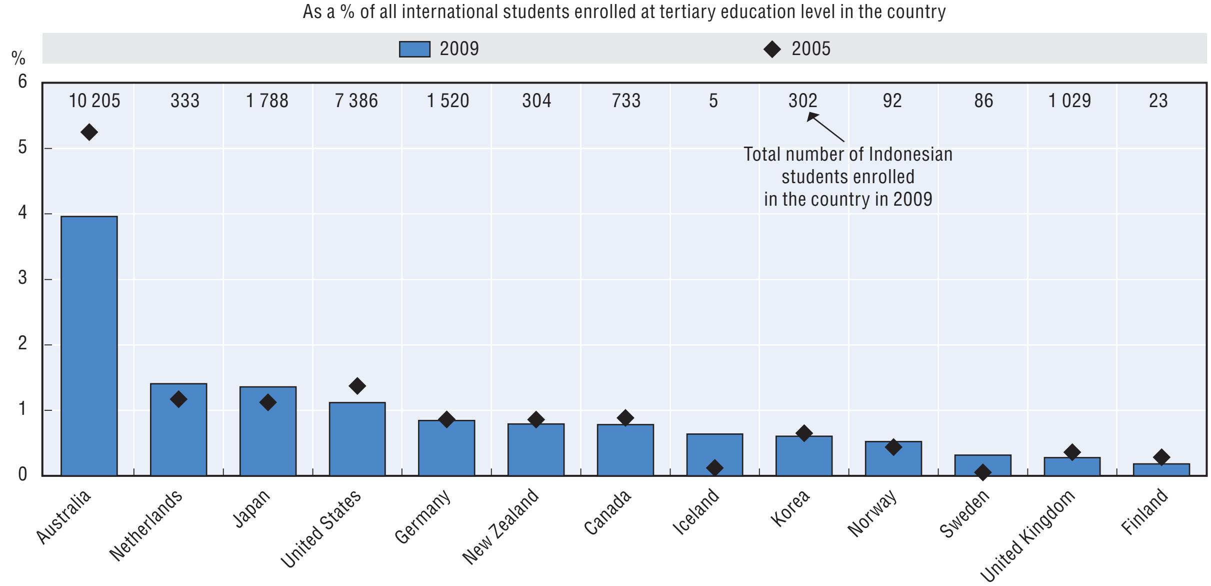


Note: ICT industries include communications services, computer and related services, communications goods and semiconductors, and computers and office machinery.

Source: National Science Board (2012), *Science and Engineering Indicators 2012*, National Science Foundation (NSF), Arlington (US).

Panel 3. Indonesian students enrolled in tertiary studies abroad, 2005 and 2009

As a % of all international students enrolled at tertiary education level in the country



Source: OECD Education Database, 2012.

StatLink http://dx.doi.org/10.1787/888932690529

IRELAND

Hot STI issues

- Prioritising fourteen research areas over the next five years.
- Dealing with the effects of budgetary constraints on public investment in innovation.
- Increasing efforts to host R&D operations of foreign-owned firms.
- Boosting innovative entrepreneurship.

General features of the STI system: As a service-based economy Ireland had a period of substantial economic growth based in part on an FDI-oriented development strategy. In the wake of the global financial crisis it suffered a severe recession and has adopted austerity measures to address its public debt. Investment in innovation is likely to remain under pressure in the years ahead. BERD represents 1.18% of GDP, roughly at the OECD median in 2010 (Panel 1[(d)]). Most BERD (70%) is carried out by foreign affiliates (Panel 2). Ireland has a relatively large number of top R&D investors (1[(e)]), and is at the top of the mid-range of OECD countries in terms of the relative number of young innovative companies (1[(i)]). Venture capital is well developed (1[(h)]) and the ease of entrepreneurship index is well above the OECD median (1[(j)]). With 34% of PCT patent applications produced with international collaboration, Ireland stands well above the OECD median (1[(r)]). In terms of industry financing of public R&D, it performs relatively poorly as compared to the OECD average (1[(o)]). Graduates in science and engineering (1[(u)]) and the quality of education in sciences (1[(t)]) lie in the mid-range of OECD countries. ICT infrastructures also correspond to the OECD median (1[(k)(l)(m)(n)]).

Recent developments in STI expenditures: GERD stood at USD 3.2 billion in 2010. At 1.77% of GDP, this is below the OECD average. The target of the Strategy for Science, Technology and Innovation (SSTI) was to reach research intensity of 2.5% of GDP by 2013 but this has been advanced to 2020. Budgetary constraints are likely to place severe pressure on investment in research in the years ahead. GBAORD declined in constant prices from USD 948 million in 2009 to USD 853 million in 2011.

Overall STI strategy: Goals of SSTI 2006-13 include promoting innovation by improving the human capital base (especially in science and engineering), strengthening the research capability and capacity of the enterprise sector and increasing the contribution of research to development in the agriculture, health, environment and marine sectors. The National Recovery Plan 2011-14 also considers R&D an investment priority.

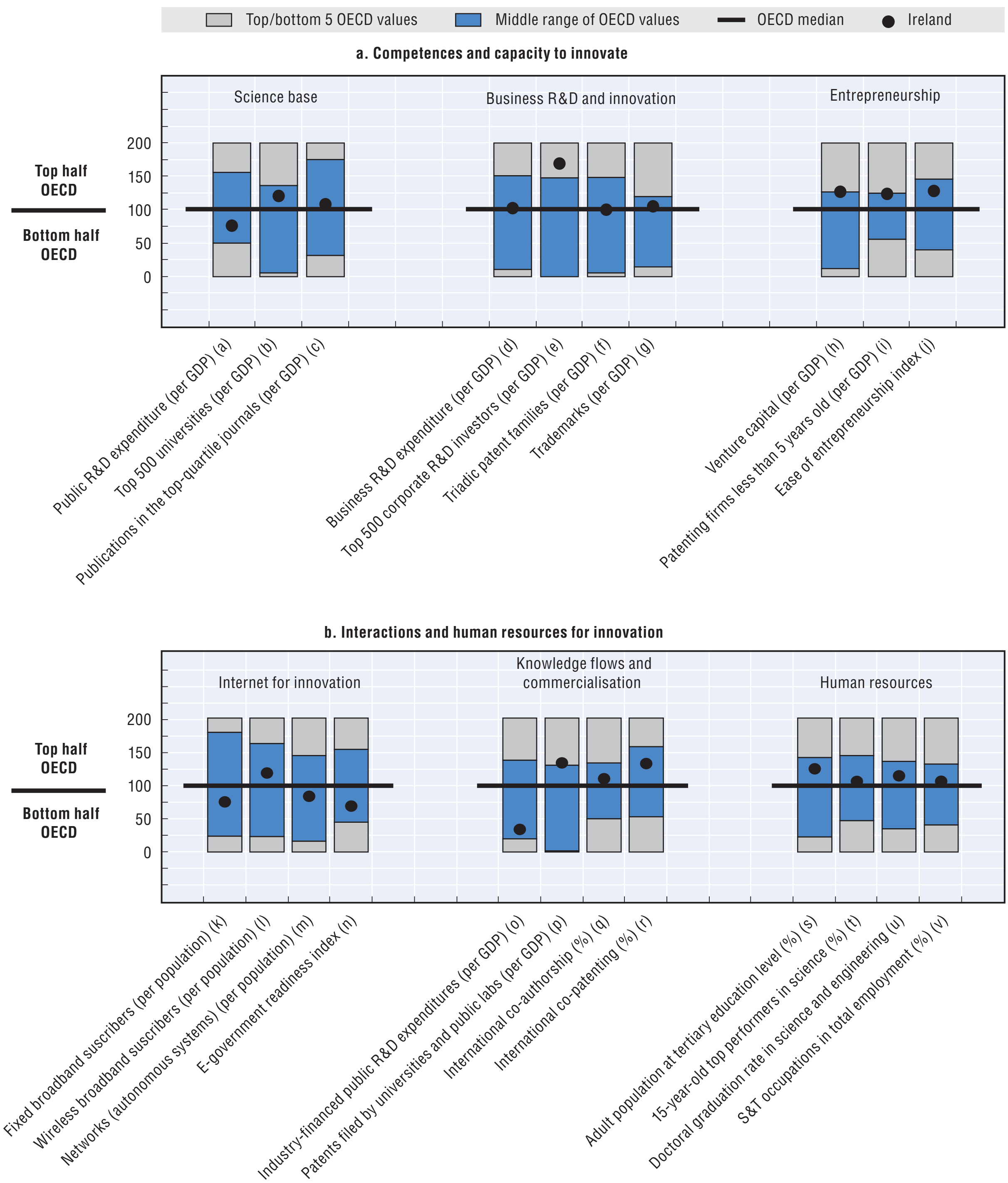
STI policy governance: In response to financing constraints, the government established in February 2010 a single funding stream that includes STI budgets of different agencies involved in implementing relevant policies. Consolidating spending allows for closer governance.

Key figures

Labour productivity, GDP per hour worked in USD, 2010	**63.6**	**GERD, as % of GDP, 2010**	**1.77**
(annual growth rate, 2005-10)	(+2.6)	(annual growth rate, 2005-10)	(+7.2)
Environmental productivity, GDP per unit of CO_2 emitted in USD, 2009	**4.55**	**GERD publicly financed, as % of GDP, 2010**	**0.58**
(annual growth rate, 2005-09)	(+2.6)	(annual growth rate, 2005-10)	(+6.7)

Figure 10.22. **Science and innovation in Ireland**

Panel 1. Comparative performance of national science and innovation systems, 2011



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

Science base: Ireland has an above-median share of top universities (1[(b)]) and a good level of publications (1[(c)]). However, public R&D expenditures are below the OECD median (1[(a)]). The National Strategy for Higher Education of January 2011 aims to improve scale and critical mass by developing regional clusters of collaborating institutions and promoting consolidation and mergers of institutions.

Knowledge flows and commercialisation: The Innovation Partnership Scheme, funded by Enterprise Ireland with a budget of USD 12 million in 2012, provides financial support for industry-university collaborative research projects with direct industrial and commercial applications. The Innovation Voucher Initiative, with USD 5 million for 2012, aims to support links between public knowledge providers and small businesses. Another effort is the Technology Centres Programme, with USD 24 million in 2012, which supports collaboration by funding industry-led technology centres at which researchers from research institutions conduct market-focused R&D. Also, a new National Intellectual Property Protocol is being developed to replace the existing national codes of practice on managing and commercialising intellectual property from public and public-private collaborative research.

Globalisation: The innovation system is well integrated in the international S&T system. Ireland has an attractive tax system for foreign multinationals, and IDA Ireland, the Investment Promotion Agency, supports their engagement in R&D. Ireland has some 142 international agreements, partnerships and similar activities with Europe and to a lesser extent with the United States. Also, the EU Framework Programme's National Support Network encourages Irish firms' participation in FP7 calls that emphasise cross-country collaborative research projects; it offers advice on project proposals and help in searching for partners.

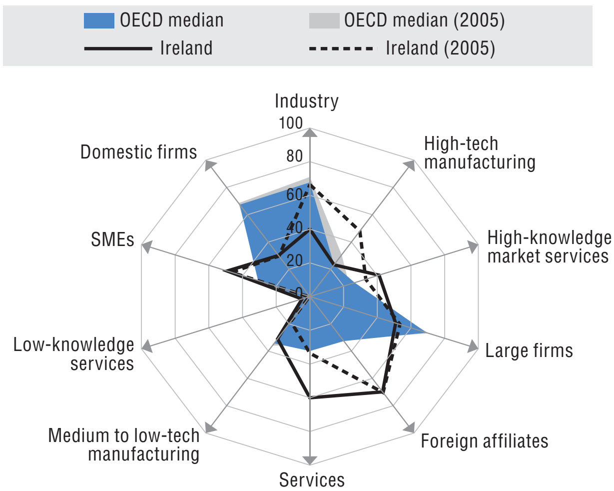
Human resources: Ireland has increased the emphasis on science and mathematics in elementary and secondary school curricula. This included Project Maths, with USD 9 million in 2009-10, which trained secondary school maths teachers. At university level, the Undergraduate Research Experience and Knowledge Award (UREKA) programme seeks to involve students in research to attract them to careers in science and engineering. The Discover Science and Engineering programme, working with the education and research systems, strives to promote awareness and increase student uptake in schools and colleges. Science-related events organised as part of the Dublin – City of Science 2012 programme also aim to boost the popularity of science. The National Strategy for Higher Education published in 2011 promotes increased emphasis on generic skills, and in particular on creativity and entrepreneurship as essential for innovation and economic growth. All higher education institutions are encouraged to introduce such educational initiatives at both undergraduate and postgraduate levels.

Emerging technology fields: The Irish Research Prioritisation Exercise aimed to identify areas of opportunity with the greatest potential to deliver economic returns, with a view to determining the government's public investment priorities. The priority areas include smart grids, health applications and medical devices, innovation in services and business processes, marine renewable energy and digital platforms, content and applications.

Green innovation: The report of the High Level Action Group on Green Enterprise (2009) made recommendations on how best to foster the green economy in Ireland and create a growing sector able to create up to 80 000 jobs. The recommendations emphasised a need to support sectors with high potential (such as water and waste management, recovery and recycling, and renewable energy technologies), to build up needed research capacity, and to use policy tools such as finance and green procurement. Implementation is continuing under the Actions Plan for Jobs 2012.

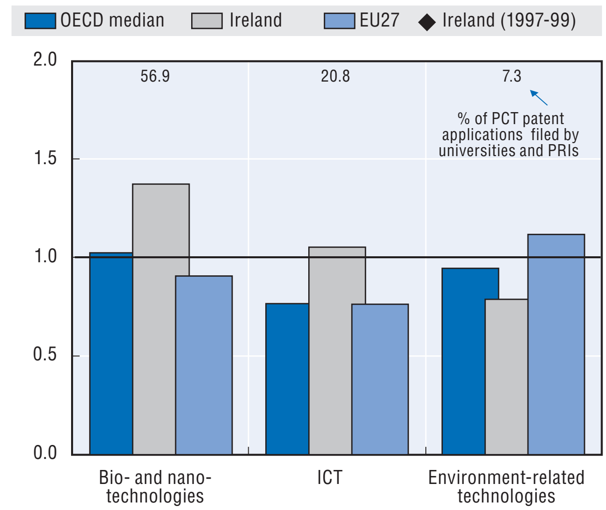
Panel 2. Structural composition of BERD, 2009

As a % of total BERD

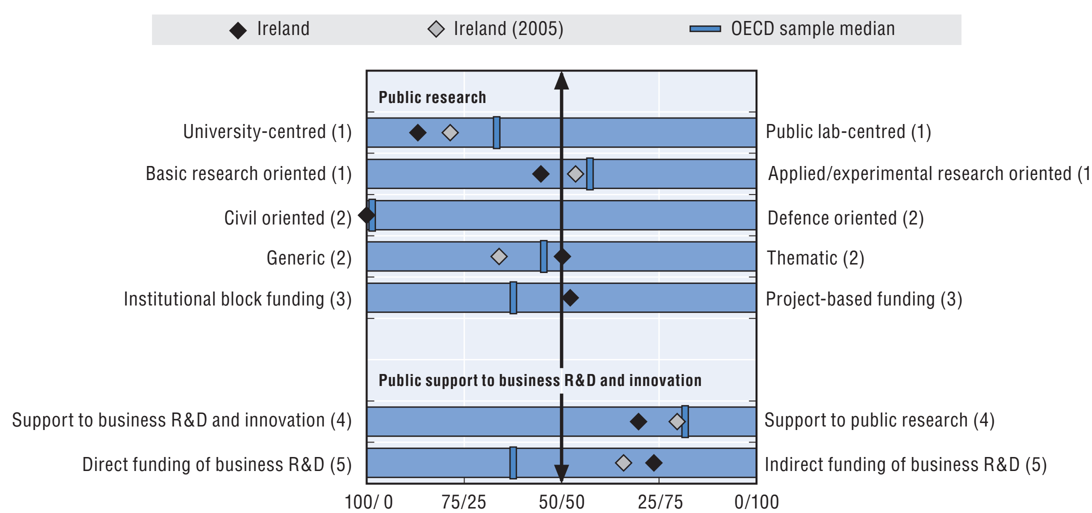


Panel 3. Revealed technology advantage in selected fields, 2007-09

Index based on PCT patent applications



Panel 4. Overview of national innovation policy mix, 2010



1. Balance as a percentage of the sum of HERD and GOVERD.
2. Balance as a percentage of total GBAORD.
3. Balance as a percentage of total funding to national performers.
4. Balance as a percentage of the sum of HERD and GOVERD funded by government and higher education and components of (5).
5. Balance as a percentage of the sum of indirect funding of business R&D and innovation through R&D tax incentives and direct funding of BERD through grants, contracts and loans.

Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888932690548

ISRAEL

Hot STI issues

- Leveraging the scientific and technological labour force by supporting entrepreneurship and better linking scientific research and private industry.
- Improving the evaluation and monitoring of STI policy.
- Strengthening capacity in fields such as clean tech, computer science and biotechnology.

General features of the STI system: Israel is a small economy with world leadership in dynamic high-technology sectors such as software. The global financial crisis only briefly slowed its growth. With BERD of 3.51% of GDP in 2010 Israel led OECD countries (Panel 1[(d)]). Its share in triadic patents per GDP is at the upper middle level (1[(f)]) and trademark registrations are above the OECD median (1[(g)]). Its share of top R&D investors corresponds to the OECD's median (1[(e)]). For entrepreneurship Israel leads the OECD in venture capital (1[(h)]). The national ICT infrastructure is in the medium range (1[(k m)]). With 45% of the adult population with tertiary education, Israel stands among leading OECD countries. However, the quality of its science education is in the lower middle range (1[(t)]); this suggests a need for quality-enhancing reforms. The share of S&T occupations is at the OECD median (1[(v)]). Links between research and industry correspond to the OECD median: public R&D expenditures financed by industry were only 0.06% of GDP (1[(o)]) in 2008. However, Israel leads OECD countries in terms of relative number of PCT patents filed by universities and public labs (1[(p)]). The share of international co-authorship (1[(q)]) is close to the OECD median, while participation in international co-inventions (14% of total PCT patent applications, 1[(r)]) is well below that benchmark.

Recent changes in expenditures: Israel has very high R&D intensity in the OECD area, with GERD of 4.40% of GDP (excluding defence) in 2010. R&D investments grew on average by 4.1% annually over 2005-10. The private sector funded about 52% of GERD in 2008.

Overall STI strategy: While there is no national plan or strategy for STI policy, several reports and policy documents provide orientations. Certain areas have been identified for policy attention: biotechnology, nanotechnology, clean technology sectors and improving the performance of low-technology industries. Attention is also paid to improving the quality of human capital.

STI policy governance: There have been no recent significant changes in STI governance. A main priority with respect to governance is to improve policy evaluation. This led to the creation of a policy and evaluation unit in the Office of the Chief Scientist which advises on policy aspects of governmental support for R&D and evaluates programmes.

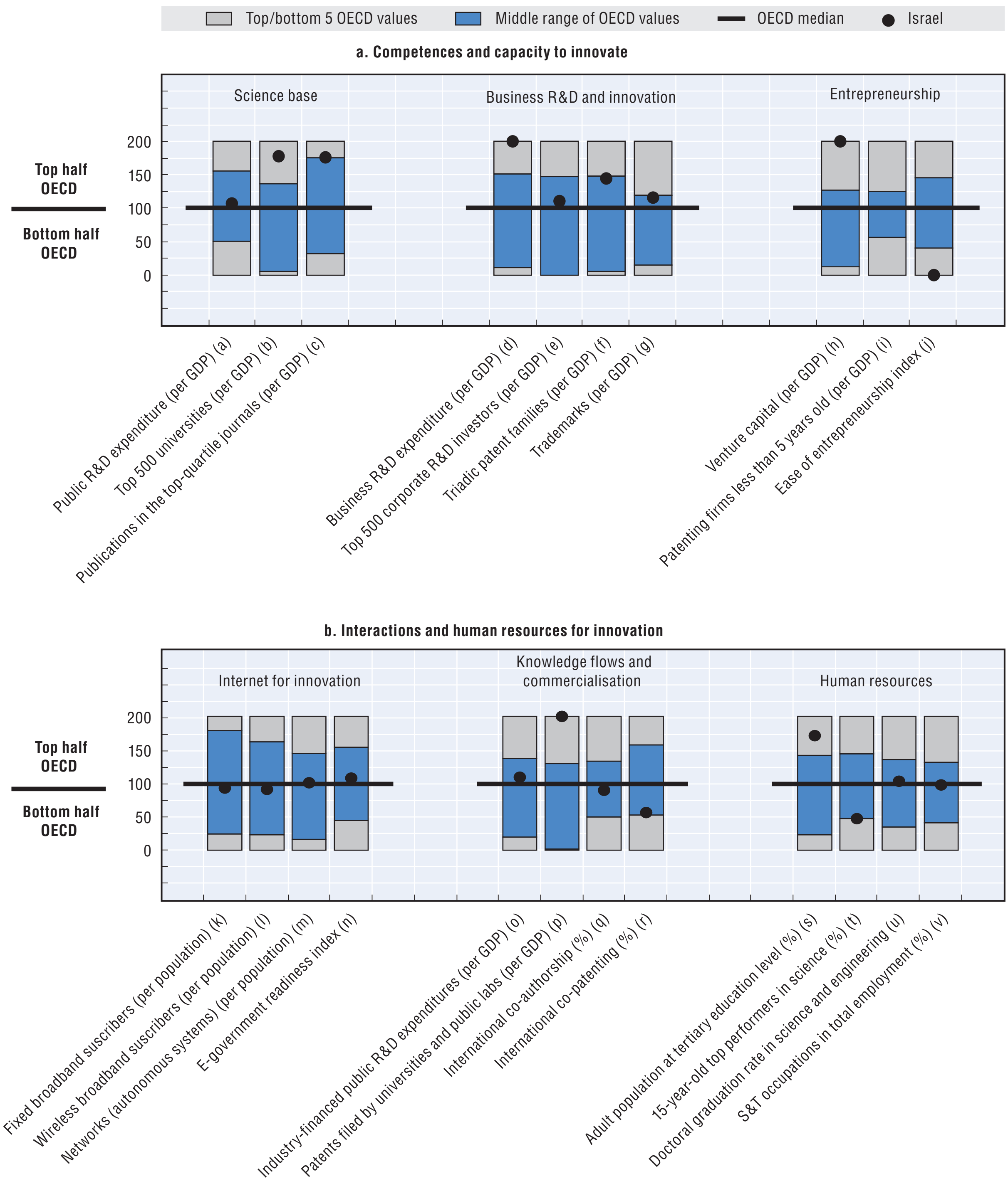
Science base: Israel has a strong science base and its share in the top 500 universities is among the OECD leaders (1[(b)]). Israel's publications are also at the upper end of the middle range (1[(c)]). Public R&D expenditures as a share of GDP are at the median (1[(a)]).The Higher Education Plan 2011-15 seeks to improve the quality of higher education and research. Several measures have been implemented. Funding provided by the Israel Science Foundation for competitive research is to increase from USD 75 million to USD 139 million. Moreover, to stimulate

Key figures

Labour productivity, GDP per hour worked in USD, 2010	**35.2**	**GERD, as % of GDP, 2010**	**4.40**
(annual growth rate, 2005-10)	(+0.9)	(annual growth rate, 2005-10)	(+4.1)
Environmental productivity, GDP per unit of CO_2 emitted in USD, 2009	**3.16**	**GERD publicly financed, as % of GDP, 2008**	**0.82**
(annual growth rate, 2005-09)	(+2.1)	(annual growth rate, 2005-08)	(+4.9)

Figure 10.23. **Science and innovation in Israel**

Panel 1. Comparative performance of national science and innovation systems, 2011



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

quality research, a new funding formula based on more substantial performance evaluation has been adopted. Additional resources have also been made available to allow hiring new staff at universities and to improve universities' infrastructure. The centres of excellence I-CORE project aims to boost research infrastructure in chosen fields (see below). The project was endorsed by the government and adopted by Israel's Council of Higher Education in March 2010. It has a total budget of about USD 362 million.

Business R&D and innovation: Several measures support business R&D; about 80% of the R&D budget goes to SMEs. The R&D Fund was specifically created to reduce risks for industrial innovators. It approves projects of all types of firms – start-ups and SMEs but also large firms – based on industry experts' advice and systematic project evaluations. It has been instrumental in the successful development of the ICT sector and now mainly focuses on new priority fields such as biotechnology.

Entrepreneurship: Support for start-ups is an important dimension of Israel's STI policy. The Technological Incubators programme supports early-stage technological entrepreneurship by providing support for turning innovative ideas into potentially successful commercial products. The programme's budget is about USD 40 million. The TNUFA programme also supports innovative technological entrepreneurship at the pre-seed stage by helping to prepare patent applications and evaluating the initiatives' technological and financial feasibility.

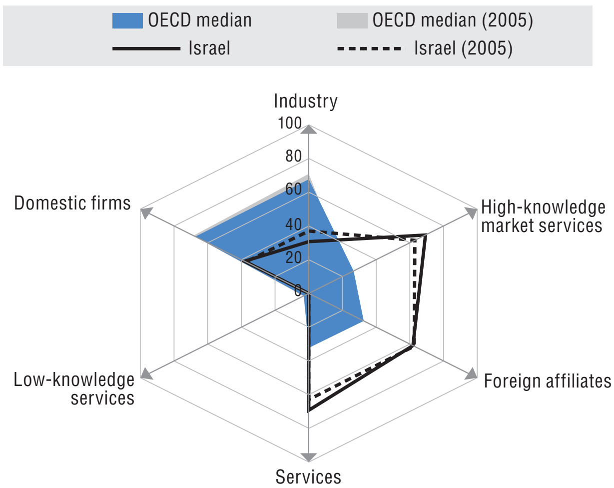
Knowledge flows and commercialisation: Several programmes support interaction between the public research sector and private industry. One is the MAGNET programme, which was established in 1994 and had a budget of USD 57 million in 2011. It supports pre-competitive generic research conducted by consortia of industrial firms and academic institutions. The programme supports proposals from academia and industry and MAGNET staff also propose ideas to academia and industry as a way to generate the creation of consortia. An additional objective of the programme is to support development of technological clusters. The NOFAR programme actively supports commercialisation by financing applied academic research in biotechnology and nanotechnology to adjust innovations for use by industry and promote their take-up. Budgets allocated for these 12-15-month projects tend to be around USD 100 000.

Emerging technologies: The four research fields selected by I-CORE as key policy priorities also include investments in relevant tertiary education in the coming years. They are: the molecular basis of human diseases, cognitive science, computer sciences, and renewable and sustainable sources of energy. The objective is to develop new industries able to provide Israel with a competitive edge in international competition. Other priority sectors include brain research, nanotechnology and biotechnology, this last with support from the Israeli Biotechnology Fund.

Green innovation: Green innovation is an important priority, with a specific focus on renewable and sustainable sources of energy. A technology centre has been established to support the transfer of knowledge from academia to industry up to the "proof of concept" stage and to provide opportunities for testing such technologies. Another technology centre relevant for green innovation focuses on water technologies, an area in which Israel has contributed frontier innovations.

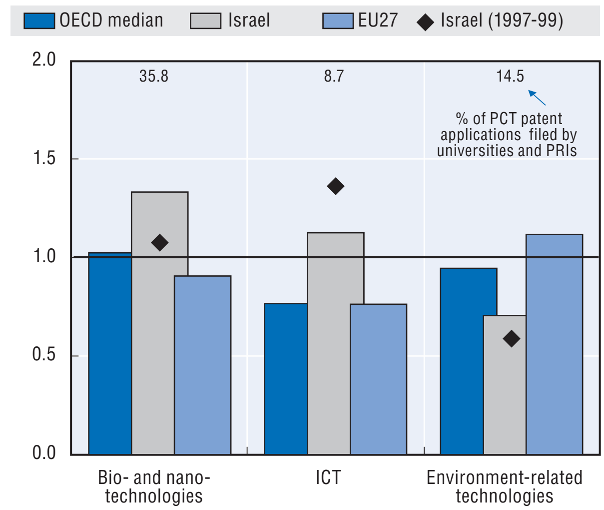
Panel 2. Structural composition of BERD, 2009

As a % of total BERD

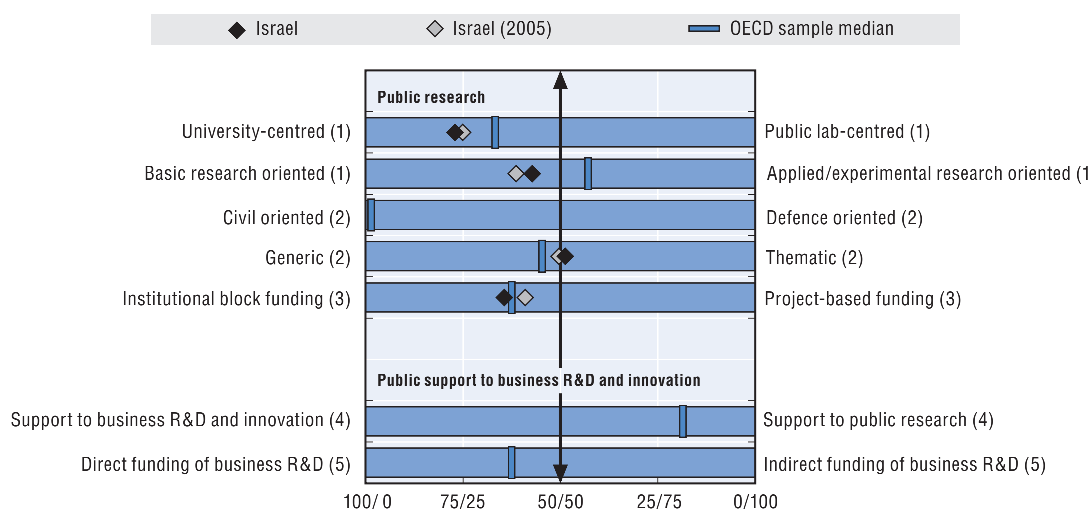


Panel 3. Revealed technology advantage in selected fields, 2007-09

Index based on PCT patent applications



Panel 4. Overview of national innovation policy mix, 2010



1. Balance as a percentage of the sum of HERD and GOVERD.
2. Balance as a percentage of total GBAORD.
3. Balance as a percentage of total funding to national performers.
4. Balance as a percentage of the sum of HERD and GOVERD funded by government and higher education and components of (5).
5. Balance as a percentage of the sum of indirect funding of business R&D and innovation through R&D tax incentives and direct funding of BERD through grants, contracts and loans.

Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888932690567

ITALY

Hot STI issues

- Improving the framework conditions for innovation.
- Strengthening the human resource base for innovation.
- Improving the co-ordination of STI policy across government and between the central government and the regions.

General features of the STI system: To put the economy on a sustainable growth path based on sound macroeconomic fundamentals, the Italian government has embarked since 2011 on a substantial process of fiscal consolidation and structural reform. Innovation will be crucial for boosting competitiveness and sustainable growth in the longer term. Although many indicators point to a modest level of STI activity, attention is being given to increasing it. In 2010 GERD was just 1.26% of GDP, about half of the OECD average, and more in line with the R&D intensity of emerging economies. The business sector performs only around half of GERD, a low share for an advanced economy. At 0.66% of GDP BERD lags behind the OECD average (Panel 1[(d)]), with business sector innovation performance varying across firms and regions. In fact, a segment of innovative firms, including flexible SMEs, coexists with many non-innovative firms operating at low levels of productivity. Moreover, much R&D and innovation capacity is concentrated in northern and central regions of the country. The low share of industry-financed public R&D (1[(o)]) is indicative of weak industry-science linkages. Venture capital is in short supply (1[(h)]) and the patenting rate of young firms is low (1[(f)]). In general, Italy tends to perform better on indicators of non-R&D-based innovation (for example, it leads in Community designs). A very low share of the population has completed tertiary education (1[(s)]) in spite of a significant increase since 1999. In line with its GERD, Italy has few researchers by international standards. Participation in international networks is quite strong, however: 41% of scientific articles and 13% of PCT patent applications were produced with international collaboration (1[(q)(r)]). Internet subscriptions are close to the median (1[(k)(l)]) and e-government readiness is relatively low (1[(n)]).

Recent changes in STI expenditures: GERD has recorded annual growth of about 2.7% over the second half of the last decade. In 2009, industry funded 44% of GERD, government accounted for 42%, and 9% was funded from abroad. With a budget of USD 2.5 billion (2010-11), the Fund for the Promotion of Research (FAR) contributed significantly to increasing public funding for business firms, universities and PRIs.

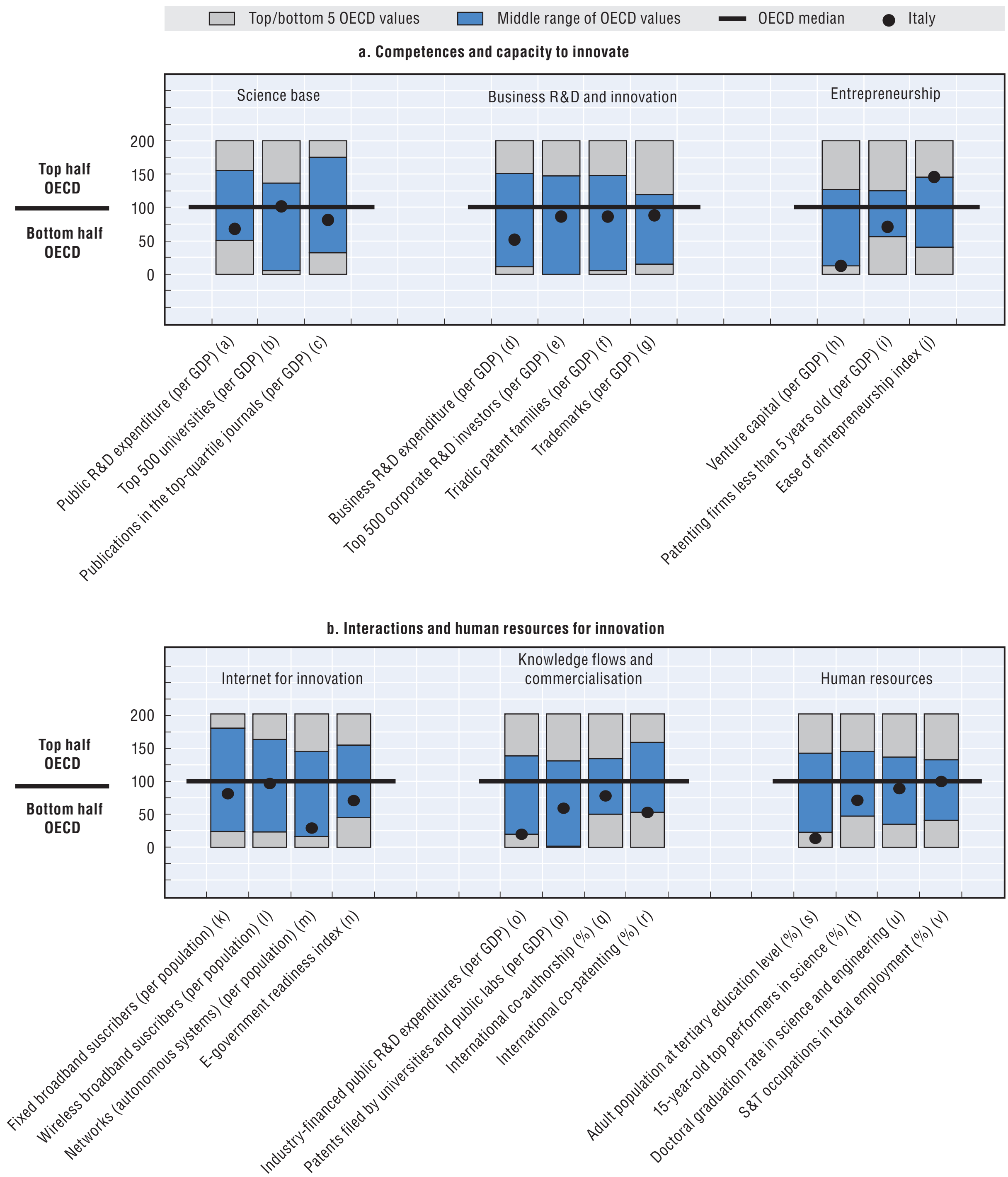
Overall STI strategy: The National Research Plan (2011-13) aims to promote research by strengthening business sector co-operation with the public sector and supporting the internationalisation of research. The Industry 2015 programme (2006-15) sets out to support business networks and industrial innovation projects and includes a fund for enterprise finance. However, the National Reform Programme 2011-12 requires general policies to have a small impact on the national budget. The country's south and SMEs have attracted special attention in STI strategies and policies. The National Strategic Framework 2007-13 includes the National Operational Programme (PON) Research and Competitiveness 2007-13, funded by the European

Key figures

Labour productivity, GDP per hour worked in USD, 2010	**43.9**	**GERD, as % of GDP, 2010**	**1.26**
(annual growth rate, 2005-10)	(–0.1)	(annual growth rate, 2005-10)	(+2.7)
Environmental productivity, GDP per unit of CO_2 emitted in USD, 2009	**4.99**	**GERD publicly financed, as % of GDP, 2009**	**0.55**
(annual growth rate, 2005-09)	(+3.6)	(annual growth rate, 2005-09)	(–0.9)

Figure 10.24. **Science and innovation in Italy**

Panel 1. Comparative performance of national science and innovation systems, 2011



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

Regional Development Fund (ERDF) and by the national Revolving Fund (Fondo di Rotazione), which is of high importance for regional cohesion and competitiveness.

STI policy governance: The Ministry for Economic Development (MISE) is in charge of industrial innovation, and the Ministry for Education, University and Research (MIUR) is responsible for the national education system, including higher education, but also for promoting research at national and international level. The National Agency for the Evaluation of Universities and Research Institutes (ANVUR) has operated under MIUR since 2010.

Science base: The public research system, with HERD of 0.36% and GOVERD of 0.18% of GDP in 2010, performs the greater part of R&D. Higher education and PRIs contribute to innovation in a number of ways but their co-operation with business firms needs to be improved. In order to improve public research performance, a reform of funding mechanisms for and management of universities was approved in 2010 by Parliament and is being implemented. The reform of the PRIs under MIUR has also recently been undertaken.

Business R&D and innovation: As in other OECD countries, there has been a shift towards indirect funding of R&D in recent years. As stated in the National Reform Programme 2011, for 2011/12, tax incentives have been strengthened for research commissioned by firms to universities and PRIs as well as for research developed in collaboration with them.

Public-sector innovation: The e-Government Plan 2012 of the Department for Public Administration defines a set of digital innovation projects to modernise the public administration, to make it more efficient and transparent, and to improve the quality of services and reduce costs. The plan sets out some 80 projects and 27 targets to be achieved by 2013.

Knowledge flows and commercialisation: Various initiatives aim at bridging the gap between academia and industry. Technological districts and high technology poles as well as public-private laboratories are established in different parts of the country. The National Innovation Fund (FNI) was created in 2012 by MiSE to facilitate the financing of innovative projects based on the exploitation of industrial designs and patterns. In addition, the Innovation Package introduced in 2011 supports the patenting activity of SMEs. The National Technology Platforms and Industrial Innovation Network (RIDITT) were set up in 2010 to ensure dissemination of innovation and technology between research system and enterprises.

Globalisation: The Strategy for the Internationalisation of Italian Research (SIRIT 2010-15) integrates the national research priorities in international strategies and priorities, notably the EU's 2020 Strategy. Italy actively participates in EU R&D programmes, the European Strategy Forum on Research Infrastructures (ESFRI) and other European initiatives such as EUREKA (for international S&T co-operation) and Erasmus (for mobility of students and researchers).

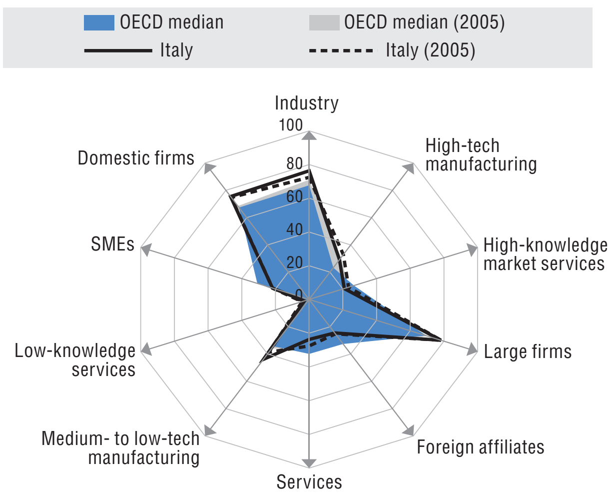
Human resources: Italy has a dearth of highly skilled human resources, and the most highly qualified sometimes find better opportunities abroad. During 2011/13 academics' salaries and career progression have been frozen in order to contain public spending. A lack of opportunities and unattractive career prospects and working conditions for talented individuals may further weaken the human resource base. A recent parliamentary act aims to support the recruitment of early career researchers. A new action plan for future youth employment (Italia 2020) aims to better align curricula with the changing demand of industry.

Emerging technologies: Italy is addressing various cross-cutting research issues considered crucial for enhancing economic growth, *e.g.* research on the natural and cultural heritage and on the complex systems of smart cities.

Green innovation: Italy has improved its RTA in environment-related technologies over the past decade and will soon develop a specialisation if this trend continues (Panel 3). The government provides a number of incentives for renewable energy production. The Energy Account (Conto Energia) initiative promotes solar photovoltaic, and a Kyoto Fund was set up to finance measures to reduce greenhouse gas emissions. Green Certificates (CV) promote electrical energy produced from renewable sources and White Certificates – energy efficiency labels (TEE) – encourage energy-saving measures. A package of fiscal incentives for energy efficiency interventions in existing and new buildings was approved by Parliament in 2011.

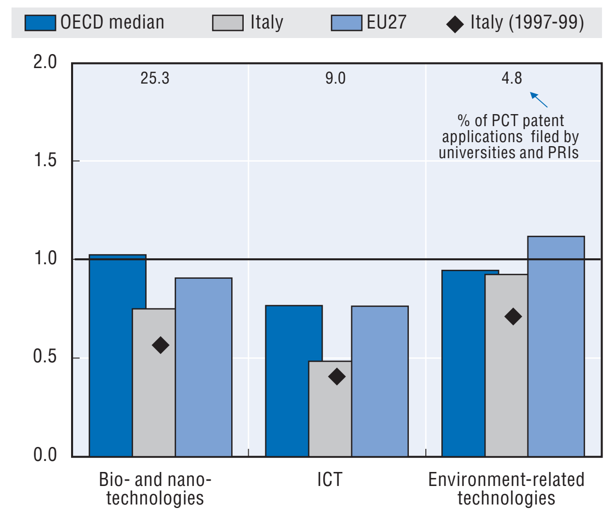
Panel 2. Structural composition of BERD, 2009

As a % of total BERD

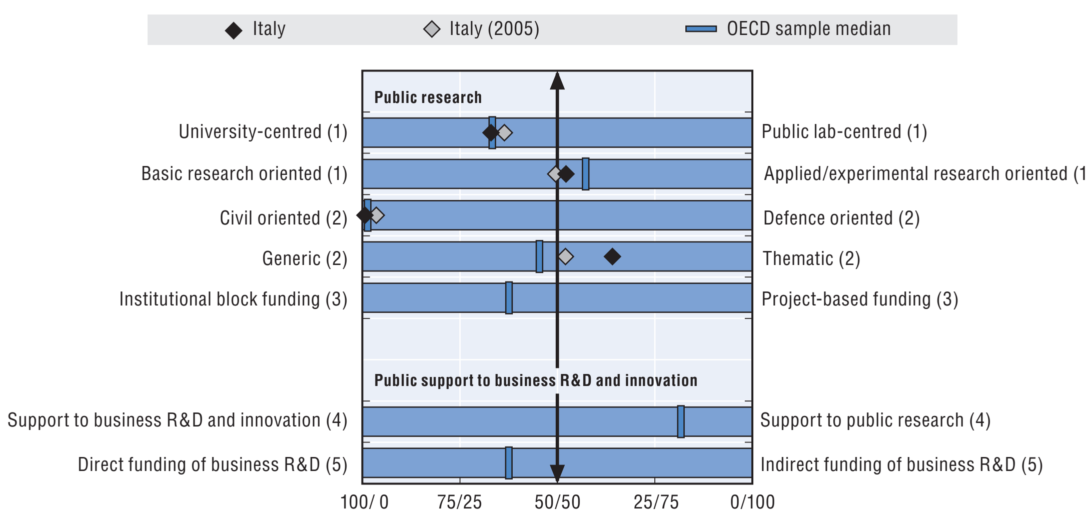


Panel 3. Revealed technology advantage in selected fields, 2007-09

Index based on PCT patent applications



Panel 4. Overview of national innovation policy mix, 2010



1. Balance as a percentage of the sum of HERD and GOVERD.
2. Balance as a percentage of total GBAORD.
3. Balance as a percentage of total funding to national performers.
4. Balance as a percentage of the sum of HERD and GOVERD funded by government and higher education and components of (5).
5. Balance as a percentage of the sum of indirect funding of business R&D and innovation through R&D tax incentives and direct funding of BERD through grants, contracts and loans.

Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888932690586

JAPAN

Hot STI issues

- Reconstructing and revitalising economic and social infrastructure destroyed by the Great East Japan Earthquake.
- Improving the return on R&D activities to respond better to the needs of Japanese society.
- Improve governmental co-ordination.

General features of the STI system: Japan is the third largest economy in terms of GDP after the United States and China. It has experienced a persistent economic slowdown since the 1990s and its growth prospects are threatened by an ageing population, fiscal pressures on social security spending, high national debt (over 180% of GDP), and the impact of recent crises and natural disasters. Japan's STI system is dominated by major corporate groups that rank among the world's largest corporate R&D investors (Panel 1[e]). Japan's business sector accounts for 77% of total GERD and is one of the most R&D-intensive (2.49% of GDP in 2010) in the OECD area (1[d]). The main R&D performers are essentially in high-technology and medium-high-technology manufacturing: TV and communication equipment (17% of BERD), motors vehicles (16%), and pharmaceuticals (10%) (Panel 2). The participation of small and young enterprises in national R&D efforts and output is relatively limited (1[i]). Innovation by large Japanese firms relies less on contracted public research (1[o]) and international collaboration (1[q][r]) than on open innovation within the corporate group. Triadic patent output (as a share of GDP) is the highest in the OECD area (1[f]). Japan accounts for 32% of OECD triadic patents but only 14% of OECD GERD. It has a strong and growing RTA in environment-related technologies and ICTs (Panel 3). It has widespread ICT infrastructures, especially wireless broadband access (1[l]), and a sound skills foundation. The share of the adult population with tertiary education (44%) is well above the EU average (26%) and slightly above the United States (41%) (1[s]). At 17% of top performers in science in the PISA Japan ranks third in the OECD area after Finland and New Zealand (1[t]). However, there are few doctoral graduates in science and engineering (1[u]) owing to low participation of youth (especially women) in doctoral programmes and low enrolments in science and engineering studies.

Recent changes in STI expenditures: Japan's GERD was 3.26% of GDP in 2010 (USD 141 billion), well above OECD and EU levels, and at the level of the most R&D-intensive countries (Sweden, Denmark, Korea). However, it stagnated in real terms between 2005 and 2010 owing to a sharp decline in business spending during the crisis which the USD 8.6 billion allocated by the government to S&T as part of the recovery plan did not offset. In spite of severe budgetary stringency, S&T budgets have been preserved. Certain budgetary lines have even been enlarged (energy, green technologies, science).

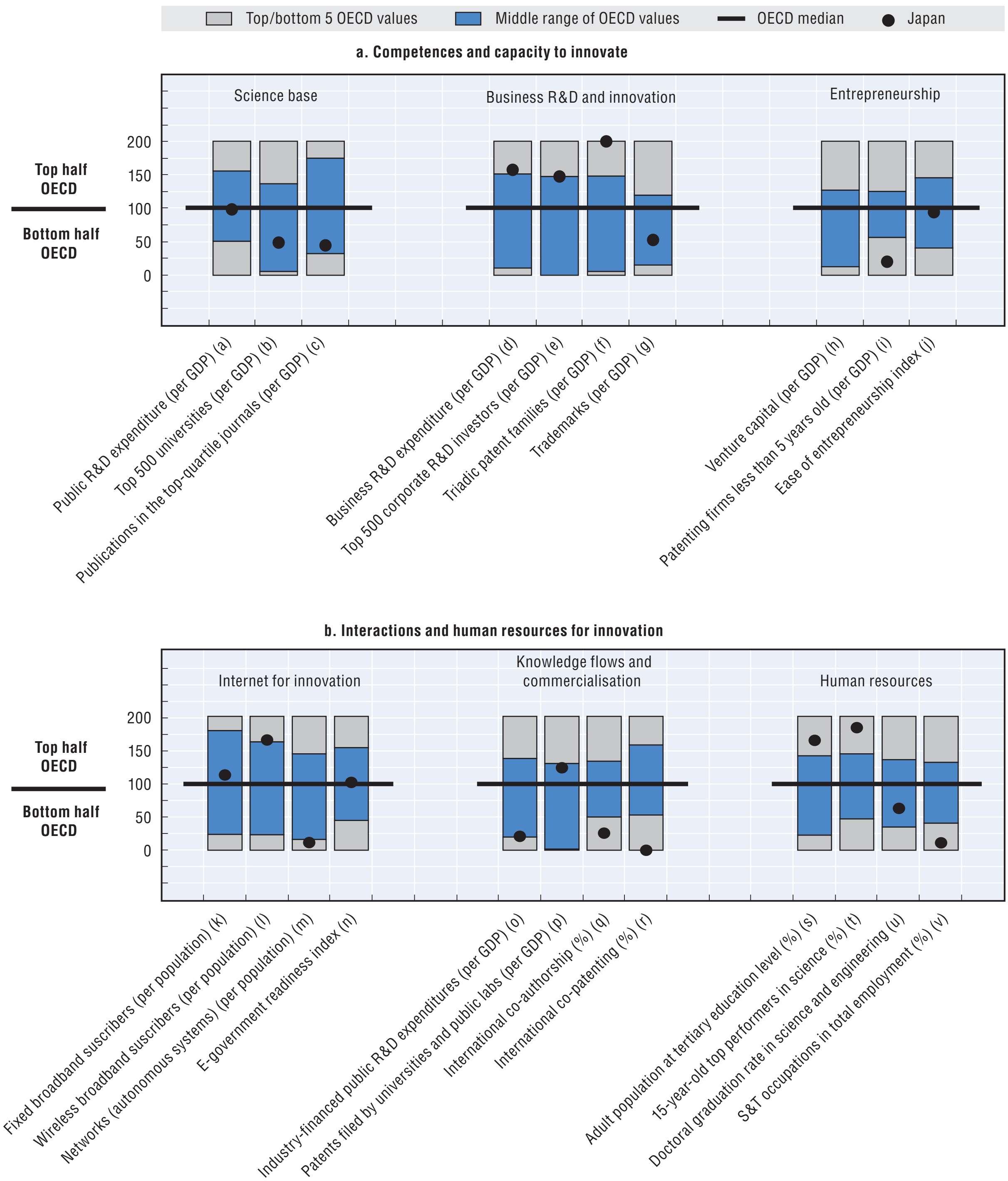
Overall STI strategy: The New Growth Strategy (2010) set an objective for GERD at 4% of GDP by 2020 and introduced substantial changes in STI policy to shift from a discipline-oriented to an issue-driven approach. Promoting green innovation and promoting life innovation have been identified as strategic priorities in the Fourth Science and Technology Basic Plan (2011-15). Restoration and reconstruction after the Great East Japan Earthquake which devastated northeast Honshu Island in 2011, at a cost estimated at at least USD 210 billion, is now a third pillar of national S&T policy.

Key figures

Labour productivity, GDP per hour worked in USD, 2010	**39.4**	**GERD, as % of GDP, 2010**	**3.26**
(annual growth rate, 2005-10)	(+0.9)	(annual growth rate, 2005-10)	(+0.0)
Environmental productivity, GDP per unit of CO_2 emitted in USD, 2009	**3.74**	**GERD publicly financed, as % of GDP, 2010**	**0.74**
(annual growth rate, 2005-09)	(+2.3)	(annual growth rate, 2005-10)	(+0.0)

Figure 10.25. **Science and innovation in Japan**

Panel 1. Comparative performance of national science and innovation systems, 2011



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

STI policy governance: The Reform of Independent Administrative Organisations, including public research institutions and research funding agencies, aims to reduce their number and to reform their governance structure.

Science base: Japan's public research system is strongly oriented towards applied and experimental R&D (70% of public expenditures) and relies on public labs (41%) (Panel 4). There are few Japanese universities of global stature (1[(b)]) and few articles by Japanese researchers in the top scientific journals (1[(c)]). This is well below what might be expected given public spending (0.71% of GDP) and quite moderate at the OECD level (1[(a)]). The 2012 S&T Budget increases funding for basic research to support future economic growth.

Business R&D and innovation: Public financial support to the business sector is limited as firms self-finance 98% of their R&D activities. Tax incentives are the main funding instrument, but direct funding has increased in relative terms since 2005. In 2009 grants, loans and contracts accounted for an estimated 35% of public support to business R&D (Panel 4).

Clusters and regional policies: The empowerment of regions is one of the most important issues in Japan, especially for recently devastated areas. In 2011, a new strategic regional innovation support programme was launched for regional revitalisation through knowledge transfer between universities and industry. It capitalised on prior cluster initiatives such as the Knowledge Cluster Initiative which ended in 2010. The Reconstruction Agency is also contributing to invigorate local industry.

Knowledge flows and commercialisation: The commercialisation of scientific research has been a priority of Japanese STI policy in recent decades as reflected in the number of measures since the mid-1990s to foster technology transfer from academia to industry. For example, the A-step programme (Adaptable and Seamless Technology Transfer Programme through Target-Driven R&D) defines overall objectives to facilitate medium- and long-term collaboration on R&D and combines several funding programmes to enable technological development at various stages of commercialisation. The New Growth Strategy also encourages the use of intellectual property rights. In a context of increasingly open innovation, a new patent licensing and patent co-ownership system will be in force in 2012.

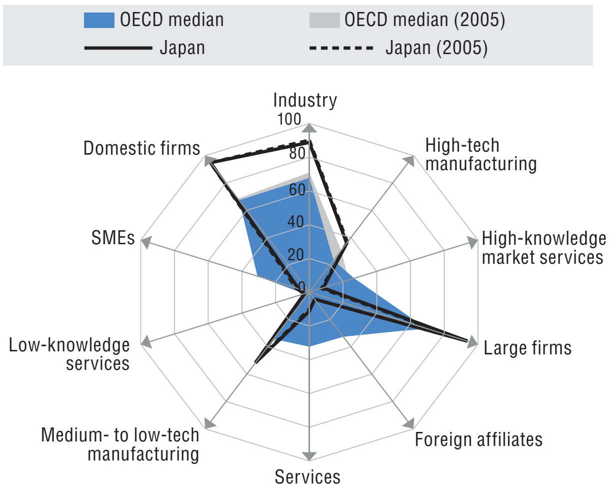
Globalisation: The New Growth Strategy has set an objective of doubling the flow of people, goods and money to Japan within ten years. Today, with Korea, it has the lowest share of GERD funded by abroad in the OECD area (0.4%). In 2010, the Inward Investment Promotion Programme suggested accelerating FDI through a cut in the corporate tax rate and deregulation of investment procedures. It also includes a broader series of initiatives to attract R&D facilities and global companies' regional Asian headquarters to Japan. Incentives, such as tax treatment and subsidies, are also to be developed under the corporate certification system.

Human resources: The government has invested in lifelong learning by improving the facilities of the Open University of Japan, by promoting specialised college education training, and by reinforcing the qualification and equivalency framework. A national forum on the lifelong learning network has been held to address social challenges through lifelong learning activities.

Green innovation: Green innovation is a high priority for Japan. A Comprehensive Green Innovation Strategy was announced to develop environmental and energy technologies. It aims to create over USD 468 billion of new demand and 1.4 million jobs in the environment sector by 2020, and to reduce greenhouse gas emissions by 25% relative to 1990 using Japanese private-sector technology. After the Great East Japan Earthquake in 2011, the Japanese government decided to draw up a Green Growth Strategy (tentative name) in 2012.

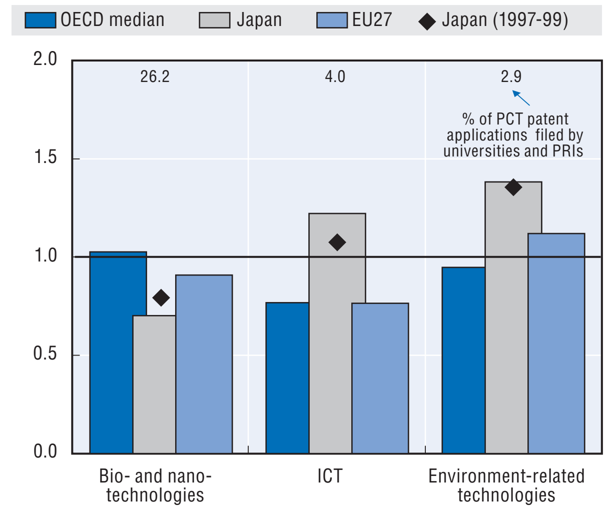
Panel 2. Structural composition of BERD, 2009

As a % of total BERD

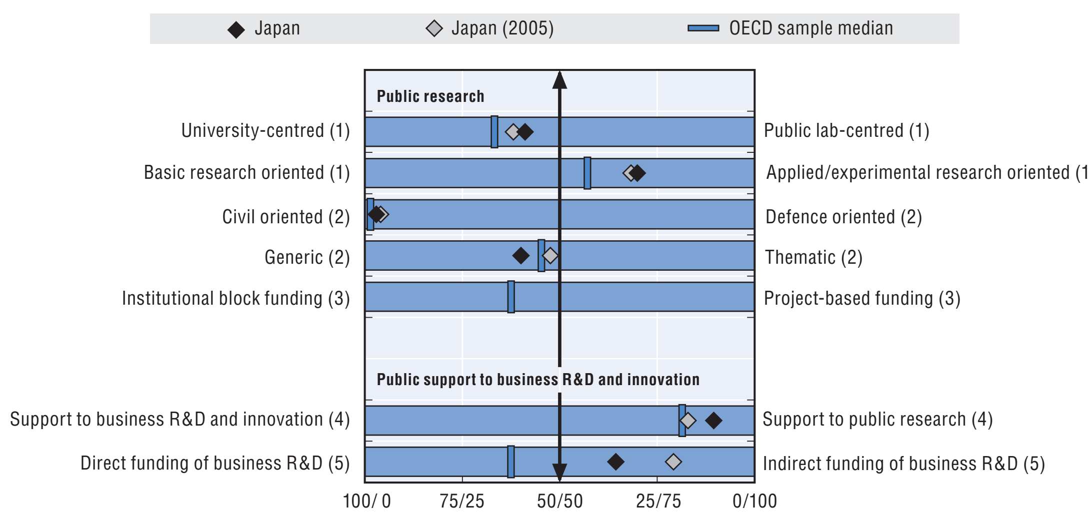


Panel 3. Revealed technology advantage in selected fields, 2007-09

Index based on PCT patent applications



Panel 4. Overview of national innovation policy mix, 2010



1. Balance as a percentage of the sum of HERD and GOVERD.
2. Balance as a percentage of total GBAORD.
3. Balance as a percentage of total funding to national performers.
4. Balance as a percentage of the sum of HERD and GOVERD funded by government and higher education and components of (5).
5. Balance as a percentage of the sum of indirect funding of business R&D and innovation through R&D tax incentives and direct funding of BERD through grants, contracts and loans.

Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888932690605

KOREA

Hot STI issues

- Achieving more balanced and sustainable growth with a strong, innovative SME sector.
- Diversifying the economy into newly emerging technology areas.
- Implementing the five-year-plan for green growth with green R&D at 2% of GDP.

General features of the STI system: Korea is committed to technology-based economic development and enjoys a national consensus on the importance of STI. It has high levels of R&D expenditure, a highly educated labour force, good and improving innovation framework conditions, large knowledge-intensive and internationally competitive firms, and a strong ICT infrastructure. Almost three-quarters of Korean R&D is performed by business, with 88% in manufacturing in 2010, second only to Germany; 48% was carried out in a single sector, Radio, television and communication equipment, by far the largest share among OECD countries. BERD grew by 9.5% a year in real terms during the decade to 2010, rising from 1.70% of GDP in 2000 to 2.80% of GDP in 2010. The shares of public research funded by industry and of patents filed by universities and public labs per GDP are well above the OECD median (Panel 1[(o)(p)]). Levels of international collaboration are very low: just 26% of scientific articles are produced with international co-authorship (1[(q)]), and only 4% of PCT patent applications were produced with international collaboration (1[(r)]), the latter owing in part to Korea's conglomerate industrial structure which tends to retain technology development within the group. Korea has a high tertiary attainment rate of 39% (1[(s)]) and the 8th highest PISA scores in science for 15-year-olds (1[(t)]). It has a strong and increasing RTA in ICTs; it is considerably weaker in bio- and nano-technologies (Panel 3). ICT infrastructures are strong: there are 36 subscribers per 100 inhabitants to broadband and 99 per 100 to wireless networks (1[(k)(l)]). Korea's e-government readiness index is the highest in the OECD (1[(n)]).

Recent changes in STI expenditures: Korea's GERD was 3.74% of GDP in 2010 and has grown by a robust 9.3% a year over the past decade, and by 10% a year over the five years to 2010. In 2010, 72% of GERD was funded by industry, 27% by government and only 0.2% from abroad.

Overall STI strategy: Korea's 577 Initiative aims to increase GERD to 5% of GDP by 2012, nurture seven strategic technology areas, and become the world's seventh "S&T power". To meet these targets, the government has increased government expenditure on R&D and has used various tax incentives to encourage more private investment in R&D. In line with a decade-long trend, government support has continued to shift away from large firms towards SMEs.

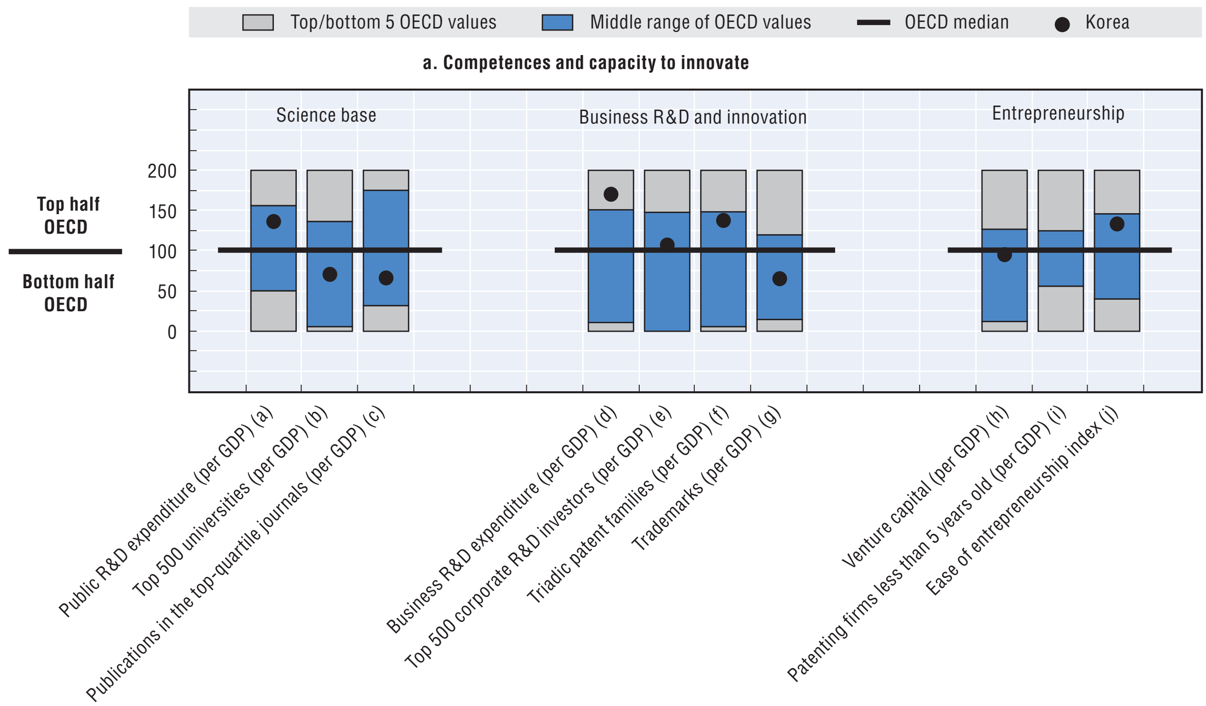
STI policy governance: In 2011, the National Science and Technology Commission (NSTC) was reconstituted as a co-ordinating agency with considerable responsibility for national STI policies and allocation of public R&D funding. The key STI funding ministries are the Ministry of Education, Science and Technology (MEST), the Ministry of Knowledge Economy (MKE) and the Ministry of Strategy and Finance (MOSF). MEST and MKE have agencies that administer much of their funding.

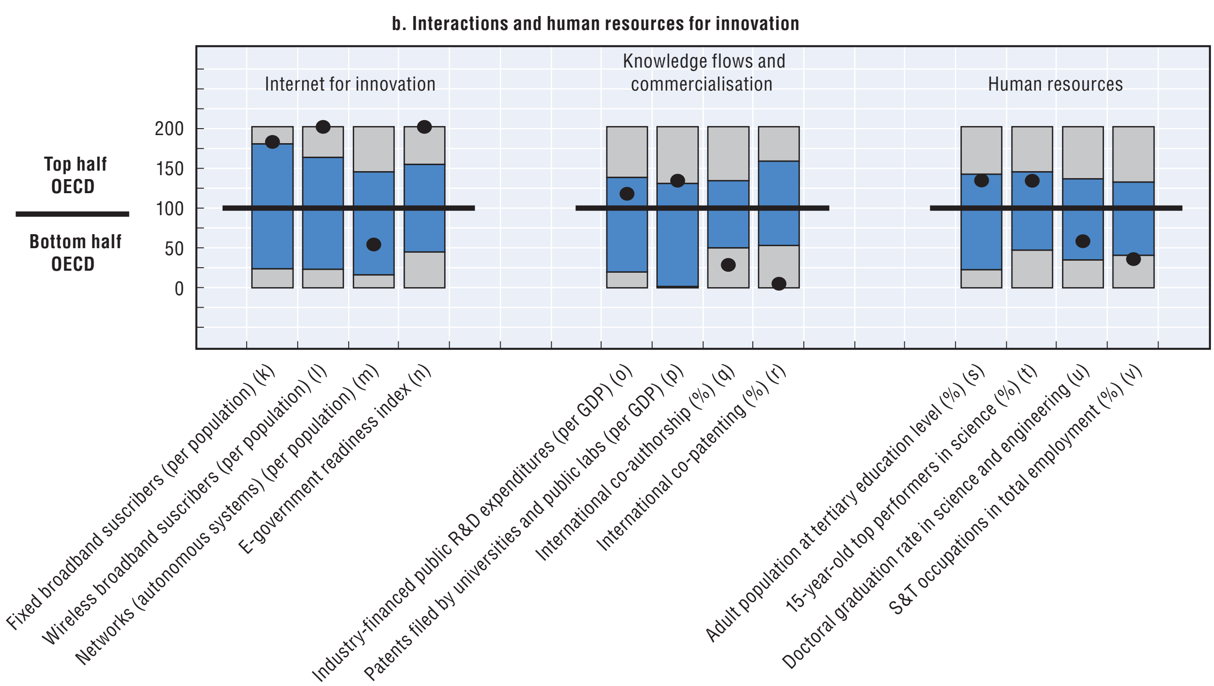
Key figures

Labour productivity, GDP per hour worked in USD, 2010	**27.2**	**GERD, as % of GDP, 2010**	**3.74**
(annual growth rate, 2005-10)	(+4.4)	(annual growth rate, 2005-10)	(+10.0)
Environmental productivity, GDP per unit of CO_2 emitted in USD, 2009	**2.57**	**GERD publicly financed, as % of GDP, 2010**	**1.03**
(annual growth rate, 2005-09)	(+0.6)	(annual growth rate, 2005-10)	(+13.2)

Figure 10.26. **Science and innovation in Korea**

Panel 1. Comparative performance of national science and innovation systems, 2011





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

Science base: Although Korea has relatively high public-sector expenditures on R&D, its universities and research publication outputs rank comparatively low by international standards (1[(a)(b)(c)]). Its university research sector has only recently started to perform a larger share of public-sector R&D (Panel 4) and still produces small numbers of PhDs in S&E (1[(u)]). The research system is also heavily skewed towards thematic R&D which is largely applied and development-oriented (Panel 4) with a focus on industrial technologies. There are signs of change, however: as part of the 557 Initiative, basic research increased to 35% of the total in 2012 and government support is placing greater emphasis on "high-risk, high-return" research.

Business R&D and innovation: The structure of BERD shows that R&D is mainly conducted by large manufacturing conglomerates (Panel 2). Small and young firms have contributed relatively little to innovation, though there are signs of improvement. Much government support to the business sector goes to SMEs. The Small and Medium Business Administration's R&D investments for start-ups will increase by 33% in 2012, and MKE has announced that the share of its R&D budget allocated to SMEs will reach 40% of the total by 2015.

ICT and scientific infrastructures: Given the presence of Korea's home-grown global IT firms the ICT sector is exceptionally strong. The Telecommunication Technology Association plays an important role in ICT standardisation. Other ICT initiatives include a software bank for innovation in software ecology. Korea invests heavily in research infrastructures and has established the National S&T Information Service (NTIS), a centralised database on S&E human resources and S&T infrastructure, to better monitor these developments.

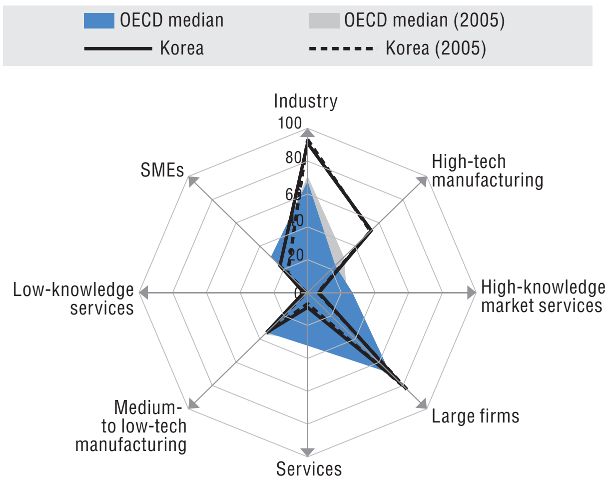
Clusters and regional policies: The Seoul Metropolitan Area is the focus of much S&T and innovation activity and this has led to quite unbalanced regional growth. In response, the government has introduced a number of schemes over the years. As a result, Korea had 105 regional innovation centres and 18 techno-parks in 2010, as well as seven programmes to strengthen the competitiveness of industrial cluster programmes.

Knowledge flows and commercialisation: A raft of schemes aim to improve commercialisation and knowledge transfer from public sector research. These include the Technology Holding Company system, which promotes the establishment of venture businesses by universities and research institutes, as well as the Leaders in Industry-University Programme (LINC) and the Brain Korea Programme (BK), both of which seek to improve industry-academia collaboration. In a more global perspective, the Intellectual Management Property Council manages overseas patent disputes, while various IPR-related laws were amended in 2011 to protect core national technologies.

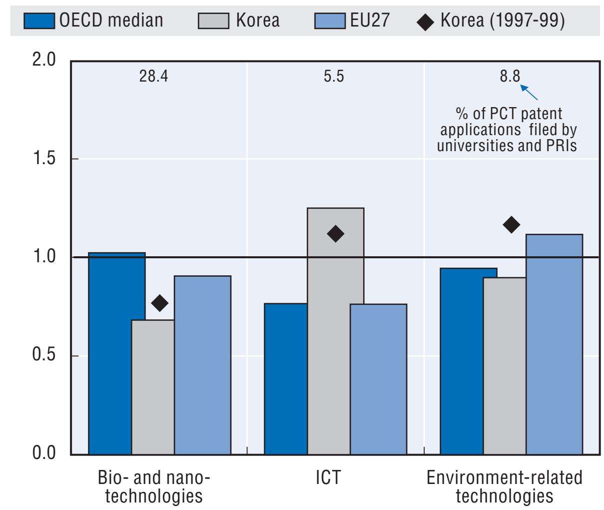
Human resources: Korea's R&D system has one of the widest gender gaps. To reduce this gap, several programmes (WIST, WISE and WIE) support women in S&T careers. Korean R&D has also been relatively closed; few foreigners work in Korean labs. Several schemes have been launched to internationalise the Korean research system, including the CAMPUS Asia Programme and Global Korea Scholarships Programme, as well as adjustments in various laws to promote researcher mobility. The World Class University Project was launched in 2008 with funding of USD 143 million; its aim is to attract leading researchers to Korea. To encourage entrepreneurship, the Entrepreneurship Leading Universities Programme supports entrepreneurship education with block funding.

Green innovation: Korea has prioritised green innovation at the highest level. The Presidential Committee on Green Growth was established to address climate challenges through low-carbon green growth and the Global Green Growth Institute (GGGI) was launched in 2010 to conduct policy research. The 557 Initiative has earmarked USD 2.4 billion to invest in green technology.

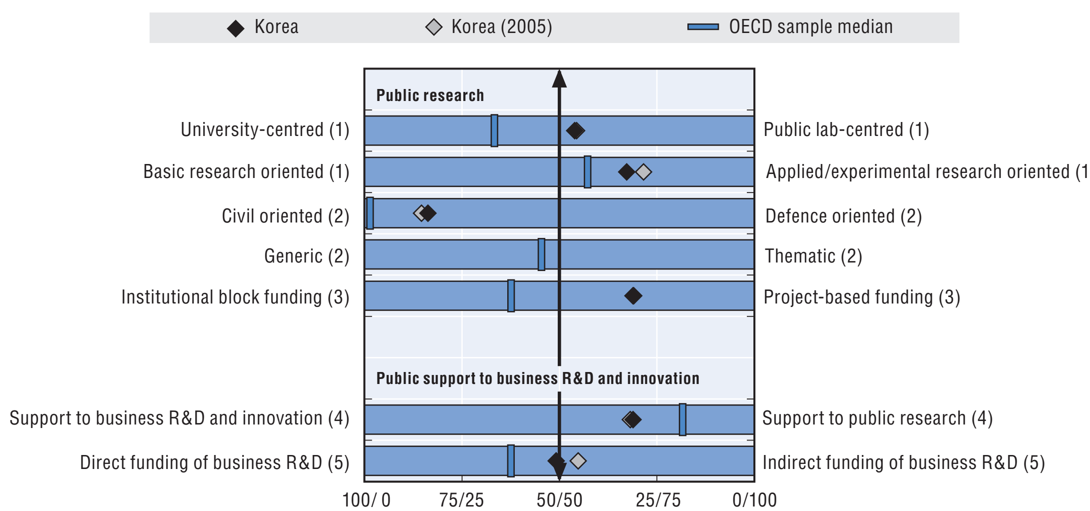
Panel 2. Structural composition of BERD, 2009
As a % of total BERD



Panel 3. Revealed technology advantage in selected fields, 2007-09
Index based on PCT patent applications



Panel 4. Overview of national innovation policy mix, 2010



1. Balance as a percentage of the sum of HERD and GOVERD.
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3. Balance as a percentage of total funding to national performers.
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5. Balance as a percentage of the sum of indirect funding of business R&D and innovation through R&D tax incentives and direct funding of BERD through grants, contracts and loans.

Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888932690624

LUXEMBOURG

Hot STI issues

- Developing and consolidating the S&T infrastructure.
- Encouraging the efficiency of public research through performance contracts and policies to attract researchers.
- Intensifying connections between public research and industry.

General features of the STI system: Luxembourg is a small open economy of about half a million inhabitants with one of the world's largest GDP per capita. Relative to its size, it hosts the headquarters of the largest number of top corporate R&D investors among OECD countries (Panel 1[e]). However, BERD accounted for only 1.16% of GDP in 2010, almost at the OECD median (1[d]), but below the OECD average (1.27%). Large firms accounted for 83% of national BERD in 2009 (Panel 2). The entrepreneurship index (1[j]) reflects the very small contribution of SMEs and young firms to the national innovation system (Panel 2). Luxembourg files more trademarks (1[g]) than triadic patents (1[f]), partly owing to the service orientation of its industry structure. Links between research and industry by industry funding of public R&D expenditure are weak (1[o]). During 2005-09 Luxembourg had one of the lowest relative number of patents filed by universities and public labs among OECD countries (1[p]). With 36% of the adult population tertiary-qualified (1[s]) and PISA performance in science below the OECD median (1[t]) in 2009, Luxembourg led in S&T occupations (1[v]). A salient feature of the labour market is the high proportion of cross-border workers. High shares of international co-authorship (1[q]) and international co-invention (56% of total PCT patent applications, 1[r]) reflect the country's small size and its close economic integration with Belgium, France and Germany. The national ICT infrastructure is well developed (1[k][l][m]). The e-government readiness index is on a par with the OECD median (1[n]).

Recent developments in STI expenditures: Luxembourg's R&D efforts are below the OECD and EU27 averages: GERD was 1.63% of GDP in 2010 and increased on average by 2.8% annually over 2005-10. The Luxembourg 2020 Strategy targets R&D spending of 2.3-2.6% of GDP by 2020, with 1.5-1.6% from the private sector, and 0.7-0.8% from the public sector.

Overall STI strategy: The objectives of the EU Horizon 2020 figure in the national reform programme, Luxembourg 2020, which was approved in 2011. The main objectives are to foster R&D and innovation in the public and private sectors by increasing R&D efforts, human capital supply, and encouraging and facilitating the creation of innovative new companies.

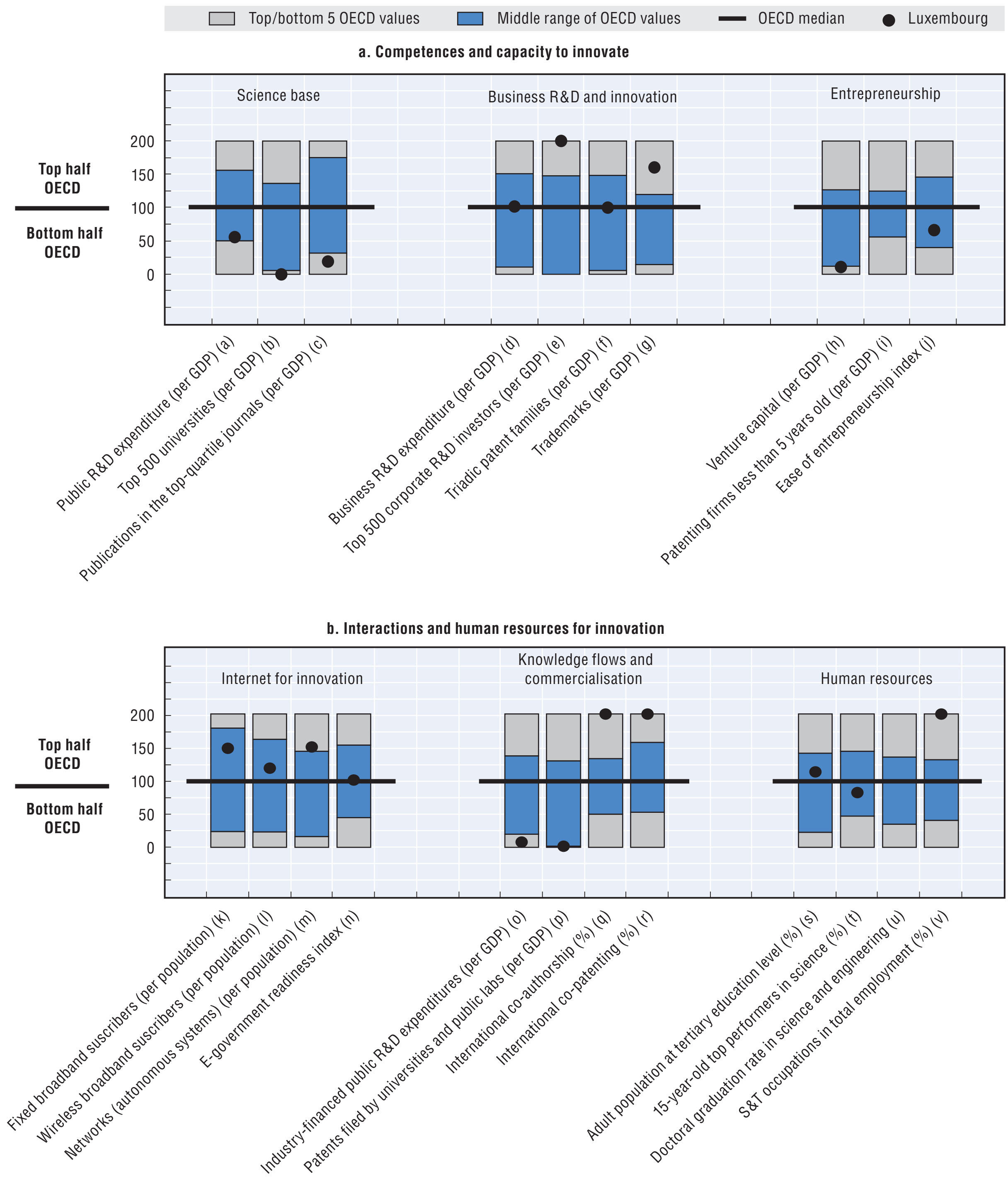
STI policy governance: No major changes were introduced recently. Among the most significant recent changes in STI governance are the introduction of performance contracts in 2008 (renewed in 2011) between the government and the University of Luxembourg, Luxinnovation, the National Research Fund, and the public research centres (PRCs) which were established on the basis of the OECD recommendations formulated in the 2007 *OECD Reviews of Innovation Policy: Luxembourg*.

Key figures

Labour productivity, GDP per hour worked in USD, 2010	**75.3**	**GERD, as % of GDP, 2010**	**1.63**
(annual growth rate, 2005-10)	(–1.8)	(annual growth rate, 2005-10)	(+2.8)
Environmental productivity, GDP per unit of CO_2 emitted in USD, 2009	**4.13**	**GERD publicly financed, as % of GDP, 2010**	**0.49**
(annual growth rate, 2005-09)	(+5.6)	(annual growth rate, 2005-10)	(+15.5)

Figure 10.27. **Science and innovation in Luxembourg**

Panel 1. Comparative performance of national science and innovation systems, 2011



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

Science base: Luxembourg has a poorly developed science base. In 2010 public R&D expenditures (0.48% of GDP) (1[(a)]) and publications in scientific journals (1[(c)]) were both below the OECD median. Weaknesses in Luxembourg's science base are also due to its relative youth; its university was founded in 2003 and its PRIs were created after 1987. To improve performance, public funding is based on performance contracts, with targets of up to 40% of additional external funding in 2011. Publication indicators are also used. Regular evaluation exercises have been introduced: from 2010, one or two departments of a research centre are evaluated each year. A bill under discussion would give the public research sector more autonomy and accountability.

Business R&D and innovation: A law on state aid for R&D implemented in June 2009 extended the scope of an earlier law of 1993. It supports process and organisational innovation and includes special subsidies for SMEs and schemes to promote knowledge flows between academia and industry.

Knowledge flows and commercialisation: Luxembourg places great emphasis on public-private collaboration, which is currently weak. The Cités des Sciences, a massive infrastructure project, will bring together on one campus the university, PRCs, facilities for public-private partnerships (PPPs) and an incubator for start-ups. The first research facilities are expected to be operational by 2012. Specific measures to promote PPPs include funding for joint public-private research projects. The Luxembourg Cluster Initiative, launched in 2002, also supports the transfer of knowledge and know-how.

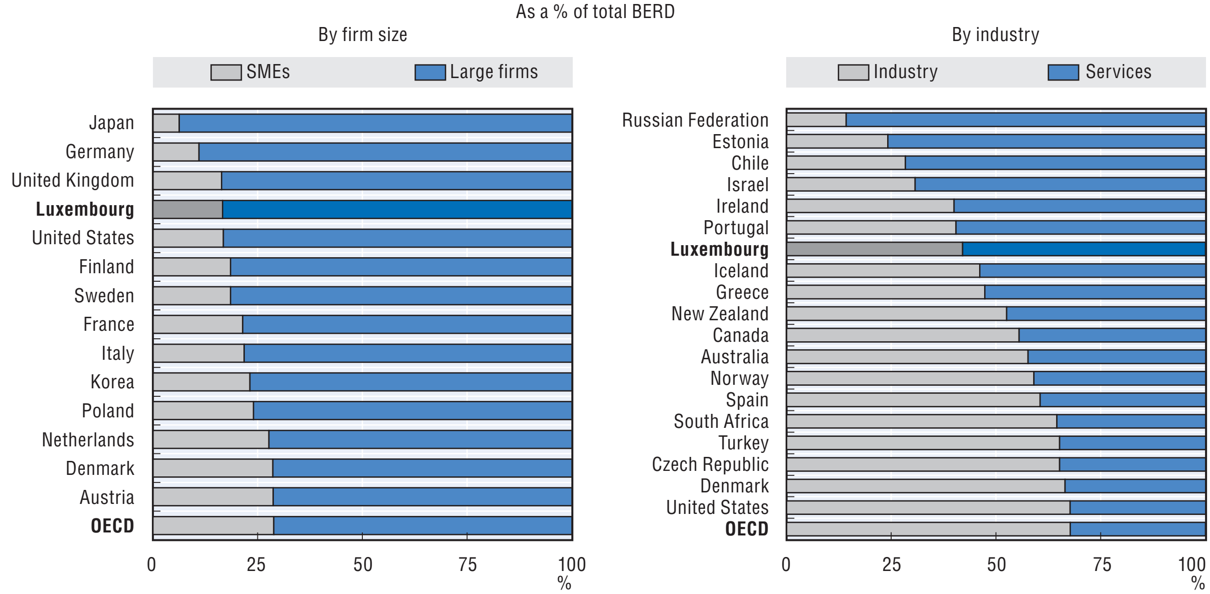
Globalisation: Because Luxembourg has a small and young science base, it actively supports co-operation with researchers from other countries through measures for training and mobility of researchers (AM2c, which also finances national researchers carrying out research abroad) and ATTRACT and PEARL, which provide institutions with funding to attract senior researchers and young researchers from abroad. Moreover, its Fit4Europe programme provides financial support for companies to prepare research proposals for EU FP7 calls that emphasise cross-country collaborative research projects.

Human resources: The Luxembourg 2020 Strategy identified a need for more qualified researchers, especially in the public research sector. One measure aimed at making researchers' careers more attractive is the AFR programme, which supports PhD and postdoctoral students by offering better work contracts, working conditions and training opportunities.

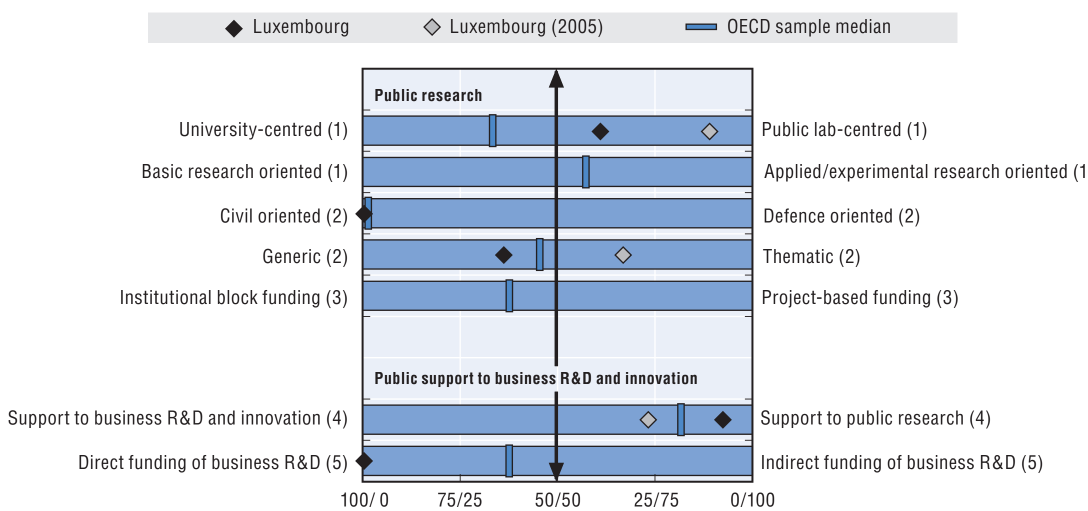
Green innovation: Eco-technologies are a priority sector of the Luxembourg 2020 Strategy. The Ecotechnologies Action Plan aims at improving energy efficiency but also at developing a private eco-technology sector. Support for R&D in environmental technologies amounts to some USD 6 million. Public aid to support the development of environmentally sustainable businesses has also increased.

Panel 2. Structural composition of BERD, selected countries, 2009

As a % of total BERD



Panel 3. Overview of national innovation policy mix, 2010



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Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888932690643

MEXICO

Hot STI issues

- Investing in human resources at all levels.
- Consolidating technology transfer from public research to business.
- Improving conditions for innovative entrepreneurship, including financial markets.

General features of the STI system: Over the past two decades, Mexico has undertaken major reforms to liberalise its economy and improve its macroeconomic management. In spite of recent efforts to improve the performance of the national innovation system, major weaknesses remain. By almost all performance indicators Mexico lags significantly behind the OECD median, and for several it lies at the bottom of the scale (Panel 1). After a sharp decline from the turn of the century, the share of the federal S&T budget in GDP increased slowly from 2008 to reach its level of 2000 in 2010. Both public and business R&D expenditures are low as a proportion of GDP (at 0.25% and 0.18%, respectively, in 2009). In constant prices and as a share of GDP, R&D performed by the business sector decreased between 2006 and 2009 and was concentrated in large enterprises in medium-high- to low-technology manufacturing (Panel 2) and to a lesser extent, according to the latest innovation survey, in innovative SMEs. Recent measures targeting business R&D and innovation have not fully succeeded in curbing Mexican firms' preference for imported technologies over the development of domestic capacity. In spite of reforms to remove legal and regulatory obstacles to the creation of enterprises, innovative companies are slow to develop. Among OECD countries, Mexico has one of the lowest scientific and innovation outcomes (as measured by number of scientific publications and triadic patents per GDP). Very few patents were filed by universities and PRIs over 2005-09 (1[p]). Although recent policy measures have encouraged industry-science linkages, PRIs' R&D expenditures financed by industry remain very low.

Recent changes in STI expenditures: In 2007, Mexico's GERD accounted for only 0.37% of GDP, the smallest share among OECD countries. As of 2008 GERD increased both in real terms and as a proportion of GDP to 0.44% in 2009. However, the major share of the increase came from government; the share of the business sector decreased from 44.6% in 2007 to 38.7% in 2009.

Overall STI strategy: The 2008-12 Special Programme for Science, Technology and Innovation (PECiTI) has an ambitious set of objectives, among which a greater focus on innovation by enterprises and in particular by SMEs, consolidation of the research and innovation capacities of the PRI and HEI sectors, including human resource development and links with the business sector, sustained efforts to improve S&T infrastructures and greater decentralisation of S&T and innovation activities.

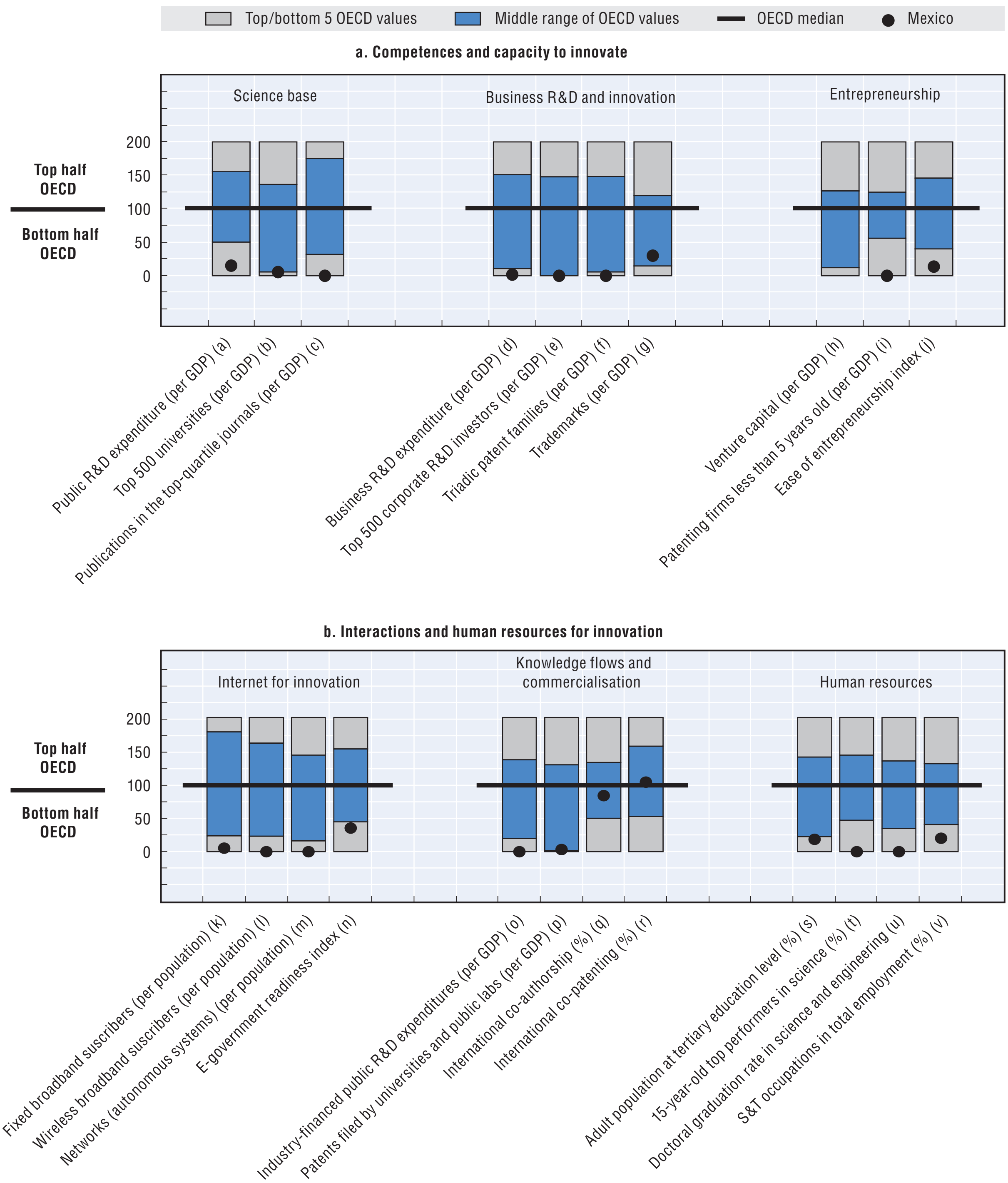
STI policy governance: The 2009 amendment to the *National Law of Science and Technology* resulted in some changes in governance, such as the creation of the Intersectoral Committee for Innovation to develop a comprehensive approach to innovation through greater inter-ministerial co-ordination. Improved policy evaluation instruments were set up, and in 2010 the Committee Specialised in Science,

Key figures

Labour productivity, GDP per hour worked in USD, 2010	**19.8**	**GERD, as % of GDP, 2009**	**0.44**
(annual growth rate, 2005-10)	(+0.4)	(annual growth rate, 2005-07)	(–1.2)
Environmental productivity, GDP per unit of CO_2 emitted in USD, 2009	**3.87**	**GERD publicly financed, as % of GDP, 2007**	**0.20**
(annual growth rate, 2005-09)	(+0.0)	(annual growth rate, 2005-07)	(–4.0)

Figure 10.28. **Science and innovation in Mexico**

Panel 1. Comparative performance of national science and innovation systems, 2011



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

Technology and Innovation Statistics was established to improve STI information and encourage its use for policy design.

Science base: In Mexico the bulk of scientific output comes from a few strong HEIs and PRIs. While performance in terms of internationally refereed publications has improved slightly in the last ten years it remains low by OECD standards in terms of output per unit of R&D expenditure and much lower as a proportion of GDP. The National Researcher System (SNI), which provides monetary incentives for publication performance, has contributed to the increase in scientific output. Policies in support of the development of technology transfer offices (TTOs) in HEIs and PRIs are beginning to have a positive effect on science/industry linkages.

Business R&D and innovation: The share of the business sector in total R&D performance rose significantly from 2000 to 2006 but then declined from 0.49% to 0.42% in 2010. Despite various support measures to boost business R&D investment, the overall results have proved disappointing in terms of increased expenditure and innovative outputs as measured by patent applications. In 2009, the OECD highlighted an innovation policy mix unbalanced in favour of indirect support and a multiplicity of poorly endowed programmes. This has recently changed: the tax incentive was eliminated in 2009, and public funding to the business sector is now direct and competitive. A new R&D and innovation stimulus package was introduced in 2009 with a strong emphasis on SMEs and links with research institutes. New innovation programmes financed by the Ministry of Economy have been introduced.

ICT and scientific infrastructures: Since 2000 the government has significantly increased its investments in S&T infrastructures. Also, the National Council for Science and Technology (CONACYT) launched an information system (to be completed by 2012) on available research infrastructures to help planning and investment decisions, to improve visibility and to guide researchers.

Clusters and regional policies: Mexico does not have a specific cluster policy, but has supported individual initiatives, such as an ICT cluster in the State of Jalisco, through the Prosoft programme, and Querétaro's Aerospace Park, notably through CONACYT's mixed funds.

Knowledge flows and commercialisation: The development of industry-science linkages has been included as a secondary objective for project selection in a number of innovation support programmes. Public-private partnerships are being encouraged by Strategic Alliances and Innovation Networks for Competitiveness (AERIs). Furthermore, support for the development of TTOs aims to accelerate the commercialisation of research outcomes and facilitate the creation of spin-offs.

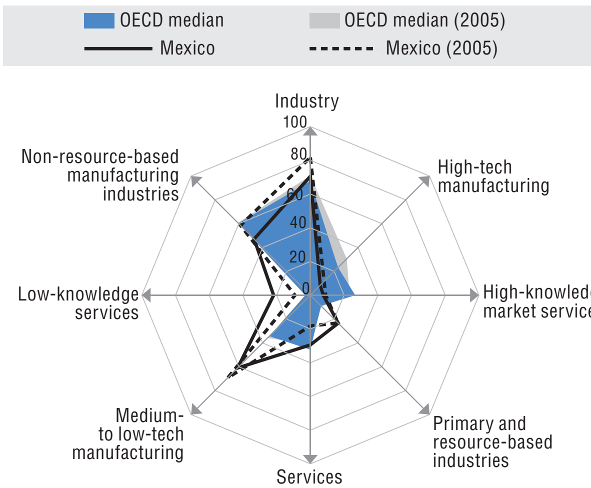
Human resources: The weak supply of human capital for S&T is a major bottleneck in Mexico's innovation system. Reforms have been recently introduced to improve primary and secondary education through more investment in school infrastructures, and attempts are made to increase teaching quality (introduction of a centralised exit exam to become a teacher in 2008, and a new incentive scheme focused on teacher performance in 2010). In higher education, the amount of scholarships has increased significantly, and collaboration with the business sector is encouraged (*e.g.* establishment of the Institutional Councils of Linkages, the IDEA programme, new curricula focused on the development of an entrepreneurship culture since 2011).

Emerging technology fields: Mexico has placed emphasis on nanotechnologies and biotechnologies, areas in which it currently has no RTA (Panel 3), through the development of two thematic networks (the Network for Agriculture and Food Biotechnology and a network dedicated to nanosciences and nanotechnologies). CONACYT has also signed bilateral agreements with Argentina and Brazil for the establishment of virtual centres in both fields.

Green innovation: Mexico's HEIs participate in the Green Agenda for Higher Education Technology Institutes which supports projects on clean technologies and renewable energy. These projects are complemented by research undertaken under the sectoral funds for environmental studies, for R&D in the water sector, and for R&D and technological innovation in forestry.

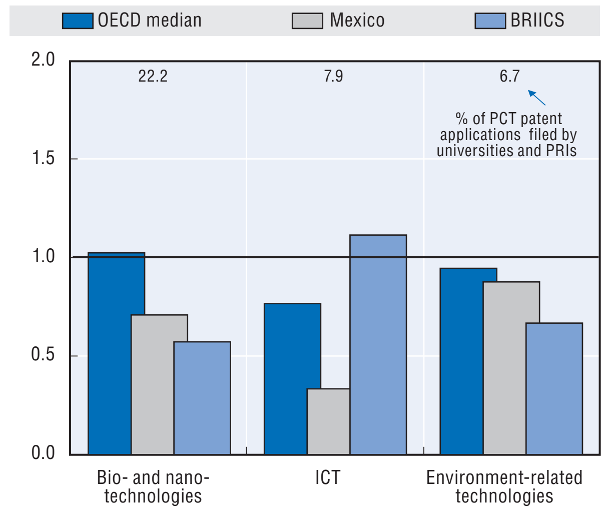
Panel 2. Structural composition of BERD, 2009

As a % of total BERD

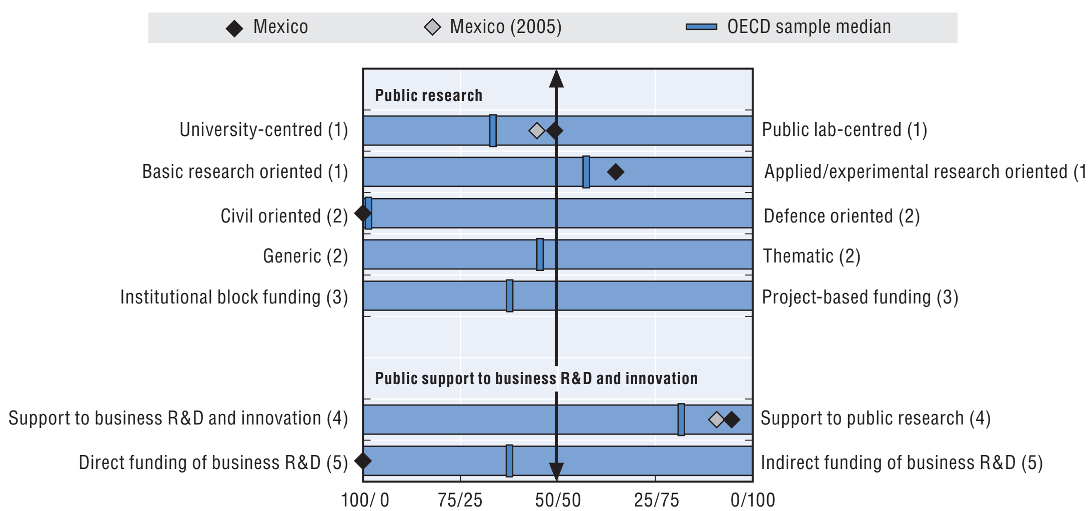


Panel 3. Revealed technology advantage in selected fields, 2007-09

Index based on PCT patent applications



Panel 4. Overview of national innovation policy mix, 2010



1. Balance as a percentage of the sum of HERD and GOVERD.
2. Balance as a percentage of total GBAORD.
3. Balance as a percentage of total funding to national performers.
4. Balance as a percentage of the sum of HERD and GOVERD funded by government and higher education and components of (5).
5. Balance as a percentage of the sum of indirect funding of business R&D and innovation through R&D tax incentives and direct funding of BERD through grants, contracts and loans.

Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888932690662

THE NETHERLANDS

Hot STI issues

- Building on strengths by focusing on the top nine performing sectors.
- Increasing R&D intensity to achieve GERD of 2.5% of GDP by 2020.
- Shifting the focus from subsidies to fiscal incentives and lower business taxes.
- Easing regulations to lower costs and increase efficiency and competitiveness.

General features of the STI system: The Netherlands has a well-performing knowledge economy, but GERD was a comparatively low 1.85% of GDP in 2010, similar to the level of three decades ago. BERD dropped from 1.07% of GDP in 2000 to 0.89% in 2010. It leans towards large manufacturing firms (Panel 2) and is leveraged by strong links with academia, with a high proportion of public research funded by industry (Panel 1[o]). The higher education sector produces world-class science and the relative number of PCT patents filed by universities and public labs is slightly above the OECD median (1[p]). The Netherland's RTA is strong and growing in emerging technologies, has lost some momentum in environment-related technologies and has declined in ICT (Panel 3). Overall performance of human resources is good, with a tertiary attainment rate of 32% (1[s]), 39% of persons employed in S&T occupations (1[v]) and the sixth highest PISA scores in science for 15-year-olds (1[t]). The 6.2 researchers per thousand total employment is below the OECD median. Researchers are well integrated in international networks; 51% of scientific articles are produced with international co-authorship (1[q]), although a modest 19% of PCT patent applications are produced with international collaboration (1[r]). ICT infrastructures are well developed with 38 broadband and 44 wireless subscribers per 100 inhabitants (1[k][l]). The Netherland's e-government readiness index is the second highest in the OECD (1[n]).

Recent changes in STI expenditures: GERD grew by a modest 0.9% a year over the five years to 2010, but is targeted to be 2.5% of GDP by 2020. In 2009, GERD was funded almost equally by industry (45%) and government (41%), and 11% was funded from abroad. Following the crisis, USD 214 million was made available to retain private-sector researchers in the labour force through secondment to universities and public research institutes. The Ministry of Education, Culture and Science (OCW) also reallocated USD 305 million to higher education.

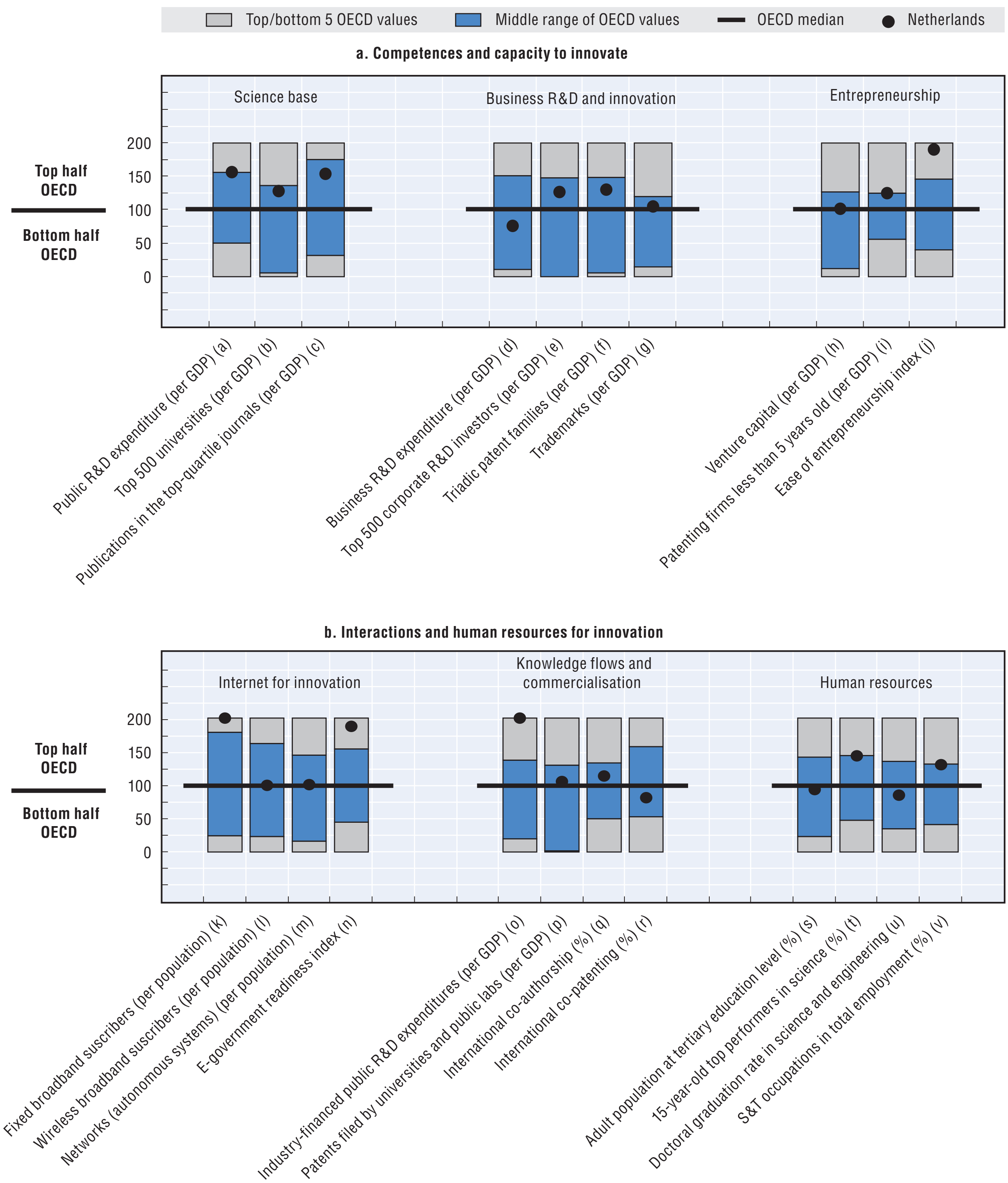
Overall STI strategy: A new strategy, To the Top: Towards a New Enterprise Policy, was launched in 2011 to reform an incoherent and ambiguous industrial policy and to become one of the world's top five knowledge economies. It focuses on nine top-performing sectors (agro-food, horticulture and propagating stock, high-technology materials and systems, energy, logistics, creative industries, life sciences, chemicals, and water), and on stimulating demand-driven innovation through access to corporate financing, better utilisation of knowledge infrastructure, and use of fiscal incentives. The strategy includes establishing public-private consortia for knowledge and innovation (Topconsortia voor Kennis en Innovatie – TKI), with funding of USD 662 million by 2015.

Key figures

Labour productivity, GDP per hour worked in USD, 2010	**58.8**	**GERD, as % of GDP, 2010**	**1.85**
(annual growth rate, 2005-10)	(+0.7)	(annual growth rate, 2005-10)	(+0.9)
Environmental productivity, GDP per unit of CO_2 emitted in USD, 2009	**3.86**	**GERD publicly financed, as % of GDP, 2009**	**0.75**
(annual growth rate, 2005-09)	(+2.9)	(annual growth rate, 2005-09)	(+1.6)

Figure 10.29. **Science and innovation in the Netherlands**

Panel 1. Comparative performance of national science and innovation systems, 2011



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

STI policy governance: To streamline a fragmented governance system, the Ministry of Economic Affairs, Agriculture and Innovation (EL&I) was created in 2010 and focuses on innovation. OCW focuses on education and science. The NL Agency is the central contact point for businesses, knowledge institutions and government bodies for information, advice, financing, networking and regulatory matters. The Dutch Research Council (NWO), the Dutch Academy of Science (KNAW) and the Dutch Bureau for Economic Policy Analysis (CPB) are also important governance organisations.

Science base: The Netherlands has a strong science base, with a high ratio of public R&D expenditures to GDP, highly rated universities and strong research publication outputs (1[(a)(b)(c)]). HERD was 0.75% of GDP in 2010, among the highest in the OECD.

Business R&D and innovation: The government recently reallocated USD 662 million to reduce business taxes; subsidies will be converted into loans. The *Research and Development R&D Promotion Act* (WBSO) is the main instrument for stimulating R&D by providing tax deductions on wages of R&D workers. The new Research and Development Deduction scheme introduced in 2012 offers tax relief for R&D-related investments. The Innovation Fund, with an annual budget of USD 159 million, provides loans and risk capital.

Entrepreneurship: There are few fast-growing SMEs and there is scope for improving the alignment of universities and enterprises (especially SMEs). The Ondernemersplein will be established as a 24-hour one-stop shop for information and advice for entrepreneurs in order to reduce administrative burdens for business. The Syntens Network assists SMEs through 15 national centres and 270 advisors. The Action Programme Education and Entrepreneurship is an EL&I/OCW initiative to stimulate entrepreneurship in education through exchanges between education institutions and entrepreneurs.

ICT and scientific infrastructures: To improve scientific research capabilities, the 2008 Roadmap for Large-Scale Research Infrastructure identified publicly funded facilities for boosting groundbreaking research with international collaboration. The Holst Centre, a joint venture public-private partnership on shared technology roadmaps and research, and the SURF Foundation promote ICT innovation.

Clusters and regional policies: The top-sector approach builds on specialised knowledge developed in nine economic sectors chosen for that purpose, such as high technology, food and chemicals. Other schemes are Regional Attention and Action for Knowledge Circulation (RAAK) and Innovation Performance Contracts (IPC).

Globalisation: The Netherlands has a strong international orientation but has been unable to translate this into an inflow of foreign knowledge workers and knowledge-intensive businesses. The Higher Education Internationalisation Agenda and a number of bilateral agreements with other countries aim to increase international collaboration. The Innovation Research Incentives Scheme extends eligibility for NWO grants to foreigners. The Netherlands Organisation for International Cooperation in Higher Education (NUFFIC) and the Science Visa Package support internationalisation of education. Prepare2Start is a free service that promotes internationalisation.

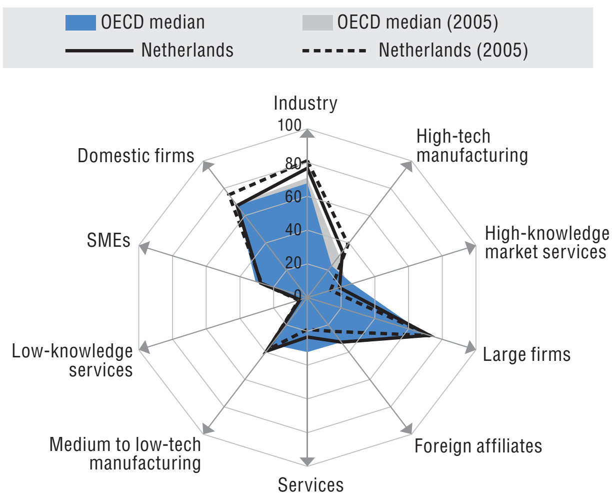
Human resources: The National Platform for Science and Technology (Delta Beta Techniek) Initiative aims to promote STEM education in all age groups. The Innovation Research Incentives Scheme is a joint initiative of NWO, KNAW and universities to support researchers and promote the scientific profession. It has a budget of USD 199 million for 2012. In 2011 the Dutch Cabinet published a Strategic Agenda for Higher Education, Research and Science: Quality in Diversity to challenge entrepreneurs, researchers, teachers and students to excel. The Science Centre, NEMO, promotes a science and innovation culture.

Emerging technologies: A number of emerging technologies are among the sectors listed in the Top Sector Strategy, *e.g.* high-technology systems and materials and life sciences. Point One conducts R&D on nanotechnologies, embedded systems and mechatronics.

Green innovation: Green innovation is a priority. A number of programmes support R&D in energy transition (EOS8 and UKR9) with a budget of USD 79 million. The Green Fund Scheme and the Venture Capital Scheme (TechnoPartner SEED facility) provide tax rebates for investing in authorised green funds.

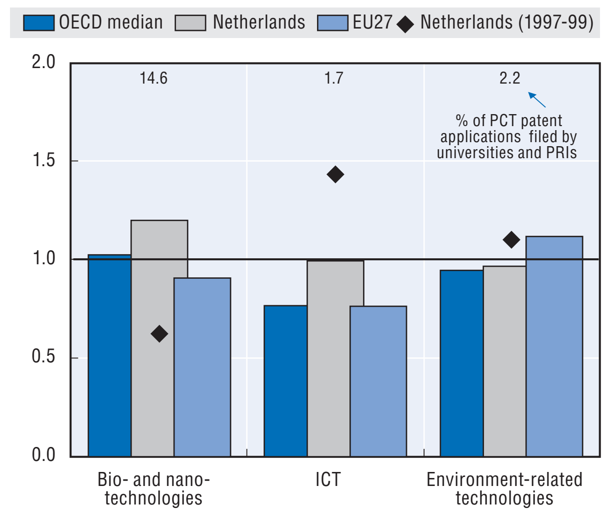
Panel 2. Structural composition of BERD, 2009

As a % of total BERD

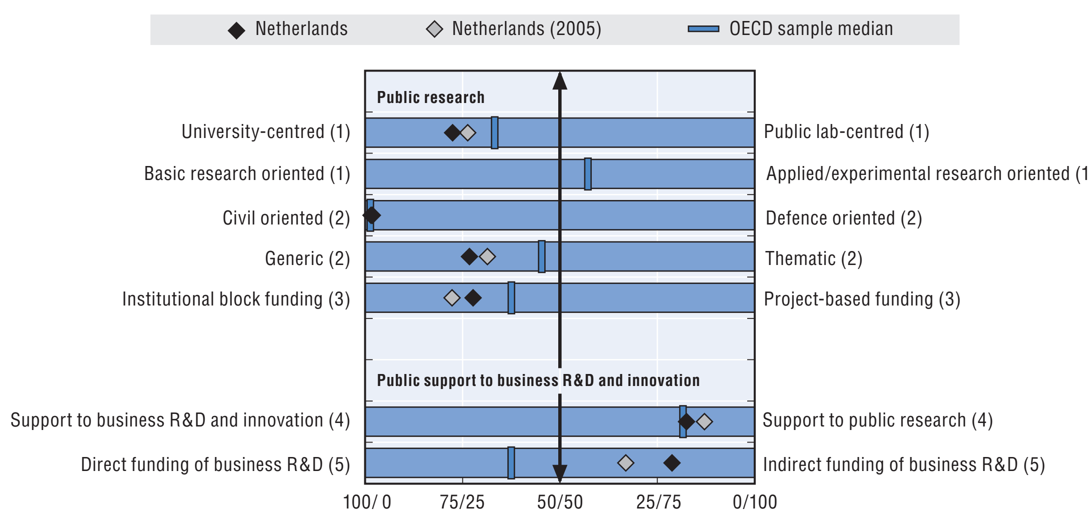


Panel 3. Revealed technology advantage in selected fields, 2007-09

Index based on PCT patent applications



Panel 4. Overview of national innovation policy mix, 2010



1. Balance as a percentage of the sum of HERD and GOVERD.
2. Balance as a percentage of total GBAORD.
3. Balance as a percentage of total funding to national performers.
4. Balance as a percentage of the sum of HERD and GOVERD funded by government and higher education and components of (5).
5. Balance as a percentage of the sum of indirect funding of business R&D and innovation through R&D tax incentives and direct funding of BERD through grants, contracts and loans.

Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888932690681

NEW ZEALAND

Hot STI issues

- Providing long-term goals and clear governance of the innovation system.
- Developing and growing knowledge-intensive businesses.
- Further strengthening the internationalisation of the innovation system.
- Rebuilding Christchurch as a high-technology city.

General features of the STI system: In spite of a significant reform effort, New Zealand's long-run productivity performance has been disappointing. Its economic geography – a small market in a peripheral location – creates challenges. Its economic structure relies heavily on its primary industries and it lacks large firms. This limits the level and leverage effects of business R&D investments throughout the broader STI system. BERD intensity is low at just 0.54% of GDP in 2009 (Panel 1[d]). Yet the innovation system has some strengths. The comparatively high share of public research funded by industry indicates sound linkages (1[o]). The country's RTA in bio- and nano-technologies has recently risen strongly and it has remained rather stable in ICTs and environment-related technologies (Panel 3). Educational attainment and skill levels are strong. PISA scores in science for 15-year-olds are the second highest in the OECD (1[t]). Some 40% of the adult population are tertiary-qualified (1[s]), 30% persons employed are in S&T occupations (1[v]) and there are 12.4 researchers per thousand total employment. Researchers are reasonably well integrated into global networks: 50% of scientific articles and 20% of PCT patent applications were produced with international collaboration (1[q][r]). ICT infrastructures are well developed. The number of fixed broadband and wireless subscribers is now a comparably high 26 and 54 per 100 inhabitants, respectively (1[k][l]), and the e-government readiness index is above the OECD median (1[n]).

Recent changes in STI expenditures: GERD is relatively low at 1.30% of GDP but grew by 4.7% between 2005 and 2009. In 2009, industry funded 38% of GERD, government funded 54% and 5% was funded from abroad. Funding was made available for national science challenges to boost "fundamental" innovation solutions. The new Ministry of Science and Innovation (MSI) is promoting the redevelopment of Christchurch, which has a number of high-technology firms, as a high-technology city and has made significant investments in the Natural Hazards Platform.

Overall STI strategy: The MSI Statement of Intent 2011-14 reflects a shift in strategy. It highlights two high-level outcomes – growing the economy and building a healthier environment and society – and remains committed to innovation in traditional resource sectors. However, it intends to add new areas of capability in knowledge-intensive activities, such as high-technology manufacturing and the services sector. It identifies six priority areas: high-value manufacturing and services, biological sciences, energy and minerals, hazards and infrastructure, the environment, and health and society.

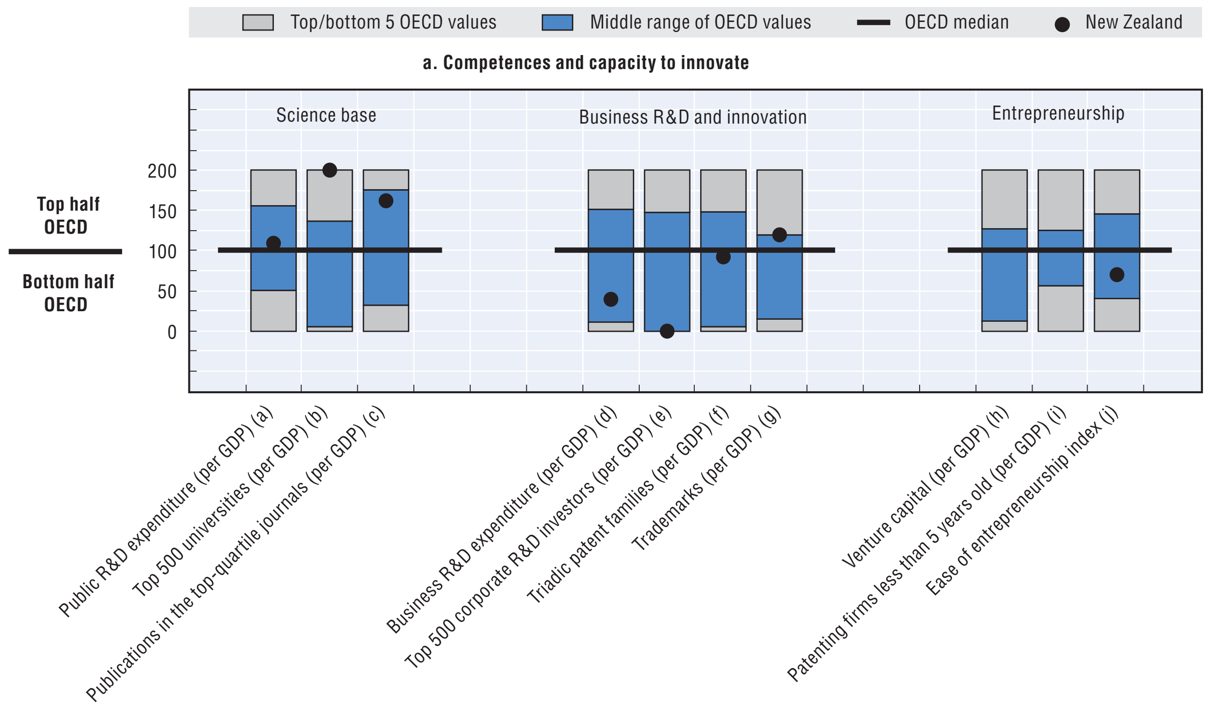
STI policy governance: MSI was created in 2010 and assumed responsibility for the Crown Research Institutes (CRIs) in close co-operation with the Royal Society of New Zealand. In line with the *OECD Review of Innovation Policy: New Zealand* (2007) and a review of

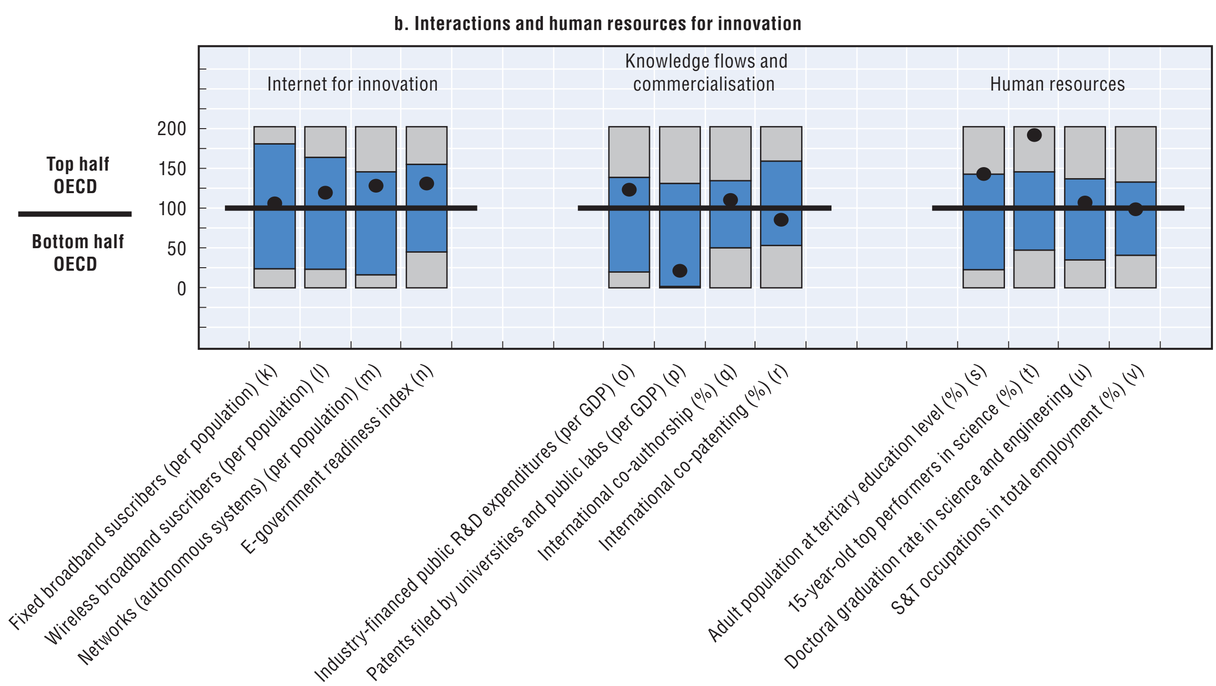
Key figures

Labour productivity, GDP per hour worked in USD, 2010	**34.0**	**GERD, as % of GDP, 2009**	**1.30**
(annual growth rate, 2005-10)	(+1.1)	(annual growth rate, 2005-09)	(+4.7)
Environmental productivity, GDP per unit of CO_2 emitted in USD, 2009	**4.08**	**GERD publicly financed, as % of GDP, 2009**	**0.70**
(annual growth rate, 2005-09)	(+3.2)	(annual growth rate, 2005-09)	(+5.5)

Figure 10.30. **Science and innovation in New Zealand**

Panel 1. Comparative performance of national science and innovation systems, 2011





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

the eight CRIs, reforms were introduced in 2011 to change their focus from profitability towards growth in the sectors they are linked with. This five-year funding agreement included shifting USD 155 million from contestable funding to core funding to increase the focus on research collaboration and technology transfer. Policy evaluation tends to be impact-oriented and will become "smaller and quicker" in the next decade, with a focus on pilot policy programmes.

Science base**:** New Zealand has a dual science system based on universities and the CRIs. The system is strong, as reflected in public expenditure on R&D, highly ranked universities and its research publication record (1[(a)(b)(c)]). Public R&D expenditure was 0.76% of GDP in 2009, but with the restructuring of CRIs, funding for health, state-owned and business-related research will increase.

Business R&D and innovation: Although BERD is comparatively low, New Zealand reversed its R&D tax credit in 2010. MSI currently offers four R&D support schemes: technology transfer vouchers, technology development grants, capability funding and funding from the New Zealand Venture Investment Fund (NZVIF).

Entrepreneurship: New Zealand's venture capital industry is relatively immature. The NZVIF has however made an impact, and invests USD 132 million through the Venture Capital Fund of Funds and the Seed Co-investment Fund. The Incubator Support programme facilitates the growth of early-stage businesses.

ICTs and scientific infrastructures: In view of New Zealand's geography, a high-performing ICT infrastructure is critical. To build on its current ICT capacity, the government will invest nearly USD 20 million over the next four years in the National e-Science Infrastructure (NeSI), a network of supercomputers, software and data services. NeSI will use the Kiwi Advanced Research and Education Network (Karen), which offers very high capacity broadband. MSI has also developed an Innovation Entrepreneurship Programme to support entrepreneurs in digital technologies. Ultra-fast Broadband in Schools (UFBiS) is a secondary school programme.

Knowledge flows and commercialisation: A National Network of Commercialisation Centres (NNCC) is to be in place in 2012, linking research organisations, entrepreneurs, incubators and regional development agencies. To ensure that the intellectual property regime remains in line with international standards, a new Patents Bill is currently under debate. Subject to commercial sensitivity, research findings are required to be published in journals and publicly available databases. This will increase the flow of publicly funded research to the general public, through platforms such as the Kiwi Research Information Service and *geodata.govt.nz.*

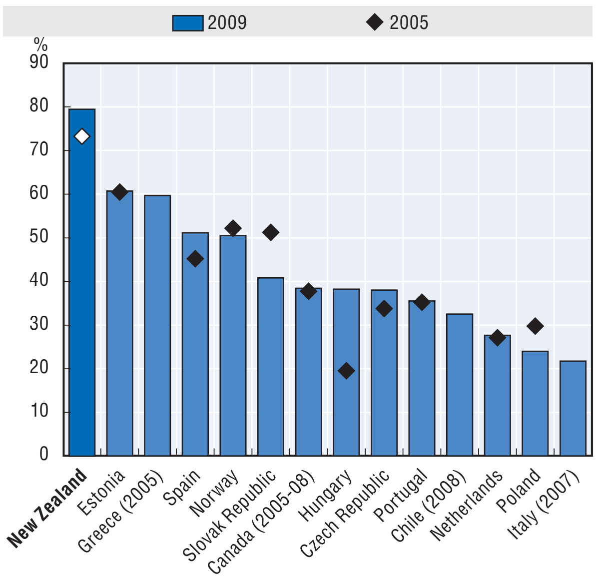
Globalisation: New Zealand has strong international networks, in spite of its remote location. Global Expert, a network of experts from universities, research institutions and global companies, assists firms to identify scientific, technological and market opportunities. New Zealand Trade and Enterprise (NZTE) and Beachheads Advisor Networks also link high-growth businesses with international investors. Allowing international PhD students to pay domestic tuition fees has increased interest from international students.

Human resources: To build on its already high level of human capital, a Science Programme was launched to raise student achievement in schools; the Tertiary Education Strategy 2010-15 outlines the vision for higher education. The Marsden Fund and Rutherford Discovery Fellowships fund exceptional research and support the career development of talented researchers. New programmes announced in 2011 include the Engaging New Zealanders with Research Science and Technology Fund, and Science and Biotechnology Learning Hubs.

Green innovation: The Green Growth Advisory Group, which represents the business and science sectors, has explored policy options for greener growth and presented a report to government in December 2011, *Greening New Zealand's Growth*. The report focuses policy advice on three topics: how to leverage an existing clean green brand, opportunities for the smarter use of technology and innovation, and options for SMEs to move to a lower carbon economy.

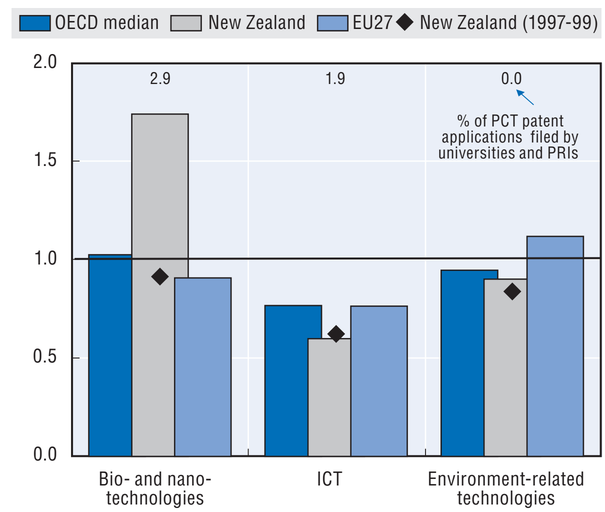
Panel 2. Share of BERD performed by SMEs, selected OECD countries (BERD < = 1% of GDP), 2005 and 2009

As a % of total GERD

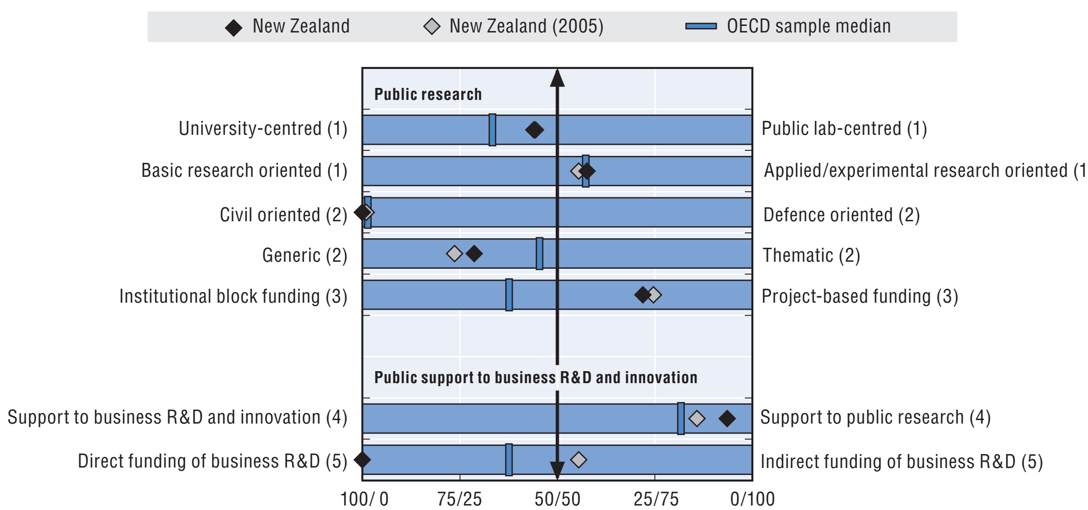


Panel 3. Revealed technology advantage in selected fields, 2007-09

Index based on PCT patent applications



Panel 4. Overview of national innovation policy mix, 2010



1. Balance as a percentage of the sum of HERD and GOVERD.
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Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888932690700

NORWAY

Hot STI issues

- Continuing economic diversification, building on the resource base and other strengths.
- Focusing on global challenges and green growth.
- Fostering innovation in services, including public services.
- Strengthening internationalisation and the attractiveness of Norway as a location for research.

General features of the STI system: Norway has one of the world's highest incomes per capita, owing in part to its rich and prudently managed natural resources (hydrocarbons in particular) but also to a highly productive economy, including business services. As noted in the *OECD Reviews of Innovation Policy: Norway*, the country's productivity performance indicates a level of innovation activity above what the country's rather modest GERD (1.69% of GDP in 2010) would suggest. BERD (0.87%) is below the OECD median (Panel 1[(d)]) but entrepreneurship indicators, notably venture capital (1[(h)]), exceed this benchmark. Indicators related to the science base (1[(a)(b)(c)]) are around or slightly above the OECD median. Norway's RTA in environment-related technologies is strong and has increased significantly over the past decade (Panel 3). It is underspecialised in bio- and nanotechnologies and ICT, despite some improvement. The ICT infrastructure is very strong and near the top of the OECD. Aspects of commercialisation, especially the filing of patents by universities and public labs, are moderate (1[(p)]).

Recent changes in STI expenditures: R&D expenditures increased to USD 4.7 billion in 2010. Between 2005 and 2010 GERD grew annually by 3.9%, and publicly financed R&D by 6.8%, indications of the resilience of the economy and government's commitment to STI. In 2009, industry funded 44% of GERD, government funded 47%, and 8% was funded from abroad.

Overall STI strategy: The *White Paper on Innovation Policy: An Innovative and Sustainable Norway* aims to increase innovation through creative people and undertakings. The *White Paper on Research* (2009-13) defines nine research policy goals (four horizontal and five thematic). Strategies for green growth and for biotechnology were presented in 2011; strategies for nanotechnology and ICT are to be completed in 2012. Ocean21 commenced in 2011 as a continuation of the previous "21-strategies". Research on the High North is also a long-term strategic priority. The Research Council of Norway (RCN) also develops research strategies, both thematic and for overarching issues such as internationalisation and innovation.

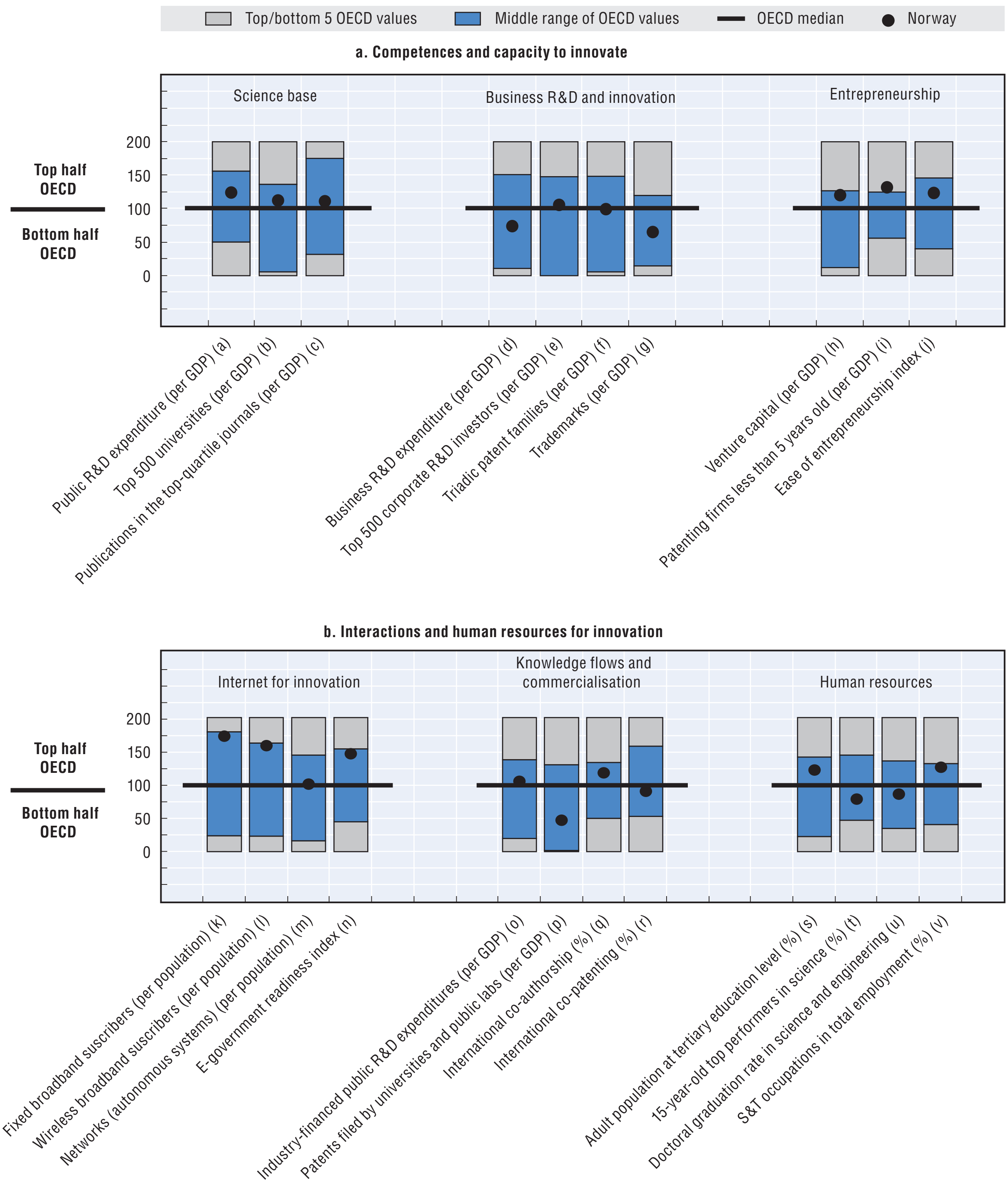
STI policy governance: The Norwegian ministries have overall responsibility for financing R&D in their sector. National priorities for research and innovation are formulated at government level. As the only research council in Norway, RCN is essential to the development and implementation of research and innovation policy and ensures co-ordination of research-related issues from basic research to innovation. RCN was reorganised as of 1 January 2011. Innovation Norway funds business innovation and regional development. It is now owned by the Norwegian Ministry of Trade and Industry (51%) and country authorities (49% on an equal basis). SIVA, the Industrial Development Corporation of Norway, provides practical

Key figures

Labour productivity, GDP per hour worked in USD, 2010	**75.3**	**GERD, as % of GDP, 2010**	**1.69**
(annual growth rate, 2005-10)	(–1.0)	(annual growth rate, 2005-10)	(+3.9)
Environmental productivity, GDP per unit of CO_2 emitted in USD, 2009	**7.14**	**GERD publicly financed, as % of GDP, 2009**	**0.84**
(annual growth rate, 2005-09)	(+0.0)	(annual growth rate, 2005-09)	(+6.8)

Figure 10.31. **Science and innovation in Norway**

Panel 1. Comparative performance of national science and innovation systems, 2011



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

information and infrastructure services for innovation; it has part-ownership of science and research parks. The Norwegian Design Council promotes the use of design as a strategic tool for innovation. Innovation Norway and SIVA underwent a comprehensive evaluation in 2010. An evaluation of RCN is under way and expected to be completed in 2012.

Science base: The public sector is a major research performer in Norway. HERD is 0.55% of GDP and GOVERD is 0.28% of GDP. The government decided to discontinue the Research Fund from the beginning of 2012 as interest rate fluctuations undermined stable funding. It will be replaced by regular funding through the national budget. Performance and indicator-based allocation mechanisms are used in all branches of the public research system, including higher education institutions, to which 30% of the funds are allocated, research institutes and health trusts.

Business R&D and innovation: A relatively large share of BERD is performed by SMEs (Panel 2). The Skattefunn tax credit scheme is the single largest R&D support scheme for business, with an expected tax expenditure of USD 135 million for 2012. The main programme for R&D grants to businesses, BIA, is an open research arena in which firms compete on project quality without thematic restrictions. Sector-oriented and specific technology programmes are also in place. Special importance is given to design. There has been some shift from indirect to direct support for business R&D and innovation (Panel 4).

Entrepreneurship: There are several specific programmes for seed capital: Argentum, a fund-of-funds invests in VC and private equity funds from start-ups to buyouts. The investment firm Investinor AS invests equity directly in companies in the start-up and later-stage venture phase. For seed capital funds, state capital is provided as loans with a risk relief element.

Clusters and regional policies: Regional R&D and innovation are promoted in clusters via programmes such as the VRI and ARENA programmes as well as in centres of expertise (NCE), and are also financed by dedicated regional funds for R&D.

Knowledge flows and commercialisation: Several instruments foster knowledge flows, including centres of excellence (SFF), centres for research-based innovation (SFI) and centres for environment-friendly energy research (FME). In addition, the Industrial and Public Sector R&D Contract Programmes (IFU/OFU) stimulate innovative development co-operation. The FORNY 2020 programme and technology transfer offices promote commercialisation. A White Paper on intellectual property is expected in 2012.

Globalisation: Internationalisation is an overall priority of the government's research and innovation policy. In 2010, RCN adopted a new internationalisation strategy under which all RCN activities must include clearly defined objectives and plans for international co-operation. In terms of funding, there is a shift from instruments dedicated to internationalisation towards including the internationalisation dimension in all activities. Norway actively promotes participation in European R&D programmes.

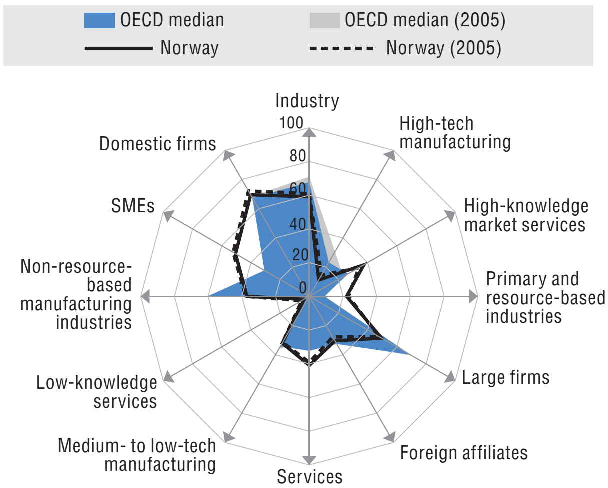
Human resources: Norway has a high share of the adult population with tertiary education (1[(s)]) and a high share of S&T occupations in total employment (1[(v)]). The Action Plan for Entrepreneurship in Education 2009-14 aims to strengthen students' personal skills, perspectives, creativity and innovative thinking. The Science for the Future Strategy 2010-14 promotes mathematics, science and technology. Career guidance and information is promoted via regional partnerships and career centres.

Emerging technologies: Green growth and environmental issues continue to develop as key areas for STI, alongside prioritised technology fields such as bio- and nano-technology, and ICT.

Green innovation: The Strategy for Green Growth supports green technology with a dedicated programme of USD 52 million (2011-13), including for offshore wind production facilities and green transport models. New centres for environment-friendly energy research (FME) have been established as has a new centre for climate research (Bjerknes Centre for Climate Dynamics).

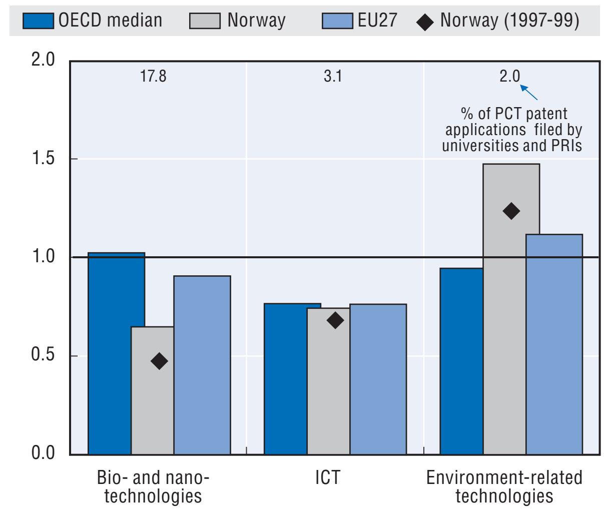
Panel 2. Structural composition of BERD, 2009

As a % of total BERD

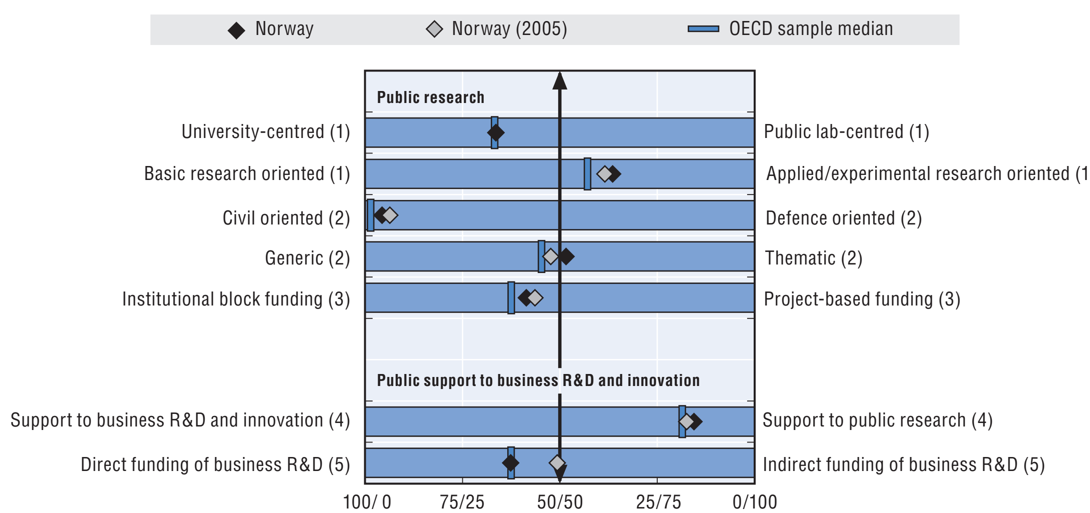


Panel 3. Revealed technology advantage in selected fields, 2007-09

Index based on PCT patent applications



Panel 4. Overview of national innovation policy mix, 2010



1. Balance as a percentage of the sum of HERD and GOVERD.
2. Balance as a percentage of total GBAORD.
3. Balance as a percentage of total funding to national performers.
4. Balance as a percentage of the sum of HERD and GOVERD funded by government and higher education and components of (5).
5. Balance as a percentage of the sum of indirect funding of business R&D and innovation through R&D tax incentives and direct funding of BERD through grants, contracts and loans.

Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888932690719

POLAND

Hot STI issues

- Implementing policies for a knowledge-based economy.
- Increasing R&D expenditure and improving the effectiveness of public research through better funding and governance.
- Stimulating innovation in the business sector and entrepreneurship.
- Increasing the qualifications and effectiveness of research personnel.

General features of the STI system: The Polish economy outperformed other EU countries during the recent global financial crisis. In spite of Polish firms' improved competitiveness on export markets, the STI system is characterised by a business sector which innovates relatively little and a weak academic system. In 2010, BERD was 0.20% of GDP, among the lowest in the OECD (Panel 1[(d)]). Links between industry and science have traditionally been weak, a legacy of the state planned economy. A small proportion of public research is funded by industry (1[(o)]) and very few patents are filed by universities and PRIs (1[(p)]). The integration of Polish science in international networks is better in industry (1[(r)]) than in academia (1[(q)]). Poland enjoys an RTA in emerging technologies such as biotechnology and nanotechnology, but has performed less well in ICT technologies (Panel 3). Enhancing human capital would improve innovation capacity: just 23% of the adult population has tertiary level education and only 27% of persons employed are in S&T occupations (1[(s)(v)]). Poland has a very low 4.1 researchers per 1 000 employment. However, PISA science scores of Polish 15-year-olds are almost at the OECD median (1[(t)]). The ICT infrastructure is well developed: Poland has 14 fixed broadband and 51 wireless subscribers per 100 inhabitants (1[(l)(m)]). The e-government readiness index, however, is comparatively low (1[(n)]).

Recent changes in STI expenditures: In 2010, Poland's GERD was 0.74% of GDP. However, GERD grew by a robust 10.3% a year between 2005 and 2010. Poland's target is for GERD to reach 1.7% of GDP by 2020. In 2010, industry funded a comparatively low 24% of GERD, while government funded 61%. The share of GERD financed from abroad doubled to 12%.

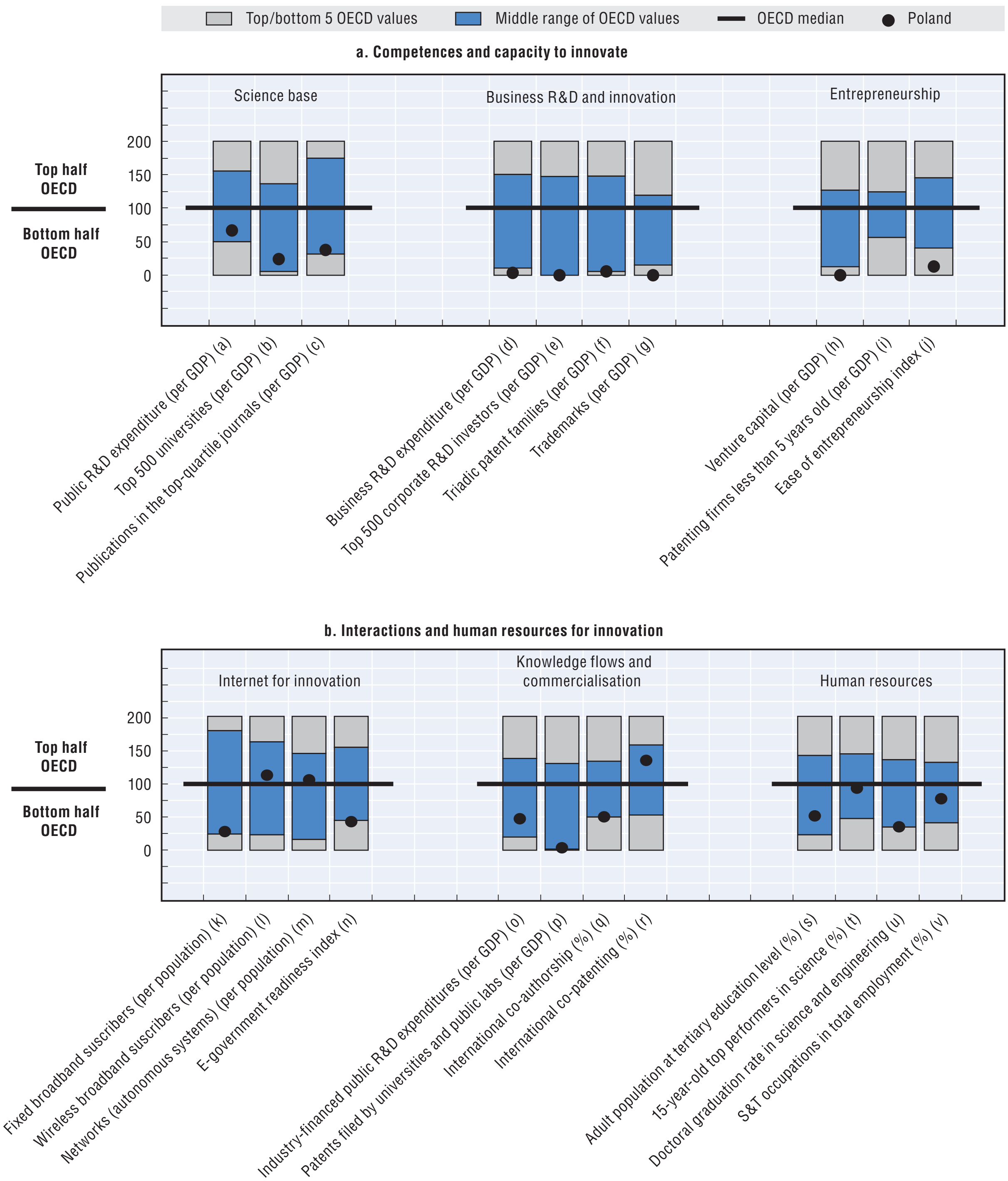
Overall STI strategy: Poland's STI strategy has recently been updated to include longer-term objectives. The more forward-looking long-term strategies, Poland 2030: The Third Wave of Modernity and the Strategy for the Innovativeness and Effectiveness of the Economy (2012-20), complement the National Reform Programme (NRP) and the Innovative Economy 2007-13. The objective of the National Cohesion Strategy (NCS) is to create favourable conditions for competitiveness. The new Science Development Programme and Entrepreneurship Development Programme promote a knowledge-based economy built on current strengths, emerging technologies and smart specialisation. The National Foresight Programme, Poland 2020, and the foresight programme InSight2030 outline potential scenarios for the next two decades.

Key figures

Labour productivity, GDP per hour worked in USD, 2010	**24.7**	**GERD, as % of GDP, 2010**	**0.74**
(annual growth rate, 2005-10)	(+2.9)	(annual growth rate, 2005-10)	(+10.3)
Environmental productivity, GDP per unit of CO_2 emitted in USD, 2009	**2.51**	**GERD publicly financed, as % of GDP, 2010**	**0.47**
(annual growth rate, 2005-09)	(+5.5)	(annual growth rate, 2005-10)	(+11.3)

Figure 10.32. **Science and innovation in Poland**

Panel 1. Comparative performance of national science and innovation systems, 2011



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

STI policy governance: Since 2010, changes to STI governance have been introduced to reduce fragmentation and improve co-ordination. The Ministry of Science and Higher Education (MSHE) is responsible for S&T policy design and the Ministry of Economy is in charge of innovation policy. The implementation of S&T policy is outsourced to the National R&D Centre (NCBiR), established in 2007, and the National Science Centre (NSC), created in 2010. The former was reformed in 2010 to improve public-private co-operation and increase private R&D spending. The Polish Agency for Entrepreneurship Development (PARP), supervised by the Ministry of Economy, is co-responsible for implementing innovation policy.

Science base: Despite a strong tradition in basic science, Poland's public-sector R&D spending as a share of GDP is low and rankings of universities and international publications are below the OECD median (1[(a)(b)(c)]). Part of the problem stems from fragmented sources of research funding, lack of competition and weak incentives for research excellence. Recently the science budget was increased by 29% and six new acts were passed to develop a more effective research system. At the same time, the government aims to increase the share of competitive-based research funding relative to block or statutory funding.

Business R&D and innovation: Polish firms are competitive on international markets as their strong export performance shows. However, they compete mainly on price, and few firms, particularly among SMEs, invest in R&D and innovation activities. This results in low ratios of BERD and patents to GDP (1[(d)(f)]).

Entrepreneurship: The government introduced one-stop shops to make business start-ups cheaper and faster. Although small, the Polish venture capital market is the biggest in eastern Europe. The National Capital Fund was launched in 2007 to boost growth. As part of the Technological Initiative programme, the Bank Gospodarstwa Krajowego (BGK) issues technology credits to micro firms and SMEs.

ICT and scientific infrastructures: The Research and Development of New Technologies Programme has received USD 359 million in funding for ICT infrastructure development. The Polish Roadmap for Research Infrastructure is being funded up to USD 2.1 billion. Finally, the NRP flagship initiative, Innovation Union, has been allocated USD 484 million to upgrade obsolete research infrastructures.

Clusters and regional policies: Cluster development is gaining increasing support. The Strategy for Increasing the Innovativeness of the Economy 2007-13 incorporates measures to support and develop clusters in national and regional operational programmes (OPs). Regional OPs operate in all 16 provinces (voivodships).

Knowledge flows and commercialisation: To facilitate knowledge flows and commercialisation, the MSHE launched a Guide for the Commercialisation of R&D for practitioners and the Patent Office assists universities. The IniTech project, Applied Research Programmes and Innovation Creator, financially supports knowledge transfer between researchers and entrepreneurs. The Innovation Voucher programme targets collaboration between SMEs and research institutions. The NCBiR also strengthens co-operation between business and technological platforms through public-private partnership.

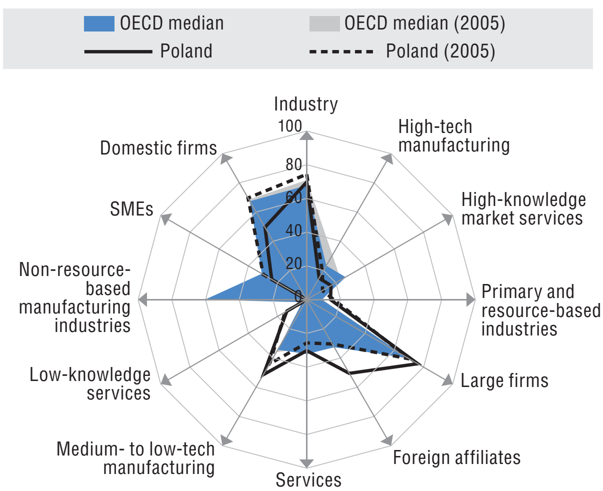
Human resources: Human capital development is a national priority, with investment from the Human Capital Operational Programme and the NCS. In 2011, almost USD 1.4 billion was budgeted for higher education and science, and the National Qualifications Framework and National Leadership Centres (KNOW) were introduced. Mobility Plus is a competitive incentive programme for academic researchers. The Top 500 Innovators Programme funds researcher exchanges with top-ranking world research institutions.

Emerging technologies: In 2011, the NCBiR introduced strategic research programmes for key technological areas for socioeconomic development. The Polish Agency for Enterprise Development funds the development and implementation of systems to support business R&D in key enabling technologies and notably the introduction of a dedicated database. The InSight2030 project identified 27 strategic key technologies for future lead markets.

Green innovation: Poland has embraced green growth in its National Reform Programme. The National Programme for Low-Emission Economy Development will be central for delivering green growth objectives. To minimise the environmental impact of government operations, the Public Procurement Office takes sustainability aspects into account in its tendering processes. The GreenEvo project supports the introduction of Polish green technologies on foreign markets.

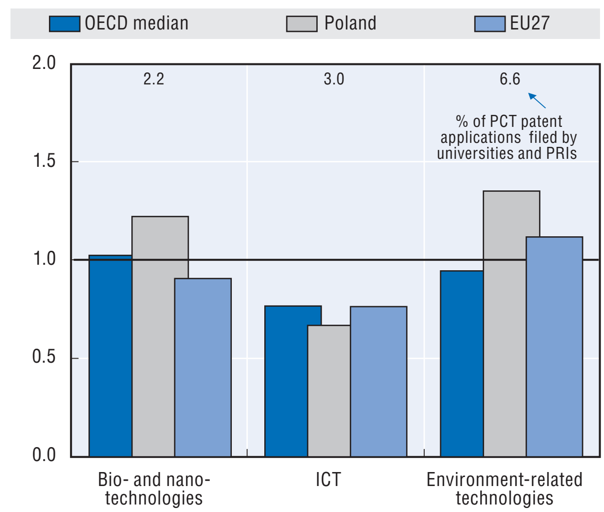
Panel 2. Structural composition of BERD, 2009

As a % of total BERD

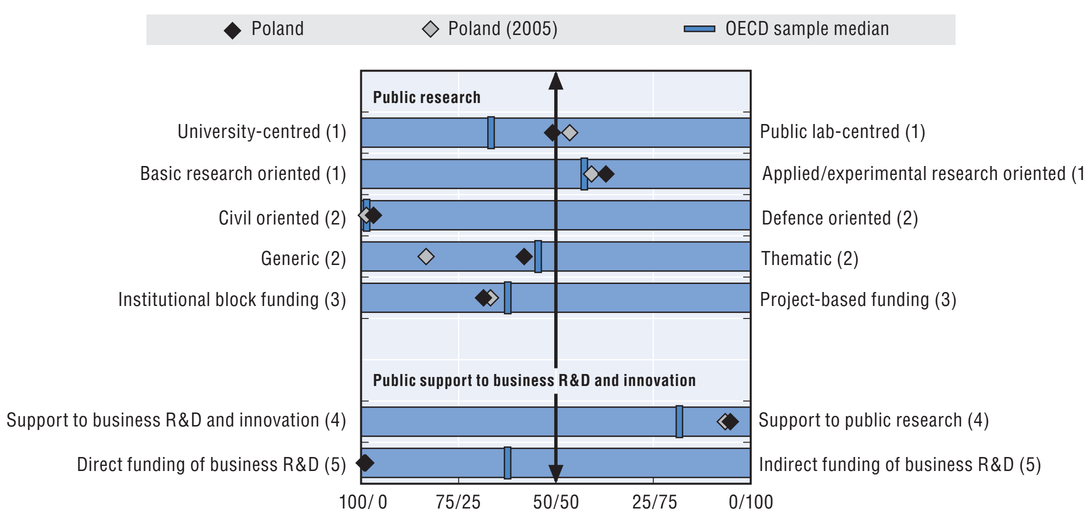


Panel 3. Revealed technology advantage in selected fields, 2007-09

Index based on PCT patent applications



Panel 4. Overview of national innovation policy mix, 2010



1. Balance as a percentage of the sum of HERD and GOVERD.
2. Balance as a percentage of total GBAORD.
3. Balance as a percentage of total funding to national performers.
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5. Balance as a percentage of the sum of indirect funding of business R&D and innovation through R&D tax incentives and direct funding of BERD through grants, contracts and loans.

Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888932690738

PORTUGAL

Hot STI issues

- Strengthening the commercial impact of public research and evaluating its performance on a regular basis.
- Increasing the level of human capital, including in relation to industry needs.
- Strengthening industrial innovation and entrepreneurship.

General features of the STI system: Boosting the country's economic potential for growth and competitiveness is a crucial target for Portugal, whose performance was weak even before the onset of the sovereign debt crisis in the euro zone. This primarily stems from an economic structure characterised by enterprises with low productivity and non-tradable services. In spite of its structural weaknesses, the Portuguese innovation system has improved significantly in recent years. Nevertheless, despite a significant increase in BERD since 2005 to 0.72% of GDP in 2010, indicators for business R&D and innovation still fall short of the OECD median (Panel 1[(d)(f)(g)]). Efforts to make the business environment more conducive to innovation include competition reform and easier new firm entry through entrepreneurship. Portugal shows good performance in terms of patents filed by universities and PRIs over 2005-09 (1[(p)]), while the share of public R&D expenditures financed by industry in GDP was at the bottom of the OECD in 2009 (1[(o)]). Although human capital remains a major bottleneck for restarting productivity growth, with only 15% of the adult population tertiary-qualified in 2010 (1[(s)]), S&E doctoral graduates in 2009 are above the OECD median (1[(u)]). Thanks to an effective proactive policy for developing ICT technologies, Portugal is a success in terms of wireless broadband penetration as of June 2011 (1[(l)]).

Recent changes in STI expenditures: In 2010, Portuguese GERD reached 1.59% of GDP, below the OECD and EU27 averages. GERD had nonetheless expanded by 15.9% annually since 2005. However, the economic crisis has resulted in a decline in R&D investment: from 2009 in private co-financing, and from 2011 in public funds.

Overall STI strategy: The national reform programme, Portugal 2020, adopted in 2011, mainly addresses business R&D and innovation. The new government has targeted entrepreneurship and innovation as priorities. A Strategic Plan on Entrepreneurship and Innovation (+E+I) was approved in 2011 to improve Portugal's overall competitiveness. Actions include the diffusion of an entrepreneurship culture and related skills and competences, the promotion of domestic and international knowledge flows, and the development of dedicated financial instruments.

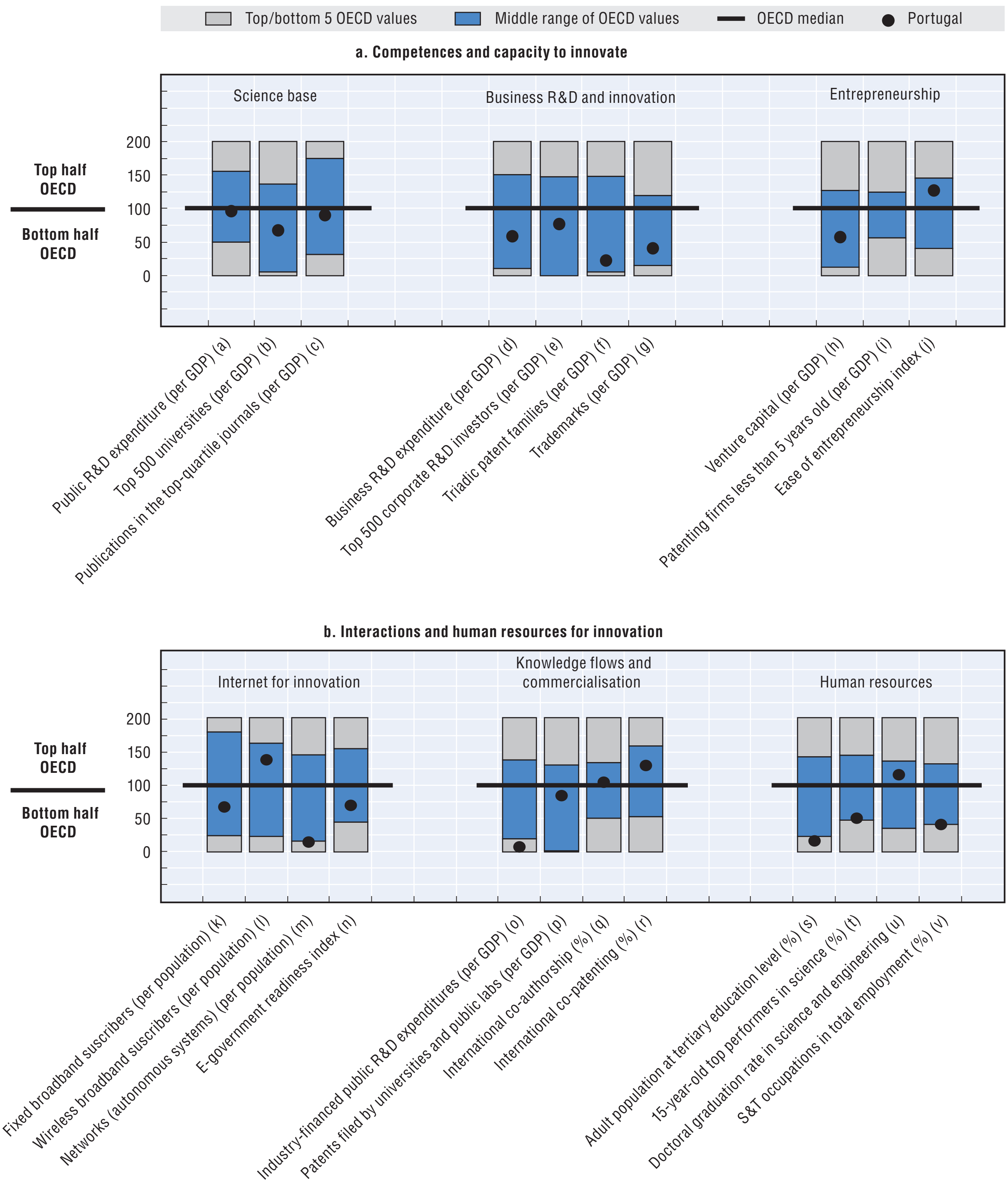
STI policy governance: Following the appointment of a new government in 2011, several ministries were merged, resulting in the establishment of a Ministry for the Economy and Employment and a Ministry for Education and Science with STI policy competences. A more significant change is the emphasis on co-ordination for the development of more comprehensive STI strategies, notably through the establishment of a new Science and Technology National Council in 2011, chaired by the Prime Minister.

Key figures

Labour productivity, GDP per hour worked in USD, 2010	**32.0**	**GERD, as % of GDP, 2010**	**1.59**
(annual growth rate, 2005-10)	(+1.6)	(annual growth rate, 2005-10)	(+15.9)
Environmental productivity, GDP per unit of CO_2 emitted in USD, 2009	**5.00**	**GERD publicly financed, as % of GDP, 2009**	**0.79**
(annual growth rate, 2005-09)	(+4.2)	(annual growth rate, 2005-09)	(+16.2)

Figure 10.33. **Science and innovation in Portugal**

Panel 1. Comparative performance of national science and innovation systems, 2011



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

Science base: Public R&D expenditure still accounted for 0.70% of GDP in 2010 (1[(a)]) and articles in scientific journals per GDP were slightly below the OECD median (1[(c)]). Portugal's science base is small but investments in the main PRIs and HEIs have been driving growth in R&D. Between 2005 and 2011, HERD as a share of GDP increased annually by 16.4%. In 2010, the higher education and government sectors accounted for approximately 44% of total Portuguese GERD. Scope for meeting the government's R&D target of 3.0% of GDP in the National Reform Programme 2020, appears limited, given fiscal consolidation.

Business R&D and innovation: In the current STI strategy, the business sector plays a central role in innovation. Public support to business R&D and innovation is mostly indirect (Panel 4), a trend reinforced by the 2009 Initiative for Investment and Employment which expanded the fiscal credit scheme SIFIDE. Still, raising the innovative capacity of the business sector will also require continued efforts to close the education gap.

Entrepreneurship: As a consequence of the economic crisis, a major issue for the government is to improve the efficiency of public expenditures. Entrepreneurship was defined as a priority and may help to increase the return on R&D investments. A dedicated strategy for the development of an entrepreneurial society, +E+I, was announced in December 2011. The EU/IMF financial assistance programme contributes to this objective by recommending the reduction of existing administrative burdens on business. The simplification of administrative procedures has continued under Simplex and Simplex Autàrquico, and licensing for some services was abolished in 2011.

ICT and scientific infrastructures: The Digital Agenda strategy promotes the development and use of new-generation networks to improve the quality of services for citizens and companies through public procurement initiatives. Its priority action lines include education, health-related services and smart mobility.

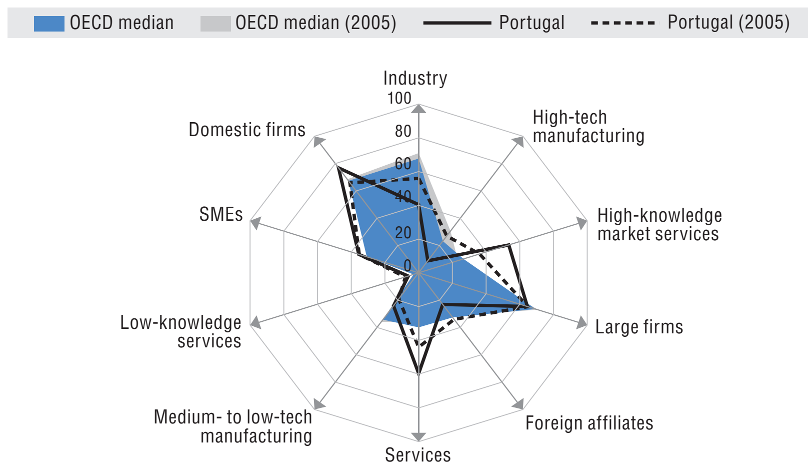
Globalisation: Internationalisation is one of the three priorities set by the new Portuguese government. An export intensity indicator (ratio of exports to turnover) was introduced as a criterion of eligibility for public support to firms to encourage them to enter global markets.

Human resources: The number of researchers in employment grew by more than 17.5% annually between 2005 and 2010 to reach 9.3 researchers per 1 000 employment (FTE) for the first time and raise Portugal closer to the levels of the most developed countries. Moreover, about 46% of researchers were women in 2009 (headcount). The Increased Commitment to Science 2020 programme aims to increase further the number of researchers by making Portugal more attractive, improving the quality of the education system, and diffusing a scientific culture. Instruments include grants, scientific visas or international collaboration programmes. Many measures have been introduced to increase secondary and tertiary education attainment: the Education Programme 2015 seeks to reduce repeat and drop rates. In addition, quality of education is addressed through the 2010 reform of the national teacher performance evaluation and the introduction of new digital teaching tools via the Digital Agenda.

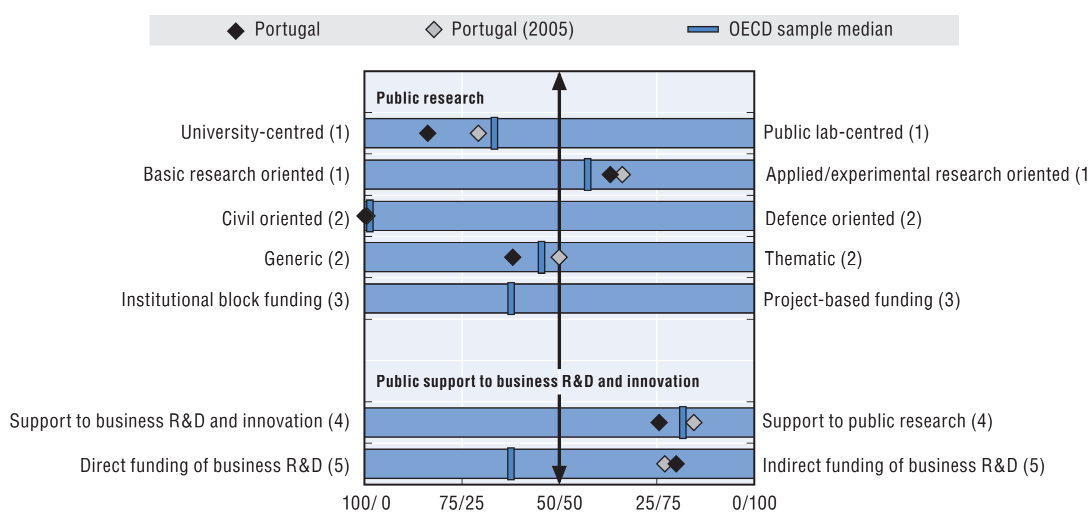
Green innovation: The action line dedicated to "smart mobility" in the Digital Agenda aims to support the development of energy-efficient technologies. It complements the National Action Plan for Energy Efficiency, adopted in 2008, whose measures include the diffusion of electric cars. This focus on energy efficiency is one of the priorities defined by the National Energy Strategy 2020, approved in 2010, to set a new vision for national energy policy with renewable energy as a key pillar.

Panel 2. Structural composition of BERD, 2009

As a % of total BERD



Panel 3. Overview of national innovation policy mix, 2010



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Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888932690757

RUSSIAN FEDERATION

Hot STI issues

- Increasing firms' innovation activities and strengthening the research activities of universities
- Better exploiting the commercial potential of public-sector R&D.
- Improving framework conditions for entrepreneurship and innovation.

General features of the STI system: The Russian Federation has a longstanding S&E tradition and many centres of excellence. It has a strong international reputation in key S&T fields such as aerospace, nuclear science and engineering, and advanced software. The bulk of Russian R&D is still performed in state-owned branch research institutes, which are mostly separate from industrial firms and HEIs. The share of public research funded by industry is slightly above the OECD median but the relative number of patents filed by universities and public labs is on a par with the bottom OECD countries (Panel 1[(o)(p)]). The picture for international collaboration is mixed: 31% of scientific articles are produced with international co-authorship (1[(q)]), which is on the low side, and 22% of PCT patent applications are produced with international collaboration (1[(r)]), which is close to the OECD median but reflects in part the patenting activities of international firms operating in the country. In spite of recent policy initiatives, overly restrictive regulation, exceptions to the rule of law, and a lack of competition are still major disincentives to entrepreneurship (1[(j)]). The tertiary attainment rate of 54% is very high (1[(s)]), well above any OECD country, but PISA scores in science for 15-year-olds are low (1[(t)]). Furthermore, the ageing of researchers and engineers raises concerns for future R&D capabilities. Russian RTA is close to the OECD average, with marked increases in nanotechnologies in recent years (Panel 3). ICT infrastructures are weak with 11 subscribers to fixed broadband networks per 100 inhabitants (1[(k)]). The e-government readiness index is below the OECD median (1[(n)]).

Recent developments in STI expenditures: GERD was 1.16% of GDP in 2010, a level significantly below the OECD median. The business enterprise sector funded just 26% of GERD in 2010, and government funded 70%, following a steady rise from 55% in 2000. R&D expenditure funded by government grew at an annual rate of 7.9% in the five years to 2010.

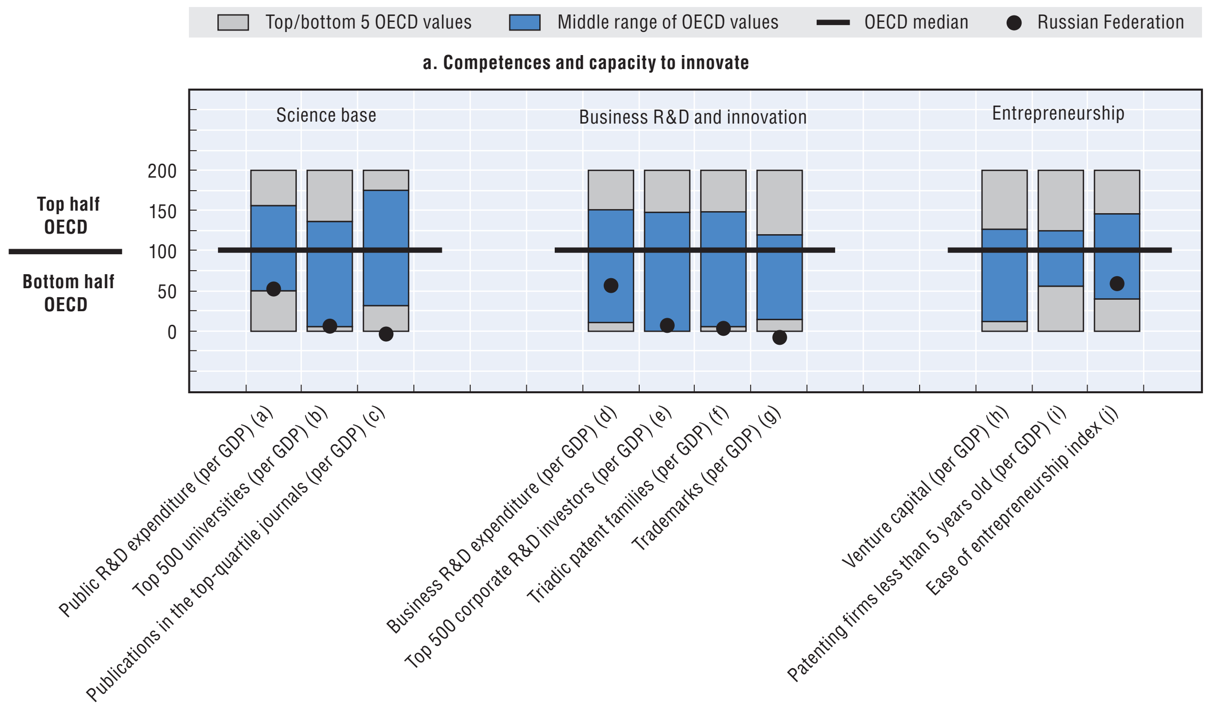
Overall STI strategy: After the onset of the financial crisis in 2008, a new strategic approach to Russia's modernisation emerged, with key long-term priorities for the national STI complex as well as a new framework for its governance. At the same time, a broader concept of innovation is being promoted, encapsulated in the Ministry of Economic Development's Innovation Development Strategy of the Russian Federation to 2020. Its objectives are to further develop human capital, stimulate innovation activities in the business sector, create a climate conducive to innovation in the public sector, increase the efficiency and dynamism of R&D, and promote international STI co-operation. In addition, the State Programme for Development of Science and Technology for 2012-20 has been established. Its goal is to concentrate resources on creating a competitive and effective R&D sector as a key driver for technological modernisation of the economy. In particular, it extends public support for priority technology areas and inter-sectoral S&T infrastructure.

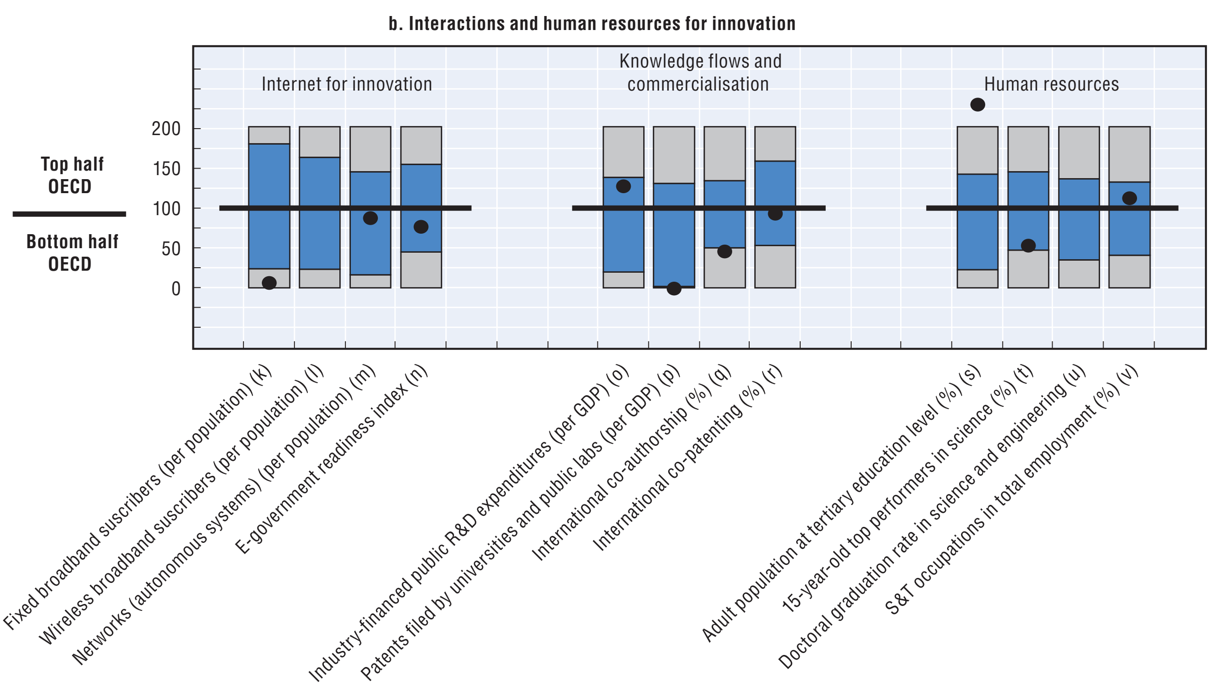
Key figures

Labour productivity, GDP per hour worked in USD, 2010	**20.6**	**GERD, as % of GDP, 2010**	**1.16**
(annual growth rate, 2005-10)	(+3.3)	(annual growth rate, 2005-10)	(+5.2)
Environmental productivity, GDP per unit of CO_2 emitted in USD, 2009	**1.75**	**GERD publicly financed, as % of GDP, 2010**	**0.82**
(annual growth rate, 2005-09)	(+3.1)	(annual growth rate, 2005-10)	(+7.9)

Figure 10.34. **Science and innovation in the Russian Federation**

Panel 1. Comparative performance of national science and innovation systems, 2011





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

STI policy governance: Several ministries support R&D and innovation, notably the Ministry of Education and Science and the Ministry of Economic Development. At the same time, the impact of the government's High Technology and Innovation Commission, as well as the President's Commission for Modernisation and Technological Development of Russia's Economy, is growing. They have become the main locus of policy decisions, with strong co-ordination powers in matters relating to R&D and innovation policies.

Science base: The public science base is large and dominated by industrial branch institutes. The institutes of the Russian Academy of Sciences also account for a significant share of publicly performed R&D and conduct the sorts of basic research carried out in HEIs in many OECD countries. Research outputs, as measured by the number of publications in scientific journals ($1^{(c)}$) and triadic patent applications ($1^{(f)}$) are weak. Efforts to strengthen research in HEIs include the launch of the programmes Research and Academic Teaching Potential of an Innovative Russia (2009-13) and Federal Targeted Support to Leading High Schools (2010-12). Much of the new investment aims to establish an elite cadre of research-led HEIs, similar to those of many OECD countries.

Business R&D and innovation: Business R&D is concentrated in larger companies, especially in resource-based industries. Besides traditional areas of excellence (*e.g.* nuclear energy, aerospace), these activities mainly support modernisation and technological renewal for productivity growth. Apart from a few high-technology firms (especially in the ICT sector), SMEs pursue non-R&D innovation strategies including technology adoption. Current policy practice for fostering innovation is twofold. A first group of measures seeks to relieve administrative barriers and improve framework conditions (including taxation and customs regimes) to stimulate innovation. A second set of measures targets major state-owned enterprises, notably the Innovation Enforcement initiative (2011-12), which obliges them to formulate and carry out innovation development strategies.

Clusters and regional policies: Russian R&D and innovation activities are largely concentrated in and around Moscow and St. Petersburg. The government has various schemes to promote regional clusters, including special economic zones, techno-parks and innovation and technology centres. In 2010, the government announced the creation of the new Skolkovo Innovation City, which offers incentives for the establishment of foreign subsidiaries.

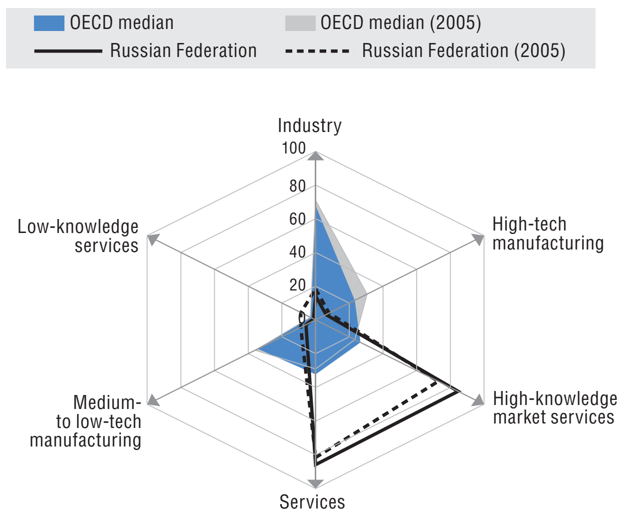
Knowledge flows and commercialisation: Limited co-operation between science, education and industry hampers innovation. The legal framework has been recently amended to promote co-operation. A series of federal laws (2009-11) encourages the creation of spin-offs from universities and research institutes, provides co-funding of research co-operation between companies and universities, and offers assistance in developing university innovation infrastructure. The Technology Platforms Initiative (2011) aims at fostering knowledge exchange and pre-competitive co-operation by enterprises, research institutes, universities and design bureaus along competitively selected thematic areas.

Globalisation: Russian innovation system has much to gain from stronger international connections. Among non-members the scale of the country's participation in the EU Framework Programmes is second only to that of the United States. At the same time, the government has continued efforts to stimulate inward FDI: in 2011, the need for prior government approval for foreign acquisitions in identified strategic sectors was removed.

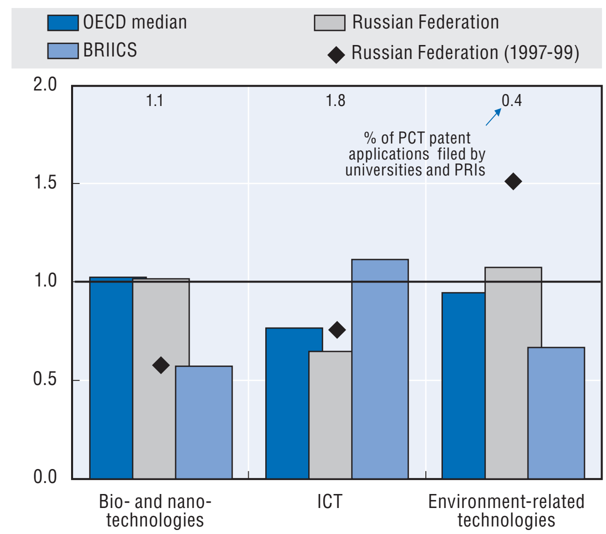
Emerging technologies: With traditional strengths in the materials and physical sciences, the government has placed great importance on becoming a world leader in nanotechnology. Federal investments increased with the creation of Rusnano in 2007. Significant support for emerging technologies also come from by the Russian Technologies State Corporation and the State Atomic Energy Corporation.

Green innovation: Owing to Russian high energy intensity, the government aims to implement measures to address energy efficiency. The *Federal Law on Energy Saving and Increasing Energy Efficiency* (2009) was the first step to promote International Energy Agency standards in the country. Further initiatives towards an energy-efficient economy are included in the Energy Strategy of Russia for the period to 2030. At the same time, investments in developing environment-related technologies have increased through dedicated programmes such as the New Generation Nuclear Energy Technologies (2011-15).

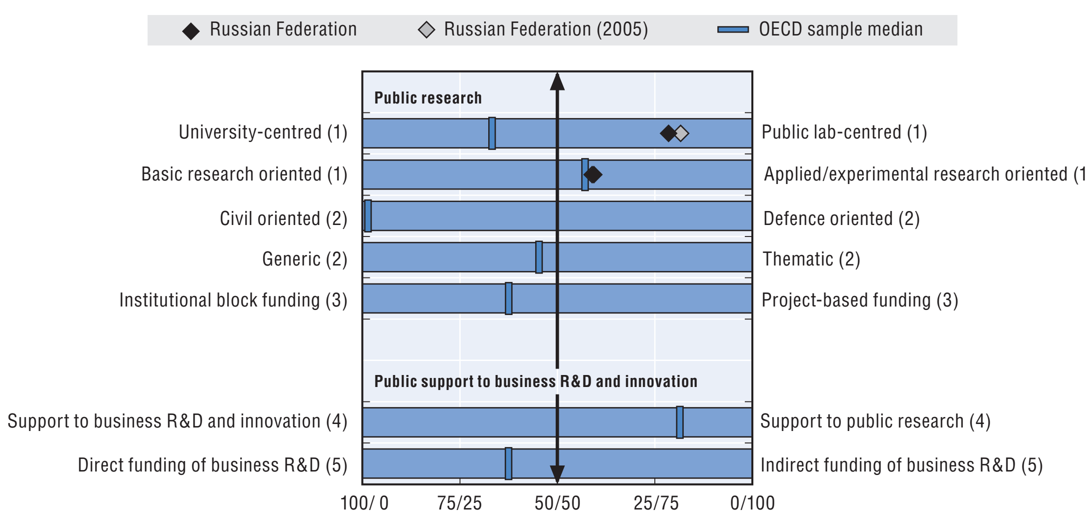
Panel 2. Structural composition of BERD, 2009
As a % of total BERD



Panel 3. Revealed technology advantage in selected fields, 2007-09
Index based on PCT patent applications



Panel 4. Overview of national innovation policy mix, 2010



1. Balance as a percentage of the sum of HERD and GOVERD.
2. Balance as a percentage of total GBAORD.
3. Balance as a percentage of total funding to national performers.
4. Balance as a percentage of the sum of HERD and GOVERD funded by government and higher education and components of (5).
5. Balance as a percentage of the sum of indirect funding of business R&D and innovation through R&D tax incentives and direct funding of BERD through grants, contracts and loans.

Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888932690776

SLOVAK REPUBLIC

Hot STI issues

- Reversing the downward trend in private investments in R&D and ensuring support for businesses to engage more in R&D.
- Developing high-quality R&D and technical infrastructures.
- Strengthening the quality of human resources from primary to tertiary levels.
- Improving the governance of the national innovation system (transparency, co-ordination, administration of EU funds, universities, etc.).

General features of the STI system: Over the past two decades, the Slovak Republic has shifted from a centrally planned economy to a free market economy and has been among the fastest-growing economies in Europe. Good economic prospects, a low-cost, medium-skilled labour force and a central location have attracted massive FDI, in particular in automotive and electronics industries. However, progress towards a more efficient STI system has been slow. Firms are little involved in research and business R&D outputs are among the lowest in the OECD (Panel 1[(d)(f)(g)]). BERD reached 0.27% of GDP in 2010, a level similar to the early 2000s, having bottomed at 0.18% in 2007. It is concentrated in a few medium-technology industries (machinery and transport equipment, 42%; rubber and plastics, 10%) or in R&D services (25%) (Panel 2). Links between industry and science are weak; industry funds only 9% of public research (1[(o)]). However, the Slovak Republic is strongly integrated in global networks: 48% of scientific articles and a high 48% of PCT patent applications are produced with international collaboration (1[(q)(r)]). ICT infrastructures are sub-optimal, with only 13 fixed broadband and 33 wireless subscriptions per 100 inhabitants (1[(k)(l)]) and the government makes little use of the Internet (1[(n)]). Skills foundations are weak but prospects for increasing human capital are robust. Only 17% of the adult population is tertiary-qualified (1[(s)]) but 29% of people in employment are in S&T jobs (1[(v)]). In spite of low R&D investments, the Slovak Republic has 7.1 researchers per 1 000 employment, above the EU27 average. Its 6% of top performers in science in the PISA ranking remains modest (1[(t)]) but the doctoral graduation rate is well above the OECD median, on a par with Austria or France(1[(u)]) .

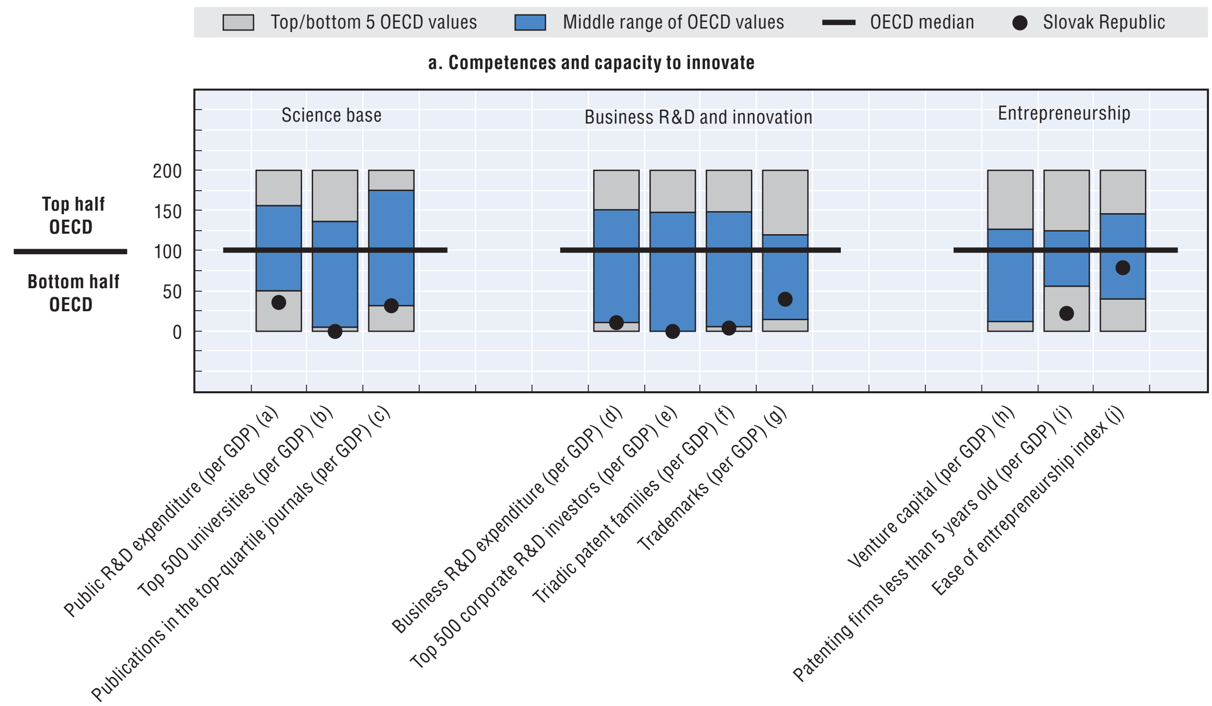
Recent changes in STI expenditures: GERD was USD 800 million and a low 0.63% of GDP in 2010. It grew however at a very fast 9.5% a year between 2005 and 2010. Business R&D investments fell in real terms from 2005 to 2009. Since 2000, the share of industry in total GERD funding dropped from 54% to 35%. Growth of GERD has been driven by the government's commitment (its share of GERD funding rose from 43% to 50%) and by massive inflows of foreign funding (from 2% to 15%) in particular from EU structural funds. Stimulus packages adopted by the government to mitigate the impact of the 2008 crisis have injected a further USD 50 million over four years to support R&D.

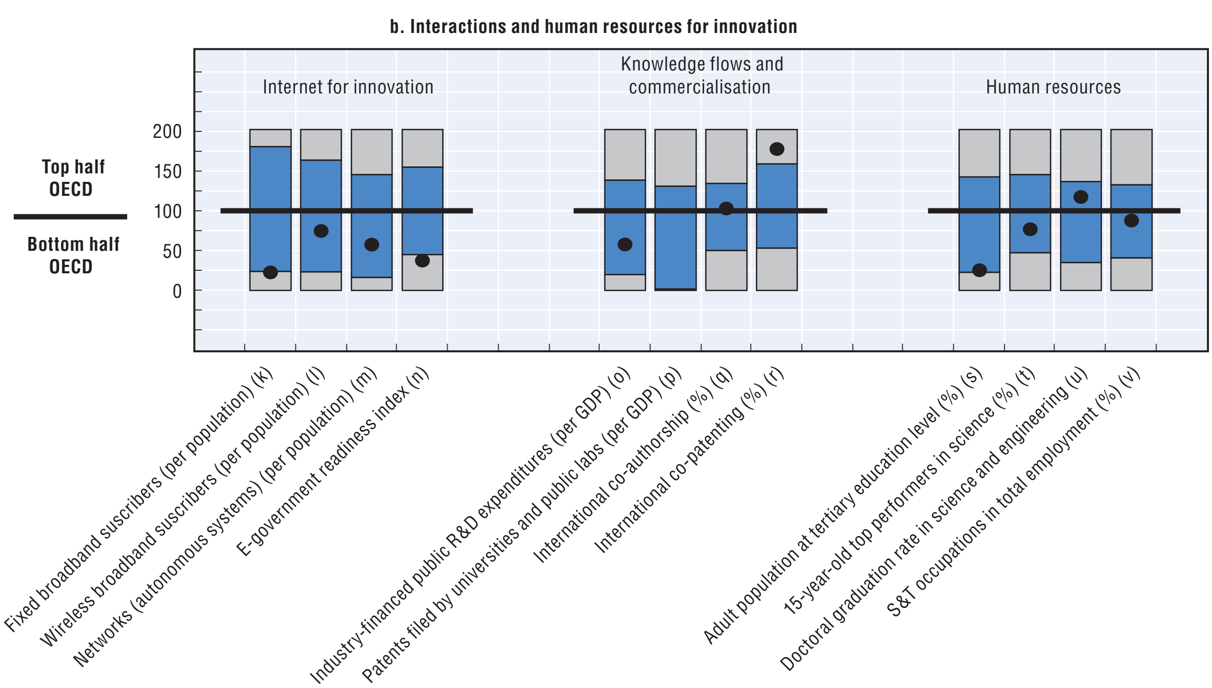
Key figures

Labour productivity, GDP per hour worked in USD, 2010	**33.6**	**GERD, as % of GDP, 2010**	**0.63**
(annual growth rate, 2005-10)	(+4.2)	(annual growth rate, 2005-10)	(+9.5)
Environmental productivity, GDP per unit of CO_2 emitted in USD, 2009	**3.71**	**GERD publicly financed, as % of GDP, 2010**	**0.32**
(annual growth rate, 2005-09)	(+9.1)	(annual growth rate, 2005-10)	(+6.5)

Figure 10.35. **Science and innovation in the Slovak Republic**

Panel 1. Comparative performance of national science and innovation systems, 2011





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

Overall STI strategy: The Long-Term Plan for Science and Technology Policy to 2015 aims to increase involvement in S&T and raise GERD to 1.8% of GDP. The Phoenix Strategy (2011) provides updates and emphasises universities as a tool for developing human resources. It fosters the internationalisation of R&D, better co-operation between the academic sector and industry, the creation of high-quality technical infrastructure, the development of human resources and the popularisation of S&T.

STI policy governance: The Phoenix Strategy identified several governance issues which need to be addressed: increasing the transparency and efficiency of the STI system; reforming public support mechanisms for effective R&D funding; less red tape in administering EU structural funds.

Science base: The Slovak Republic has a narrow science base, with public R&D expenditures at 0.36% of GDP (1[(a)]) and few articles in international publications (1[(c)]). The research system is dominated by public labs and focuses on basic research (Panel 4). University governance reform and a fundamental reform of the Slovak Academy of Sciences (SAV) are under way.

Business R&D and innovation: The R&D system relies heavily on direct financial measures. Competitive grants have become the main public funding instrument, for an estimated total of USD 111 million in 2012.

Entrepreneurship: The JEREMIE Initiative provides SMEs with equity for seed, start-up and development phases, with investment tranches up to USD 1.8 million. Boosting the Innovation of Small and Medium Enterprises in Slovakia (BISMES) also aims to provide information, analysis and funding to SMEs. The National Agency for the Development of Small and Medium Enterprises (NADSME) has conducted two important surveys to measure the innovation capacity and eco-innovation intentions of SMEs. The Ministry of Economy (MoE) uses the Innovative Deed of the Year and Young Designer competitions as incentives for innovators.

ICT and scientific infrastructures: The Research and Development Agency supports research teams at centres of excellence. The Ministry of Education, Science, Research and Sports (MESRS) is also working on a call to support R&D infrastructure. The National Information System (NISPEZ) operates an electronic information support system for R&D.

Knowledge flows and commercialisation: There is strong policy support for S&T parks and business incubators, although development is at an early stage. Minerva 2.0, a strategy to move the country into the "first league", contains a number of measures to link academics and the business sector at university science parks. A Risk Capital Programme has been operating since 2006. Minerva 2.0 and the Phoenix Strategy have a range of instruments and financial incentives to improve industry-academic co-operation and support the establishment of a national knowledge transfer centre and a better framework for protecting intellectual property.

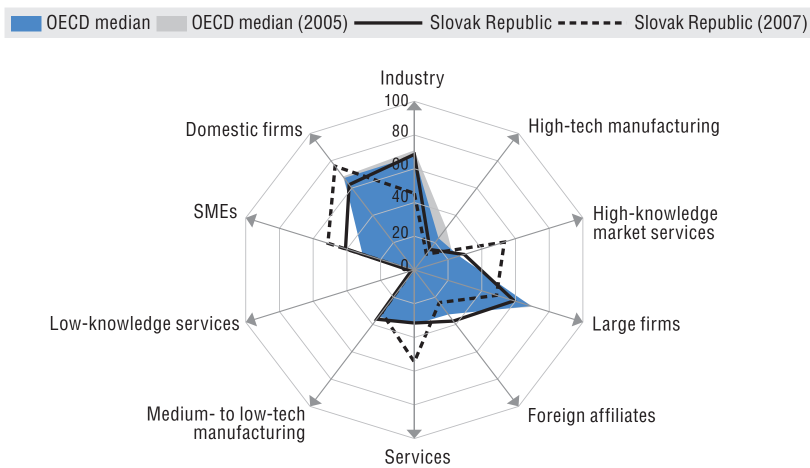
Globalisation: Minerva 2.0 noted a low level of participation in international research, and the Phoenix Strategy puts a high premium on mobility and promotes joint study programmes with prestigious foreign institutions. Mobility centres, the National Scholarship Programme for Mobility Support and the EC EURAXESS portals present opportunities to access global networks.

Human resources: One of the main priorities of the Phoenix Strategy is to popularise science. To this end, the National Centre for Science and Technology runs a variety of information campaigns. The strategy targets better secondary education through the PIAAC literacy and numeracy programme and supports doctoral studies through installation grants, English language assistance and streamlined research career paths. The Lifelong Learning Strategy and New Skills for New Jobs initiatives are directed at the adult labour market.

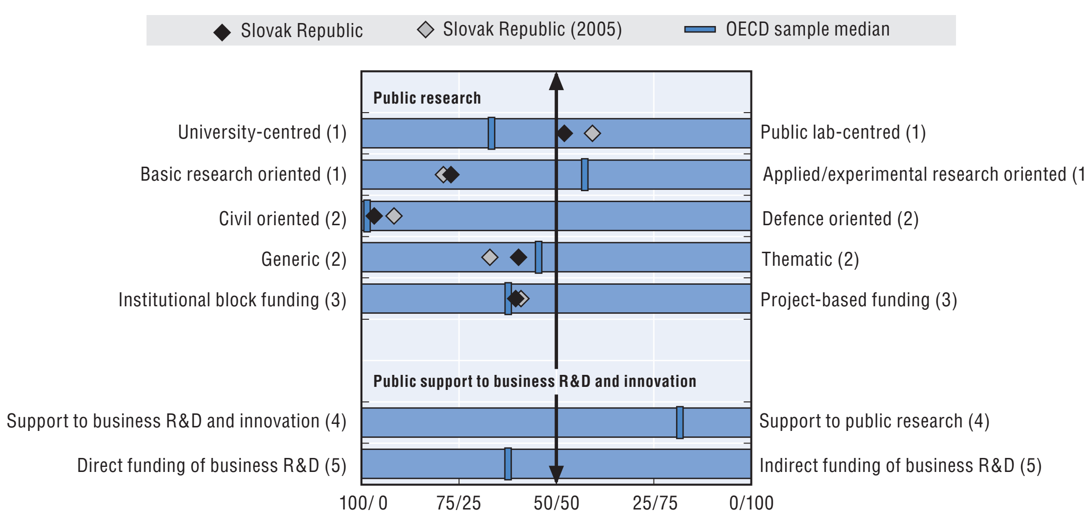
Green innovation: Eco-innovations are part of the country's Innovation Strategy and Innovation Policy to 2013. Support for eco-innovation is mainly provided through non-repayable grants from EU structural funds to increase energy efficiency in production and consumption, upgrade public lighting, promote green innovation activities in enterprises and green innovation and technology transfer. The government approved the National Action Plan for Green Public Procurement in 2012 to improve the implementation of green procurement in central and local governments through training, information, diffusion of tender models and monitoring.

Panel 2. Structural composition of BERD, 2009

As a % of total BERD



Panel 3. Overview of national innovation policy mix, 2010



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Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888932690795

SLOVENIA

Hot STI issues

- Implementing the Research and Innovation Strategy (RISS).
- Building a broad consensus on innovation.
- Increasing economic and social benefits of R&D performed in universities and PRIs through continuing reforms.
- Increasing the attractiveness of Slovenia as a location for research.

General features of the STI system: In less than two decades after gaining independence Slovenia has become a market-based economy, integrated world markets and joined the EU, the European Monetary Union and the OECD. It leads central and eastern European countries in GDP per capita and on a range of innovation-related indicators. BERD was a high 1.43% in 2010 (Panel 1(d)). Overall, business R&D has expanded rapidly in recent years, in spite of the recession and a slow recovery. Much of Slovenia's R&D is performed by a small number of firms: two pharmaceutical firms account for a large share of BERD. The services sector performs relatively little R&D (Panel 2). Yet, the sharp recession of 2009 exposed the economy's structural weaknesses. Productivity is lagging, performance in terms of new firm formation and technology transfer is not very strong, the number of high-technology firms is rather small, and high-technology and service exports are low as a share of total exports. Triadic patent applications and international co-patenting fall short of the OECD median (1(f)(r)).

Recent changes in STI expenditures: GERD reached 2.11% of GDP in 2010. It expanded by an impressive 9.9% a year between 2005 and 2010, in spite of the drop in GDP during the recession, and publicly financed GERD grew by 8.5% a year. In 2010, industry funded 58% of GERD, government funded 35% and 6% was funded from abroad. National targets are 1.5% of GDP for public R&D and an ambitious 3.6% for GERD by 2020.

Overall STI strategy: The Research and Innovation Strategy of Slovenia 2011-20 (RISS) and the National Higher Education Programme 2011-20 (NHEP) – to which the *OECD Reviews of Innovation Policy: Slovenia* contributed – provide strategic guidance. RISS aims to establish a modern research and innovation system that will improve quality of life. Its main priorities are: fostering scientific excellence, promoting co-operation between universities, research institutions and industry, and promoting international mobility and technology transfer. The Research Infrastructure Roadmap 2011-20 sets priorities for research infrastructure. More attention is given to evaluation of strategies, policies, programmes and institutions.

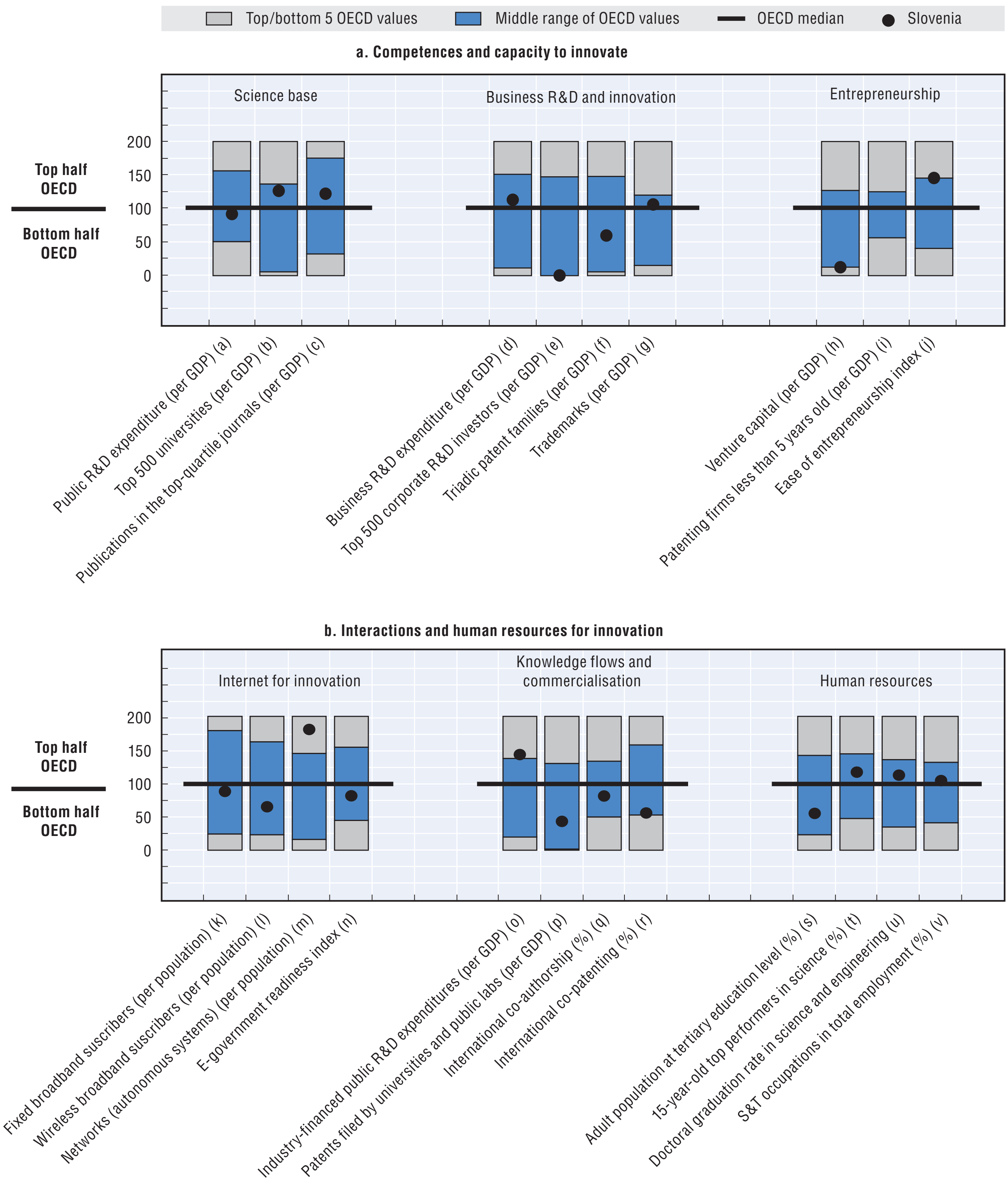
STI policy governance: Following general elections in December 2011, competences for STI policy have been reallocated and are now divided between the Ministry of Education, Science, Culture and Sports, the Ministry of Economic Development and Technology, and the Ministry for Infrastructure and Spatial Planning. The Slovenian Quality Assurance Agency for Higher Education was established in 2010 for accreditation, monitoring and evaluation of higher education institutions and study programmes.

Key figures

Labour productivity, GDP per hour worked in USD, 2010	**34.3**	**GERD, as % of GDP, 2010**	**2.11**
(annual growth rate, 2005-10)	(+1.4)	(annual growth rate, 2005-10)	(+9.9)
Environmental productivity, GDP per unit of CO_2 emitted in USD, 2009	**3.70**	**GERD publicly financed, as % of GDP, 2010**	**0.75**
(annual growth rate, 2005-09)	(+2.1)	(annual growth rate, 2005-10)	(+8.5)

Figure 10.36. **Science and innovation in Slovenia**

Panel 1. Comparative performance of national science and innovation systems, 2011



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

Science base: Slovenia has strengths in universities (1[(b)]) and in scientific output, as measured by the relative number of scientific articles per GDP (1[(c)]). Slovenia has a strong endowment of scientific and creative talent and a research culture. It has five universities and more than 40 PRIs. Unlike other transition economies, Slovenia has maintained and strengthened its PRIs. HERD stands at 0.29% and GOVERD at around 0.38% of GDP. Scientific output is outstanding in various respects, and there is considerable scope to increase the contribution of domestic research to Slovenia's socio-economic development, including through various forms of collaboration with industry. Among others, RISS sets out a plan for performance-based funding. A law on research and development that will provide a legal basis for renewed funding is in preparation.

Business R&D and innovation: To foster business R&D and innovation Slovenia operates a mix of instruments, including grants, tax incentives and instruments such as loan guarantees, mezzanine capital and equity. The Slovene Enterprise Fund grants start-up capital for new innovative companies. Mentor voucher and process voucher schemes have also been established.

Knowledge flows and commercialisation: There are several new mechanisms to foster knowledge flows. The centres of excellence (CoE) aim at strengthening quality and co-operation, building critical mass and linking up to top centres abroad through partnerships between industrial partners and academia. Competence centres (CCs) link science and industry and give a strong role to industrial partners, applied research and industrial networks. USD 188 million has been allocated for these two types of centres for 2010-14. The Development Centres programme supports projects that include R&D and investments in related infrastructure to promote technological development through consortia.

Globalisation: High absorptive capacity and integration in international research and innovation networks are critical for a small country's success in innovation. While Slovenia's innovation system is highly internationalised in some respects (*e.g.* a strong record of participation in European R&D programmes) it is much less so in others (*e.g.* attraction of foreign researchers, students and FDI, including in R&D). For instance, in 2008/09, only 1.7% of students were foreign. Several measures aim to make Slovenia more attractive internationally, such as university programmes in foreign languages, payment of European funds to foreign researchers and opening of research programmes to foreign participation (*e.g.* in the Young Researcher Programme).

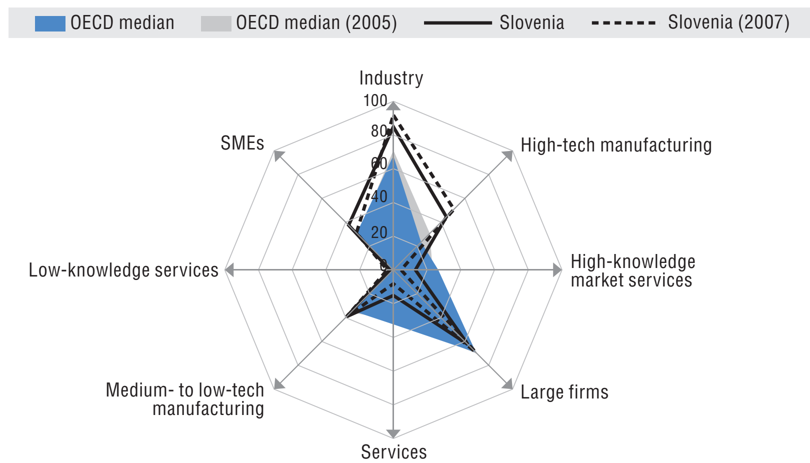
Human resources: Slovenia is comparatively strong in human resources and in S&T occupations (1[(v)]). They constitute an important pillar of Slovenia's innovation system. In the past five years, the number of researchers and R&D personnel has increased steadily. However, tertiary education completion rates are low compared to OECD and EU averages (1[(s)]). There are some disincentives for students to fast-track the completion of their courses as they may lose preferential treatment in the social and tax system.

Emerging technologies: Emerging areas of research and technology in Slovenia, which are reflected in the CoE and CC priorities, include ICTs, nanotechnology, health and life sciences, process technologies and effective use of energy.

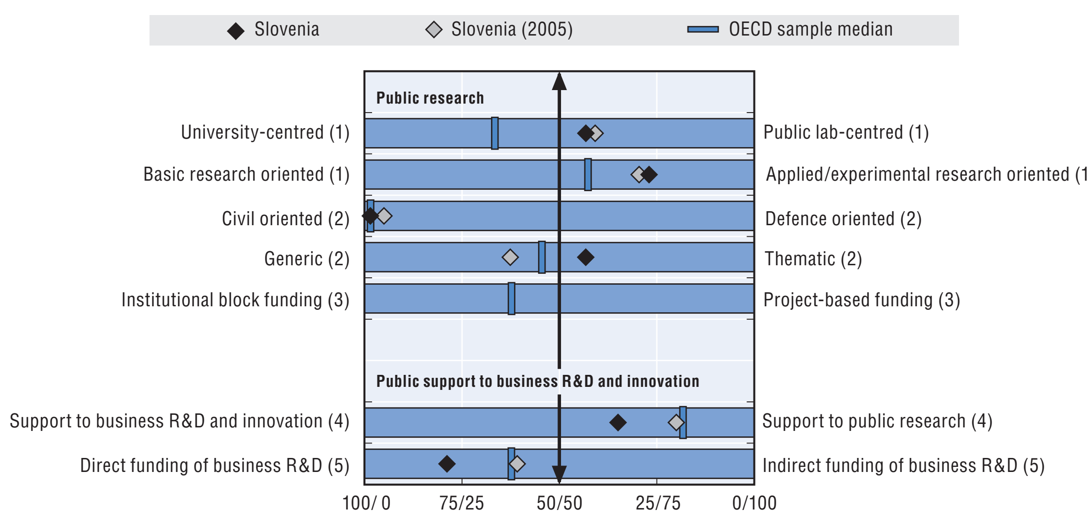
Green innovation: An action plan for the implementation of cradle-to-cradle principles is based on the concepts of eco-effectiveness, eco-efficiency and closed-loop economy.

Panel 2. Structural composition of BERD, 2009

As a % of total BERD



Panel 3. Overview of national innovation policy mix, 2010



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Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888932690814

SOUTH AFRICA

Hot STI issues

- Strengthening innovation capacity in the business and public sector to boost economic performance and address social challenges.
- Fostering collaboration between government, academia and business.
- Improving the governance of the innovation system.

General features of the STI system: South Africa is the continent's leading economy, with strong resource-based industries and strengths in services. Its innovation system has been shaped by infrastructure, assets and distortions inherited from the apartheid era. In 2008, BERD was 0.54% of GDP but 59% of GERD. While a large resource-based sector and the secondary economy limit the level and leverage of business R&D investments, the S&T base supports pockets of global excellence. Research and innovation rely on industry-science links (Panel 1[(o)]) and there is good integration in international business and academic networks. International collaboration plays a role in 46% of scientific articles and 14% of patents (1[(q)(r)]). South Africa's RTA in emerging technologies increased rapidly over the past decade, albeit from a low base, notably in biotechnology. RTA in environmental technologies has eroded, however. A major bottleneck for South Africa's economic and social development is the lack of a broad skills foundation. Only 4% of the adult population has tertiary level education (1[(s)]); 16% of workers are in S&T occupations (1[(v)]). The lack of design, engineering, entrepreneurial and management capacity is a major constraint. The ageing of the white male population of researchers and engineers further weakens the skills base. IT infrastructures are relatively under-developed: fixed broadband subscribers number about 1 per 100 inhabitants (1[(k)]) although there is a fast-growing mobile telephony market throughout all of society. The development of network industries has been hampered by market domination by state-owned firms and restrictive legislation.

Recent changes in STI expenditures: Recent growth in GERD has been driven by public money, injected since 2002 as part of the National R&D Strategy. Between 2003 and 2008, business funding of R&D hardly increased while government funding doubled (Panel 2). Public funding is expected to keep increasing owing to the government's competitiveness and growth package. South Africa attracts R&D funding from abroad from multinational companies and through its active participation in global R&D initiatives (EU Framework Programmes) as well as through joint R&D programmes with multinationals.

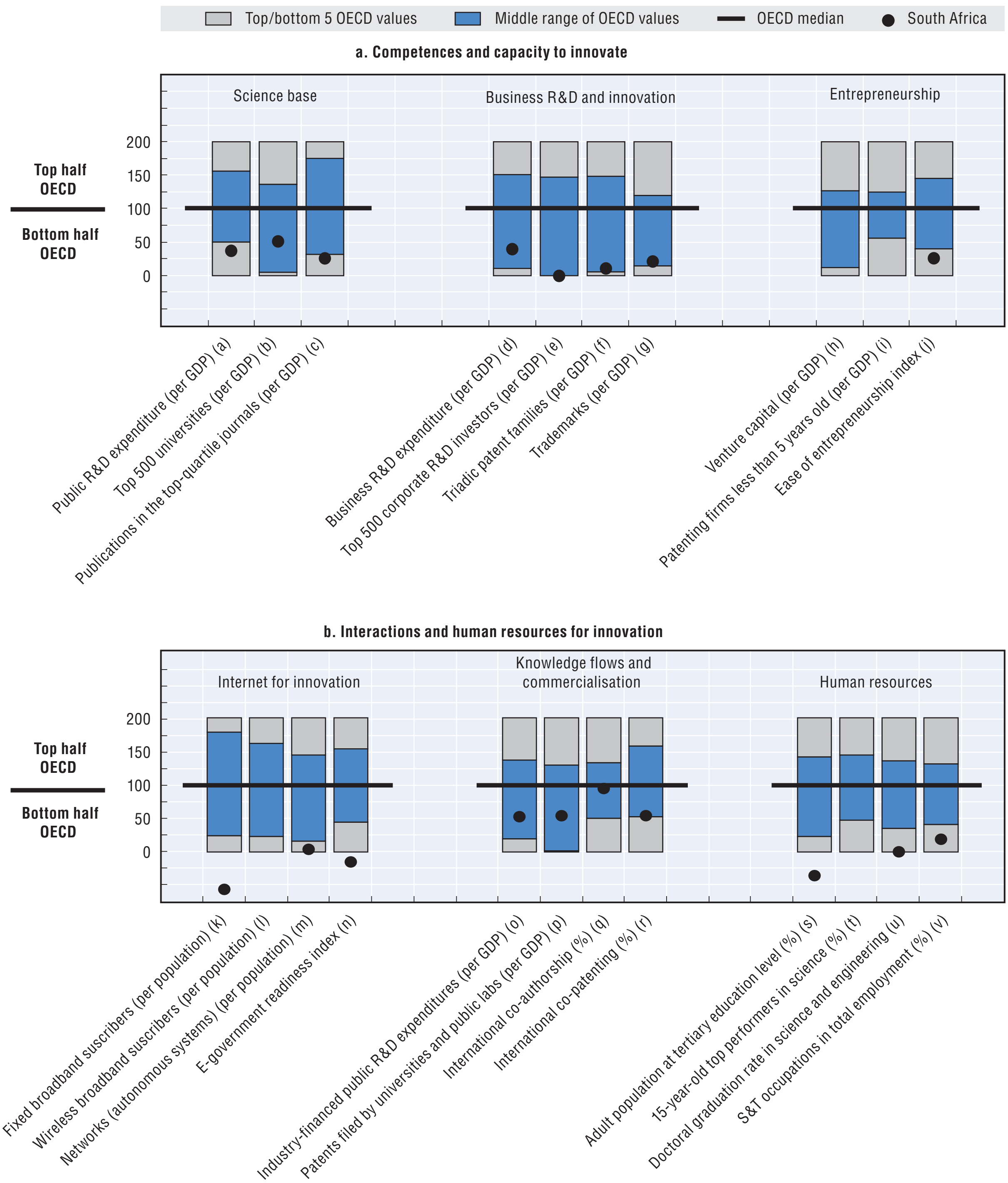
Overall STI strategy: The Ten-Year Innovation Plan (2008-18) identified five "grand challenges": biotechnology and pharmaceuticals, space, energy security, climate change, and understanding of social dynamics. These are in line with South Africa's technological advantages, dependency on coal and social challenges. Growing attention is given to allocation of public resources to address gaps in human capital and infrastructure in these areas.

Key figures

Labour productivity, GDP per hour worked in USD, 2010	**n.a.**	**GERD, as % of GDP, 2008**	**0.93**
(annual growth rate, 2005-10)	n.a.	(annual growth rate, 2005-08)	(+5.9)
Environmental productivity, GDP per unit of CO_2 emitted in USD, 2009	**1.37**	**GERD publicly financed, as % of GDP, 2008**	**0.42**
(annual growth rate, 2005-09)	(+0.4)	(annual growth rate, 2005-08)	(+9.3)

Figure 10.37. **Science and innovation in South Africa**

Panel 1. Comparative performance of national science and innovation systems, 2011



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

STI policy governance: The *OECD Reviews of Innovation Policy: South Africa* pointed to scope for improvement, including in horizontal and vertical policy co-ordination. The Ministry of Science and Technology (DST) has tasked a committee to evaluate the functioning of the national system of innovation.

Business R&D and innovation: South Africa intends to add capacity for developing advanced manufacturing technologies and new R&D-led industries in order to transform the industrial base, enhance local appropriation, benefit from natural resource endowments and increase competitiveness. The Framework for South Africa's Response to the International Economic Crisis (2009) reiterated a growing need for scientific and technological input to address national challenges in areas such as energy security, food security and industrial development. Subsequently, increased financial support to industry was announced to drive the National Industrial Policy Framework (NIPF), which had been adopted before 2008. Links to STI policies are to be strengthened with the creation of the Technology Innovation Agency (TIA) (2010).

ICT and scientific infrastructures: South Africa has made structural investments in large-scale facilities. Based on its ICT Strategy, infrastructure projects have been rolled out, *e.g.* the Centre for High Performance Computing and the South African National Research Network (SANReN), a high-speed network that connects the South African research community to global research networks. Significant investments in scientific equipment include the Centre for High Resolution Electron Microscopy (CHRTEM) and the world-class Karoo Array Telescope (MeerKAT). The National Roadmap on Research Infrastructure is currently being developed.

Knowledge flows and commercialisation: Adoption of IP policies for publicly funded R&D, the creation of the National Intellectual Property Management Office and development of infrastructures for open innovation, *e.g.* technology transfer offices at PRIs, aim to improve technology transfer and commercialisation of research. The National Technology Transfer Centre provides grants for technology transfer to the secondary economy. The Technology Localisation Programme provides non-financial assistance to local manufacturers to help them qualify for public procurement programmes, while technology stations provide innovation management and support for technical development to inventors, entrepreneurs and SMEs.

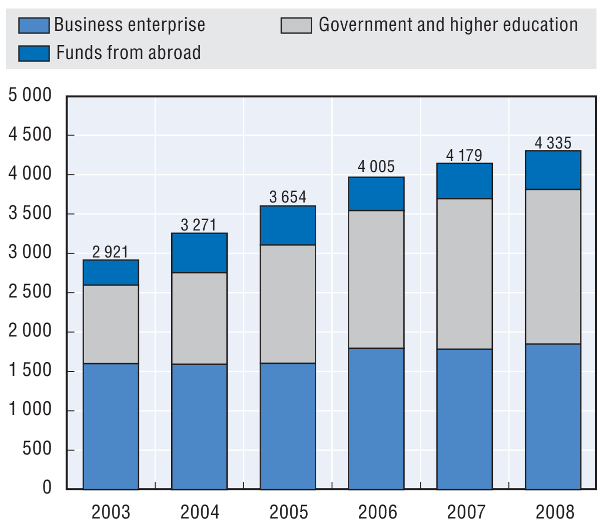
Human resources: To nurture a new generation of researchers and to address skills shortages, a series of initiatives aim to encourage participation in STEM studies (*e.g.* Youth into Science Strategy), in doctoral and postdoctoral studies (National Research Foundation Fellowships) and in research careers, including for women and the black community (*e.g.* Thuthuka Programme). Financial support to researchers has helped to mitigate brain drain. The new National Human Resources Development Strategy (2010-20) anticipates future national human resources requirements. Increased policy attention has been paid to lifelong learning and better articulation between workplace learning and higher education.

Emerging technologies: The Biosciences Park is being developed to assist biotechnology start-up firms to incubate marketable products. An Astronomy Desk has been established at the DST and the South African National Space Agency has been established.

Green innovation: Development of the renewables market is seen as key to energy sufficiency and the transition to a green economy. The South African Renewables Initiative (SARi) foresees an ambitious 25% reduction in CO_2 emissions. The Renewable Energy Finance and Subsidy Office (REFSO) was set up to manage renewable energy subsidies and offers advice to developers. The Green Efficiency Fund, which is administered by the Industrial Development Corporation (IDC), assists South African companies to invest in energy efficiency and renewable energy projects. The DST is currently developing a Waste Innovation Plan, in order to address the increasing waste problem in South Africa, and a ten-year roadmap for innovative technologies to improve water security.

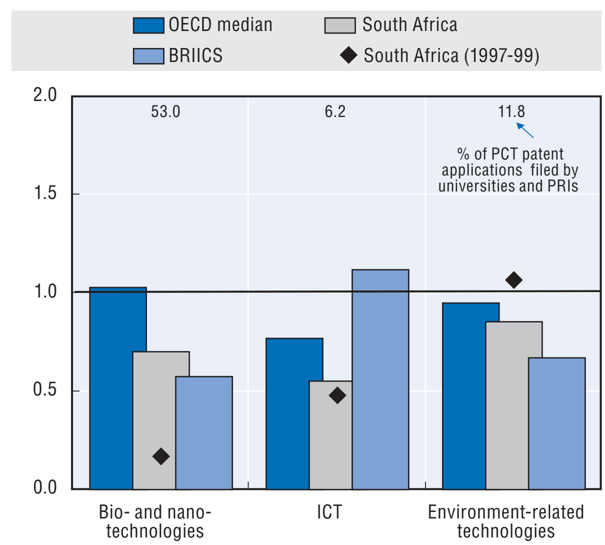
Panel 2. GERD by source of funding, 2003-08

As a % of total GERD

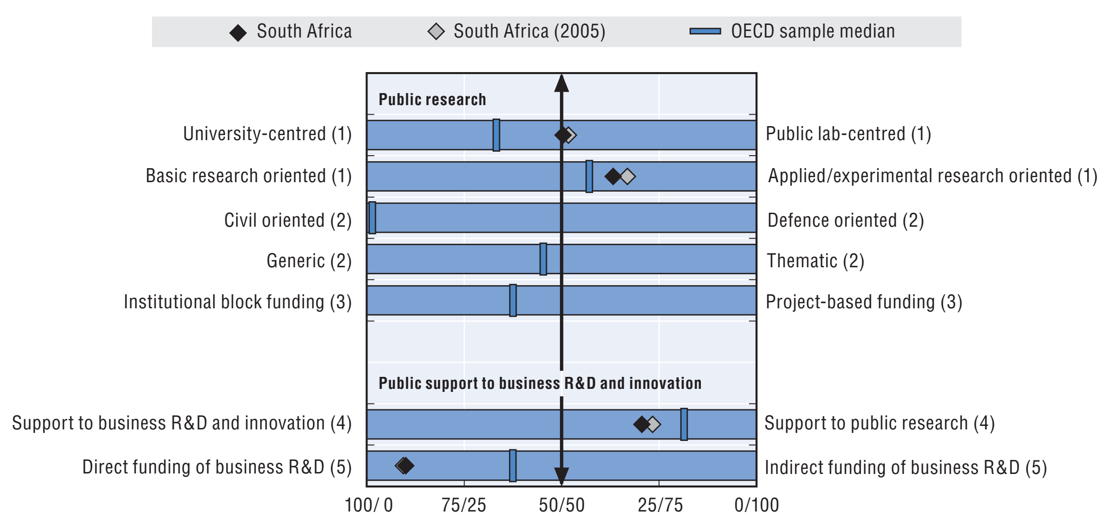


Panel 3. Revealed technology advantage in selected fields, 2007-09

Index based on PCT patent applications



Panel 4. Overview of national innovation policy mix, 2010



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Source: OECD, Research and Development Statistics (RDS) Database, June 2012; see reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888932690833

SPAIN

Hot STI issues

- Improving the quality of human resources at all levels.
- Maintaining support for R&D and innovation despite difficult budgetary conditions.
- Helping small innovative companies to grow and increasing the innovativeness of larger firms.
- Building on the dynamism in emerging technologies and improving the connection between Spanish research and global innovation networks.

General features of the STI system: Over the past decade Spain has made significant efforts to modernise and upgrade its traditional manufacturing and services sectors (*e.g.* food, textiles, chemicals, metal products, machinery and equipment, transport equipment, tourism) and to expand into more knowledge-intensive industries. BERD was 0.71% of GDP in 2010, below the OECD average of 1.62% (2009) (Panel 1[(d)]). It has expanded less than total GERD during 2005-09. Furthermore, data from the Spanish Statistical Office show that the number of companies carrying out R&D activities in 2010 fell by 15.6% from 2009, continuing a trend from 2008. International comparisons of business innovation indicators (top companies, patenting, trademarks) point to a weak competitive position (1[(e)(f)(g)]), and SMEs outperform larger firms in terms of contribution to R&D and innovation expenditure (Panel 2). Spanish efforts have resulted in an increase in the number of researchers and in scientific production, although figures for 2010 show that Spain accounts for only 3.6% of OECD scientific publications and 0.5% of OECD triadic patent families. The rate of patents filed by universities and public labs is on a par with the OECD median (1[(p)]). Spain has deepened its RTA in emerging technologies, although its position in ICTs remains relatively weak (Panel 3). For human resources, Spain's performance is low in terms of 15-year-olds performing well in science, doctorates in S&E and S&T occupations (1[(t)(u)(v)]).

Recent changes in R&D expenditures: Between 2005 and 2010, GERD expanded at an annual average 5.3% from 1.12% to 1.39% of GDP. The public sector has made most of the effort. Publicly financed GERD expanded by an annual 8.6% during 2005-09. However, in 2010 GBAORD fell from USD 10.3 billion to USD 9.8 billion in real terms. The weak fiscal outlook for 2012 may strengthen this trend and the government finances a larger share of BERD (17.1% in 2009) than in most OECD countries (average of 8.9% in 2009).

Overall STI strategy: The State Innovation Strategy (E2i) for 2010-15 aims to change Spain's production model by promoting and creating structures to improve the use of scientific knowledge and technological development. The *Act on Science, Technology and Innovation* (STI Act), which entered into force in December 2011, replaces a 1986 science law and explicitly aims to integrate technology and innovation activities with scientific research. The new governance framework defined by the STI Act will be supported by the Spanish Strategy for Science and Technology 2013-20, which is being developed, and the recently drafted State Plan for Scientific and Technological Research.

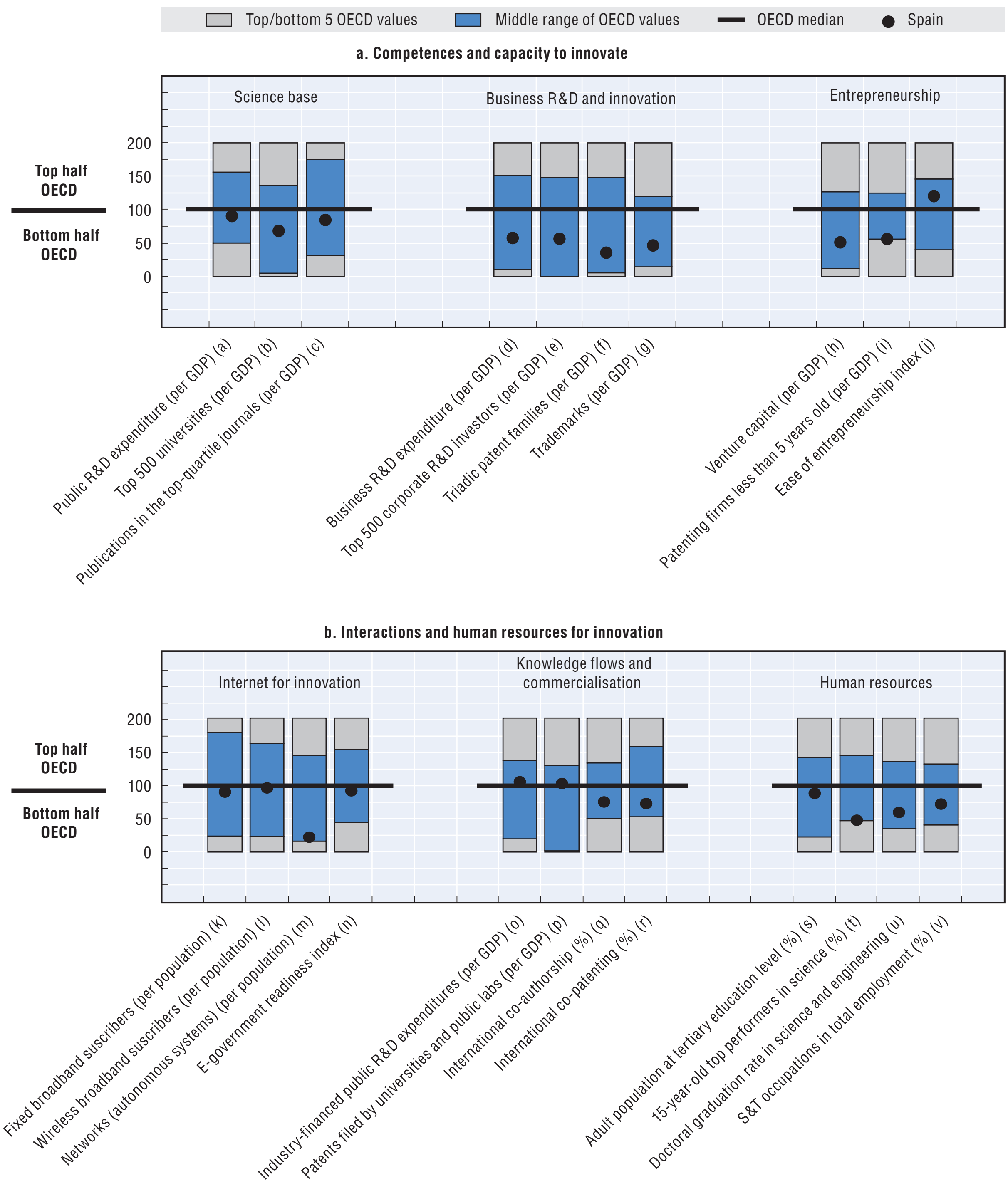
STI policy governance: The STI Act creates a new research funding and governance structure for the Spanish STI system with the creation of the State Research Agency (a funding body) and

Key figures

Labour productivity, GDP per hour worked in USD, 2010	**47.2**	**GERD, as % of GDP, 2010**	**1.39**
(annual growth rate, 2005-10).	(+1.6)	(annual growth rate, 2005-10)	(+5.3)
Environmental productivity, GDP per unit of CO_2 emitted in USD, 2009	**5.22**	**GERD publicly financed, as % of GDP, 2009**	**0.70**
(annual growth rate, 2005-09)	(+5.9)	(annual growth rate, 2005-09)	(+8.6)

Figure 10.38. **Science and innovation in Spain**

Panel 1. Comparative performance of national science and innovation systems, 2011



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

comprehensive reform of PRIs. The Act defines new governance mechanisms to ensure co-ordination of central and regional governments (*e.g.* a STI information system to share information among centraland regional administrations). The Centre for Development of Industrial Technology (CDTI) remains responsible for funding industrial and innovative activities nearer to the market. In addition, the new government, formed in December 2011, created a new Ministry for Economy and Competitiveness which took over the competences of the Ministry of Science and Innovation.

Science base: The most challenging tasks for Spain are to increase the quality of its scientific publications and to enhance the contribution of public research to the economy and society. The University 2015 Strategy aims to increase universities' contribution to social and economic needs and to improve their competitiveness. It includes an evaluation system, with international assessment, to monitor and measure universities' progress.

Business R&D and innovation: The government continues to improve the environment for business R&D and innovation and has seen significant increases in the number of innovative and R&D-performing firms even if current performance is weak. The government's corporate tax deduction for innovative activities was recently raised from 8% to 12%, and the *Sustainable Economy Act* raised the upper limit for global R&D and innovation activities from 50% to 60% of gross taxes. The CDTI also offers information services to companies interested in developing R&D projects (*e.g.* PIDI network). The State Innovation Strategy seeks to increase business expenditure on R&D and innovation by USD 8.3 billion a year by 2015, the number of innovative companies by 40 000, and the number of employees in medium- and high-technology companies by half a million.

Entrepreneurship: Venture capital is below the OECD median (1[h]), despite programmes to support start-up phases, such as INNVIERTE (USD 422 million for 2011-14). The rate of young patenting Spanish firms less than five years old is at the lower end of the middle range (1[i]). The InnoEmpresa programme for 2007-13 specifically targets SMEs and includes regional projects and supra-regional projects in which SMEs from several regions participate.

ICT and scientific infrastructures: Spain has developed a strong ICT infrastructure but has weak networking facilities. It has scientific and technological structures which are open to the entire national and international scientific, technological and industrial community. The Plan Avanza2 for 2011-15 has a budget of some USD 6 billion to promote ICTs in public administration, health care, welfare and education and to extend the telecommunications network. Recent efforts at national level include improving and upgrading existing ICTs with a budget of about USD 160 million for 2007-15.

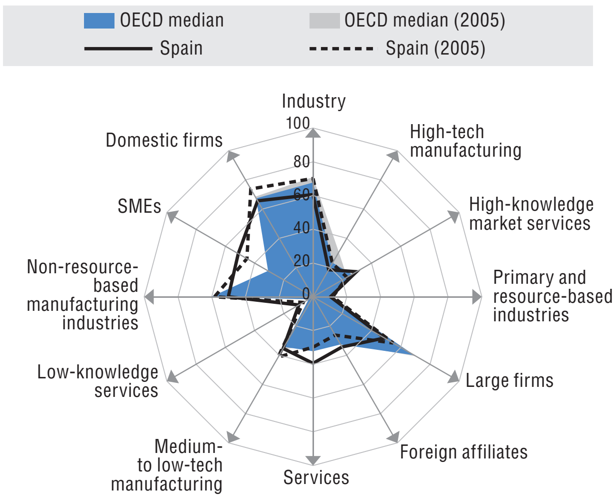
Human resources: In spite of overall improvements in education and human capital, including increases in the number of PhDs, there is a lack of high-quality human capital with strong links to industry. The new STI Act promotes higher levels of research mobility among public institutions and between public and private organisations.

Emerging technologies: Spain is investing in enabling technologies, notably ICTs and biotechnology, which are important for areas such as health sciences and energy, but also in space-related technologies. It has targeted programmes and public-private partnerships (*e.g.* CIBER, RETICS) for ICTs and biotechnology and research excellence projects in biomedicine and health. GENOMA, Spain's Technology Portfolio, develops and funds patents and the creation of spin-offs. Data on PCT applications reveal an RTA in environment-related technologies, biotechnology and nanotechnologies.

Green innovation: Green innovation remains 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.

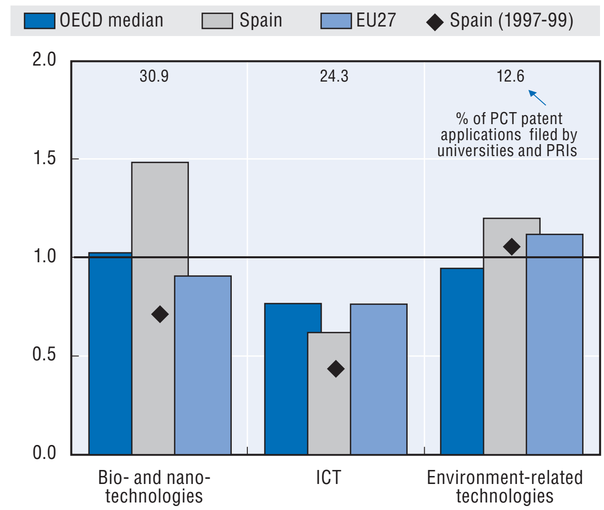
Panel 2. Structural composition of BERD, 2009

As a % of total BERD

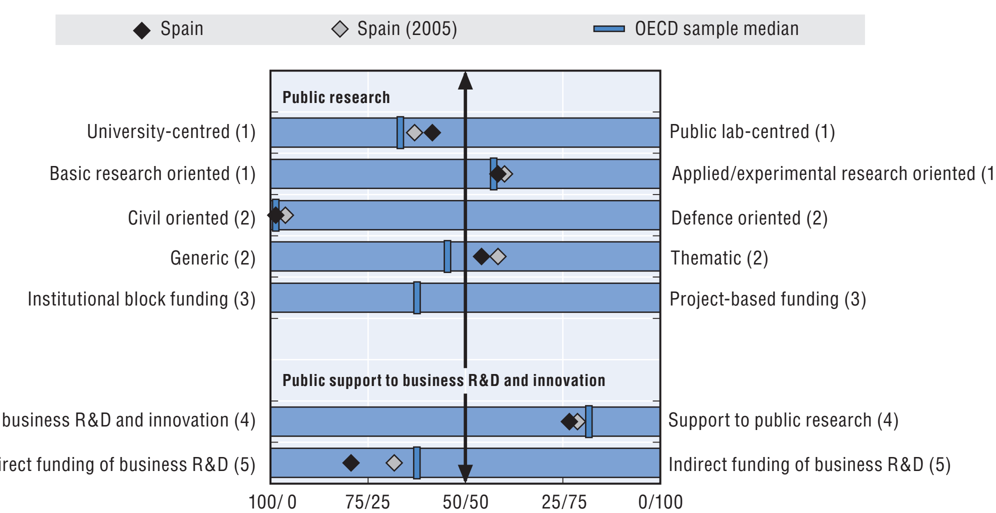


Panel 3. Revealed technology advantage in selected fields, 2007-09

Index based on PCT patent applications



Panel 4. Overview of national innovation policy mix, 2010



1. Balance as a percentage of the sum of HERD and GOVERD.
2. Balance as a percentage of total GBAORD.
3. Balance as a percentage of total funding to national performers.
4. Balance as a percentage of the sum of HERD and GOVERD funded by government and higher education and components of (5).
5. Balance as a percentage of the sum of indirect funding of business R&D and innovation through R&D tax incentives and direct funding of BERD through grants, contracts and loans.

Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888932690852

SWEDEN

Hot STI issues

- Commercialising research from HEIs.
- Reallocating block grants to HEIs on a performance basis.
- Fostering demand-side innovation policies, *e.g.* procurement.
- Promoting innovation in the public sector.

General features of the STI system: Following the recession of 2008-09, Sweden's macroeconomy has grown significantly faster than that of the OECD area as a whole. The largest Swedish firms are highly internationalised and conduct increasing amounts of their activities, including R&D, outside of Sweden. BERD is still high at 2.34% of GDP (Panel 1[(d)]), though it has fallen slightly in recent years. The proportion of public research funded by industry is close to the OECD median (1[(o)]). The small share of patents filed by universities and PRIs (1[(p)]) is due to the "professor's privilege" which entitles researchers (instead of institutions) to patent their inventions. International collaboration indicators paint a mixed picture: a high 55% of scientific articles are produced with international co-authorship (1[(q)]), while a below OECD average 19% of PCT patent applications are produced with international collaboration (1[(r)]). This reflects in part Sweden's industrial structure of large firms which are likely to retain technology development in-house. As for human capital indicators, Sweden has a median tertiary attainment rate of 34% (1[(s)]) and median PISA scores in science for 15-year-olds (1[(t)]). It has a strong RTA in ICTs but is considerably weaker in biotechnology and nanotechnologies (Panel 3). ICT infrastructures are strong: it has 32 and 94 subscribers, respectively, to broadband and wireless networks per 100 inhabitants (1[(k)(l)]). Sweden's e-government readiness index is above the OECD median (1[(n)]).

Recent changes in STI expenditures: R&D expenditures increased to around USD 12.5 billion in 2010, a GERD-to-GDP ratio of 3.40%. In 2009, industry funded 59% of total GERD, while government funded 27% and 10% was funded from abroad. This last has grown sharply over the decade as the R&D system has become increasingly internationalised.

Overall STI strategy: The Research and Innovation Bill set the framework and funding for 2009-12. It significantly increased government funding for R&D while introducing a more selective, quality-based approach. It identified 24 strategic areas (with specific budget allocations) under four themes. The Ministry of Education and Research is now working on a plan for the next Research and Innovation Bill, covering 2013-16. In parallel, the Ministry of Enterprise, Energy and Communications is preparing an Innovation Strategy covering the whole innovation system.

STI policy governance: The Ministry of Education and Research is responsible for research and some innovation policy, while the Ministry of Enterprise, Energy and Communications is responsible for mainstream innovation policy. Swedish ministries are small and set broad policy directions. They depend upon a range of agencies to design and implement policy measures, including the Swedish Research Council (Vetenskapsrådet) and the Swedish Governmental Agency for Innovation Systems (VINNOVA).

Key figures

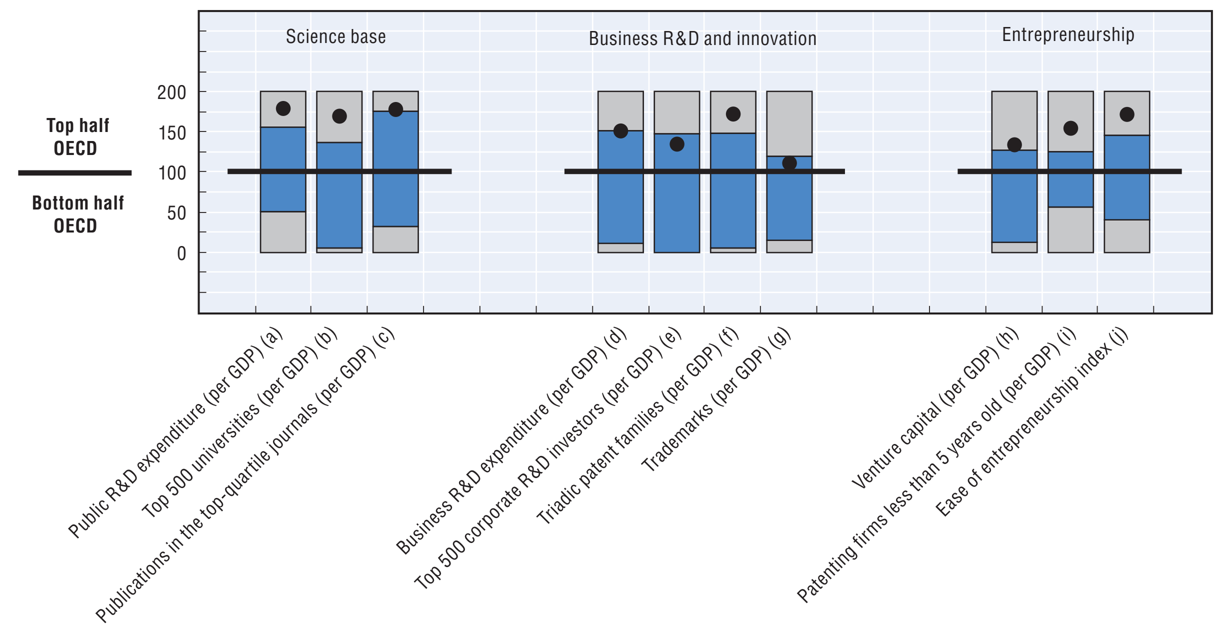
Labour productivity, GDP per hour worked in USD, 2010	**49.9**	**GERD, as % of GDP, 2010**	**3.40**
(annual growth rate, 2005-10)	(+0.4)	(annual growth rate, 2005-10)	(+0.6)
Environmental productivity, GDP per unit of CO_2 emitted in USD, 2009	**8.27**	**GERD publicly financed, as % of GDP, 2009**	**1.01**
(annual growth rate, 2005-09)	(+4.7)	(annual growth rate, 2005-09)	(+3.6)

Figure 10.39. **Science and innovation in Sweden**

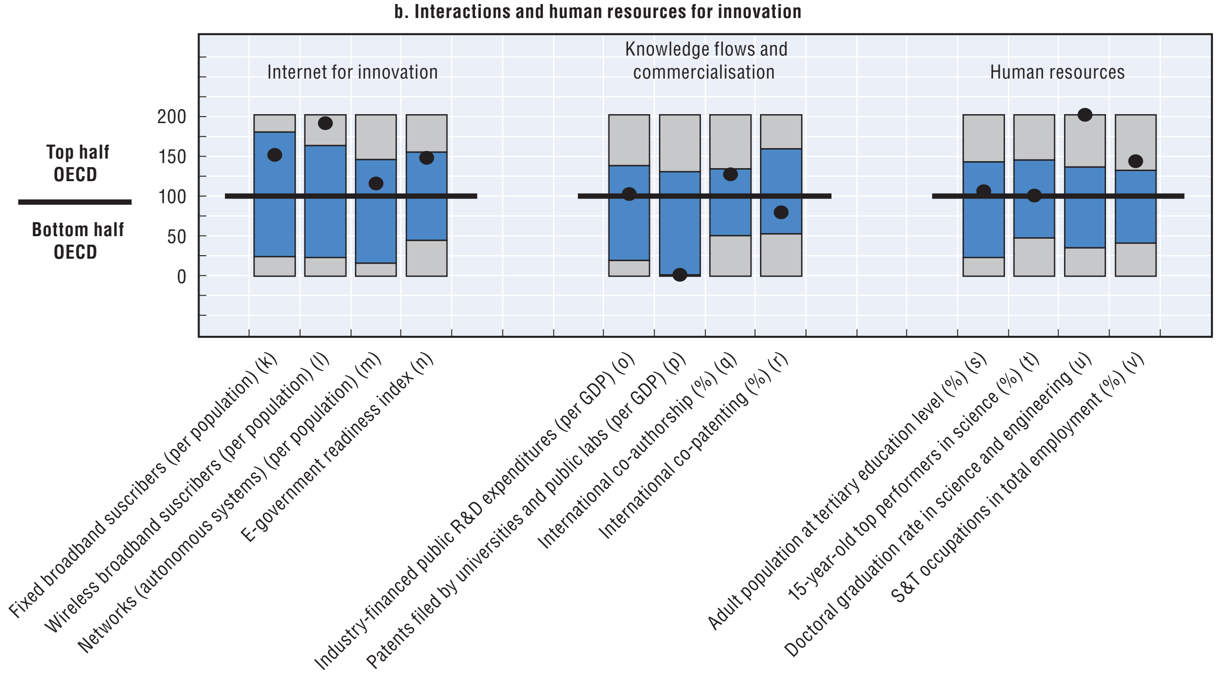
Panel 1. Comparative performance of national science and innovation systems, 2011

Top/bottom 5 OECD values | Middle range of OECD values | OECD median | Sweden

a. Competences and capacity to innovate



b. Interactions and human resources for innovation



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

Science base: Public funding for R&D is strong (1[(a)]), with the vast majority going to universities, some of which feature strongly in global rankings (1[(b)]). Levels of HERD, at 0.90% of GDP in 2010, are the highest in the OECD. Much of this funding is directed at basic research. A bill on greater autonomy for HEIs came into effect in 2011, giving them greater freedom to reorganise, and proposals for greater accountability through research assessment are being discussed. In comparison to HEIs, the PRI sector is relatively small (Panel 4) and focuses largely on serving the R&D needs of SMEs.

Business R&D and innovation: R&D investments by industry are concentrated in large firms. Sweden is one of the few OECD countries – with Germany and Finland – that does not operate an R&D tax credit scheme. Historically, public procurement has played a significant role in the development of a number of Sweden's largest and most innovative companies but state aid rules now prohibit many earlier practices. To date, initiatives to promote new-generation innovation-oriented procurement largely constitute preparatory work. For example, the 2011 Innovation Procurement Inquiry proposes the introduction of a new law on pre-commercial procurement, which facilitates multi-stage competitive procurement, and the creation of a national database for pre-commercial procurement.

Entrepreneurship: While the value of venture capital investment as a share of GDP is one of the highest in the OECD area (1[(h)]), the supply of business angel and early-stage VC activity is small and policy responses have been fragmented. To address this, a restructuring of Innovationsbron (which provides seed funding, soft loans and equity, and incubators) and ALMI (which provides advice, business development services and supplementary financing) was initiated in 2011, to create a single structure more clearly focused on early-stage funding.

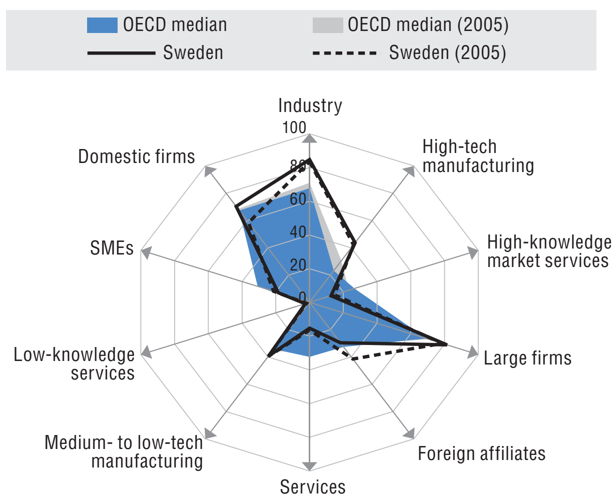
ICT and scientific infrastructures: Preparations for the construction of the European Spallation Source (ESS) are now under way in Lund. The Max IV facility for a new generation synchrotron radiation light source is also under construction in Lund. The national resource centre for molecular life sciences and medicine – the Science for Life Laboratory (SciLifeLab) – was inaugurated in 2010 in the Stockholm and Uppsala regions. "ICT for Everyone – A Digital Agenda for Sweden" was published in 2011. It sets an ICT policy goal for Sweden to become the world's leading economy in exploiting the opportunities of digitisation.

Clusters and regional policies: Regional innovation policy is mixed, with strong capabilities and programmes in southern and western regions but weaker initiatives elsewhere. Several national organisations actively promote innovation in the regions, particularly the Swedish Agency for Economic and Regional Growth and the KK Foundation. A regional venture capital firm, Inlandsinnovation AB, was established in 2011 to facilitate growth and innovation in enterprises in Sweden's northwest regions. It has capital of around USD 225 million. At the same time, the motor vehicle industry, which has been negatively affected by the economic crisis, has been singled out to benefit from another new venture capital firm, Fouriertransform AB. The fund has around USD 335 million to support the vehicle cluster.

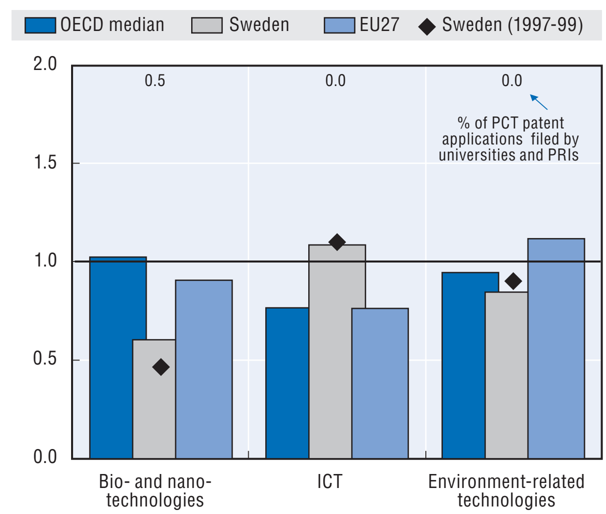
Knowledge flows and commercialisation: The so-called "professor's privilege" means HEIs have relatively weak infrastructures for commercialising their R&D and weak patenting performance (1[(p)]). Newly established innovation offices support researchers who wish to commercialise their research results and to establish spin-off companies.

Human resources: Several initiatives support research skills development. For example, VINNOVA has launched its VINNMER scheme to improve the outlook for women as future leaders of R&D institutes. It has also introduced the VINNPRO scheme to establish graduate schools with sustainable links to business. In addition, Sweden introduced tuition fees for students from outside the EEA in 2011. In the new school curricula, entrepreneurship is mandatory. Finally, the tax exemption rules for foreign experts and the highly qualified have been simplified.

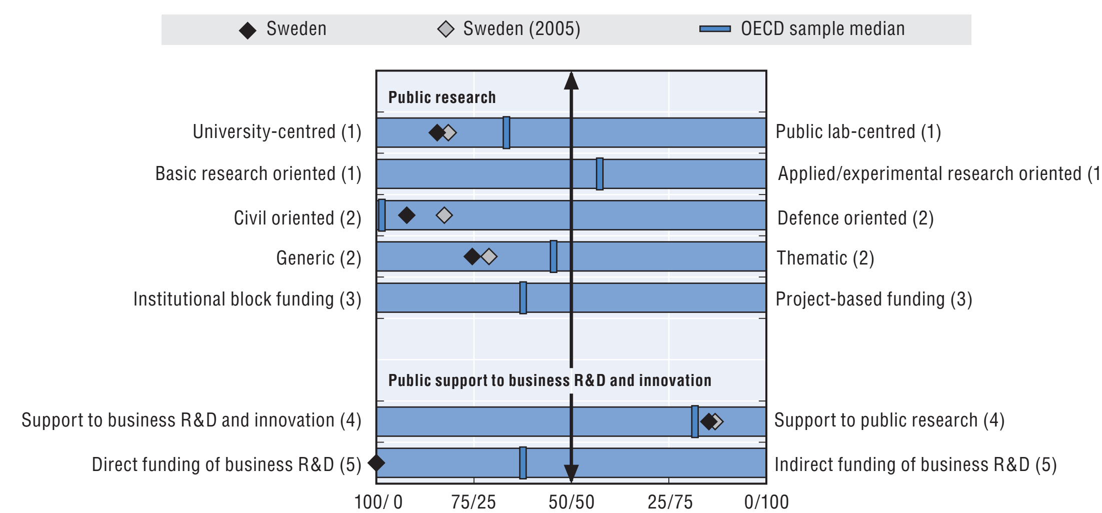
Panel 2. Structural composition of BERD, 2009
As a % of total BERD



Panel 3. Revealed technology advantage in selected fields, 2007-09
Index based on PCT patent applications



Panel 4. Overview of national innovation policy mix, 2010



1. Balance as a percentage of the sum of HERD and GOVERD.
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3. Balance as a percentage of total funding to national performers.
4. Balance as a percentage of the sum of HERD and GOVERD funded by government and higher education and components of (5).
5. Balance as a percentage of the sum of indirect funding of business R&D and innovation through R&D tax incentives and direct funding of BERD through grants, contracts and loans.

Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888932690871

SWITZERLAND

Hot STI issues

- Strengthening Switzerland's leading position in global research and innovation.
- Maintaining an excellent human resource base for innovation.
- Providing conducive conditions for green innovation.

General features of the STI system: Switzerland is a small, prosperous, open economy, with outstanding strengths in innovation. Swiss GERD was some 2.99% of GDP in 2008, above the OECD median. Most GERD is performed by the business sector with outcomes at or very near the top of the OECD in terms of triadic patents and trademarks per GDP over 2007/09 (Panel 1[(f)(g)]). BERD was 2.20% of GDP in 2008 (1[(d)]), mostly performed by large companies in high-technology (or other knowledge-intensive) manufacturing industries (Panel 2) such as pharmaceuticals. Switzerland has some of the world's top corporate R&D investors. In spite of framework conditions conducive to entrepreneurship (1[(j)]), young firms contributed little to patenting over 2007-09 (1[(i)]). Universities are internationally attractive (1[(b)]), and the science base is very efficient: public R&D expenditures were 0.83% of GDP in 2010 (1[(a)]), and publications in scientific journals led OECD countries in 2009 (1[(c)]). The share of public research financed by industry was at the top of OECD middle range (1[(o)]). The patenting rate of universities and PRIs per GDP in 2005-09 is only at the median (1[(p)]) (partly owing to the fact that patents are often left to inventors and/or partner companies). Human resources are highly skilled: graduates in S&E at doctoral level ranked second among OECD countries in 2009 (1[(u)]), and 35% of the adult population is tertiary-qualified (1[(s)]). Researchers are well integrated in international networks: 43% of PCT patent applications over 2007-09 were international co-inventions (1[(r)]). The fixed broadband penetration rate leads among OECD countries (1[(k)]), and other Internet-related indicators are slightly above the OECD median (1[(l)(m)(n)]).

Recent changes in STI expenditures: GERD increased by 3.8% annually over 2004-08. The Education, Research and Innovation (ERI) Message 2008-11 had set a target of 6% annual growth in public R&D expenditures. However, some cuts were decided in 2011, and a special ERI Message 2012 temporarily froze public investments. The new ERI Message 2013-16 foresees annual growth in public R&D expenditures of 3.7%, *i.e.* a return to the situation prior to the global financial crisis.

Overall STI strategy: The federal government's strategic planning document, the ERI Message, is released every four years to provide a general framework for education, research and innovation policy. The ERI Message 2012 mainly maintained previously set objectives. The ERI Message 2013-16 has three policy guidelines: to ensure that the education system provides skills that match market demand; to strengthen (competitive) funding and increase R&D and innovation capabilities; and to build research and economic activities on the "principles of equal opportunity, sustainability and competitiveness".

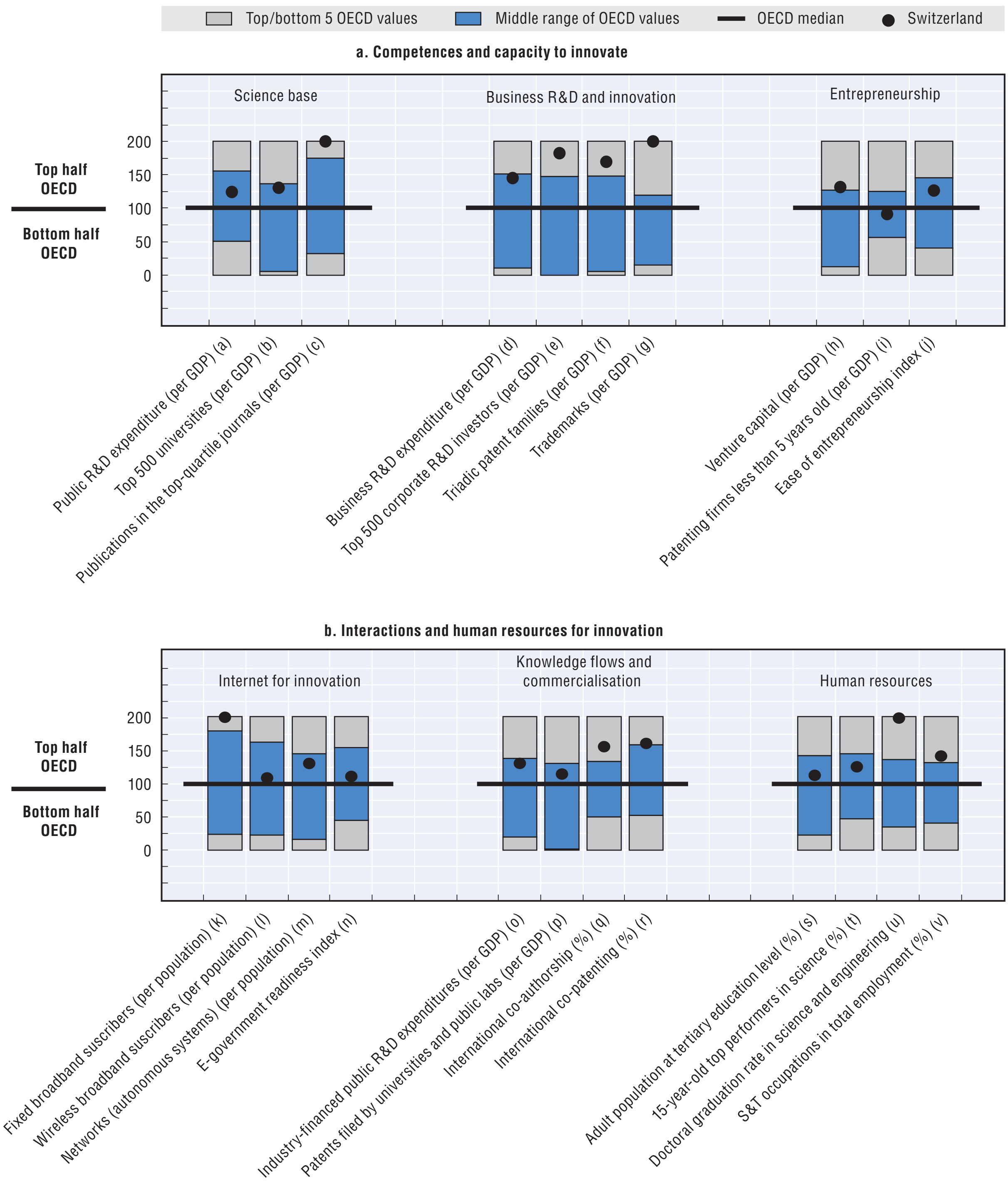
STI policy governance: The main Swiss governance features involve reliance on bottom-up processes and federalism, with the Confederation and cantons sharing responsibility for research and higher education policy. In 2013 the competences of the

Key figures

Labour productivity, GDP per hour worked in USD, 2010	**48.3**	**GERD, as % of GDP, 2008**	**2.99**
(annual growth rate, 2005-10)	(+0.6)	(annual growth rate, 2004-08)	(+3.8)
Environmental productivity, GDP per unit of CO_2 emitted in USD, 2009	**8.32**	**GERD publicly financed, as % of GDP, 2008**	**0.75**
(annual growth rate, 2005-09)	(+3.0)	(annual growth rate, 2004-08)	(+4.8)

Figure 10.40. **Science and innovation in Switzerland**

Panel 1. Comparative performance of national science and innovation systems, 2011



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

Federal Department of Economic Affairs will be expanded to include education, research and innovation. The Commission for Technology and Innovation (CTI) became an independent decision-making body within the federal administration.

Science base: Public research funding mechanisms have changed following reforms of the Swiss National Science Foundation (SNSF), the main basic research funding agency. Since 2009, overhead costs are paid to institutions hosting funded research projects. Selection procedures have moved towards harmonisation of processes, better provision of information to applicants, the creation of expert panels, and the launch of an electronic application procedure.

Business R&D and innovation: A large part of the business sector engages in R&D and innovation although Switzerland is among the OECD countries with the smallest share of BERD financed by government (Panel 4). Switzerland traditionally refrains from granting R&D subsidies to business firms. CTI, the main Swiss innovation promotion agency, supports market-oriented R&D projects, development of start-up companies and knowledge and technology transfer in various other ways.

ICT and scientific infrastructures: The Swiss innovation system benefits from modern, high-quality research infrastructures. In addition to the action lines dedicated to their development in the latest ERI Messages, the State Secretariat for Research and Education issued a roadmap for research infrastructures, the CH-Roadmap, in 2011. It maps planned investment in strategic areas and includes proposals for participation in international research infrastructures.

Knowledge flows and commercialisation: CTI aims at encouraging higher education and PRIs to collaborate with business. Most of its programmes provide support rather than funding. They include CTI Start-Up (mentoring and networking services for young entrepreneurs), CTI Invest (a venture platform), Venturelab (diffusion of entrepreneurship skills), or Diversity@CTI (promotion of female entrepreneurs). As part of the 2009 stimulus package, CTI also provides SMEs without their own R&D personnel with an innovation cheque to purchase services at universities or PRIs.

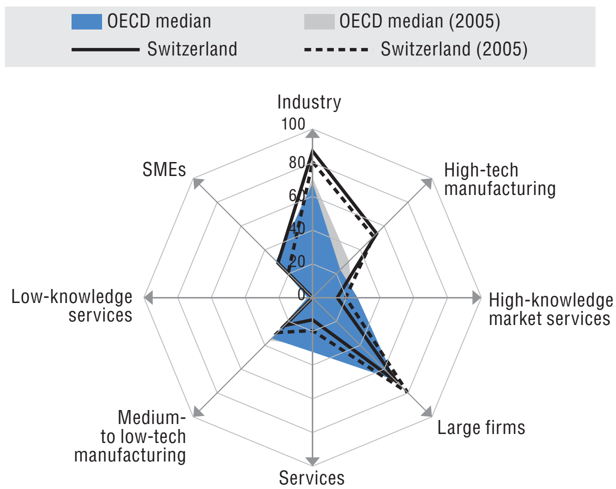
Globalisation: Swiss research and innovation has strong international links (1[q][r]) and favourable framework conditions for attracting FDI and human resources both in businesses and universities. Swiss multinationals are closely linked to global research and innovation hubs. A federal strategy for the internationalisation of education, research and innovation was adopted in 2010. In addition to bilateral research agreements or cross-border co-operation (*e.g.* the Lead-Agency process with Germany, Austria and Luxembourg to co-ordinate funding decisions), the Confederation participates in EU programmes (*e.g.* Research Framework Programme FP, COST, EUREKA and the Lifelong Learning Programme since 2011), including those targeting student and researcher mobility.

Human resources: The current strategy specifically addresses education issues to strengthen the provision of high-level skills to match market needs. In 2011 the FDEA launched the Specialists Initiative to curb the growing scarcity of this category of human resources through increased labour market participation and access to advanced qualifications. A major issue for the Swiss education system is the compartmentalisation of its different education institutions, which affects internal mobility and access to higher education. The 2011 *Law for the Support and Co-ordination of Universities* aims to improve co-ordination between the Confederation and cantons, which are responsible for the quality and permeability of the higher education system. It also introduced an independent accreditation agency. Moreover, most cantons have postponed tracking of pupils to age 13.

Green innovation: The Federal Council decided to phase out nuclear energy production and emphasised, in its Energy Strategy 2050, energy efficiency and the expansion of hydropower and new renewable energy. The Cleantech Masterplan provides a framework (but no funding) for joint actions (including R&D and knowledge transfer) by stakeholders in order to improve resource efficiency and the development of renewable energy.

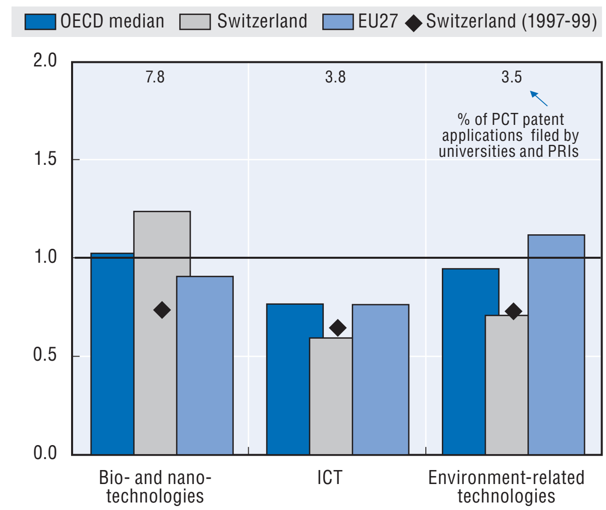
Panel 2. Structural composition of BERD, 2009

As a % of total BERD

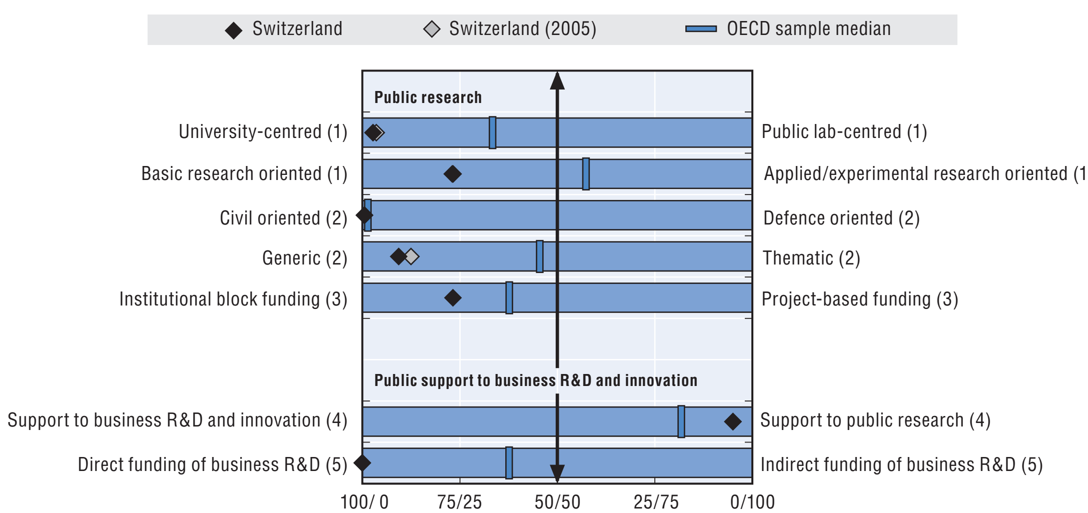


Panel 3. Revealed technology advantage in selected fields, 2007-09

Index based on PCT patent applications



Panel 4. Overview of national innovation policy mix, 2010



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Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888932690890

TURKEY

Hot STI issues

- Becoming Eurasia's production base for medium-high- and high-technology products.
- Implementing a targeted and mission-oriented STI strategy.
- Implementing evaluation and monitoring of all STI support schemes.

General features of the STI system: Turkey is a large emerging market economy. It has gone through crises (2001, 2009) and periods of fast economic growth over the past decade. It has shifted rapidly from an economy largely based on agriculture (which still accounts for 24% of total employment) and on an abundant low-skilled labour force (which supported the growth of traditional labour-intensive industries such as textiles) towards an industrial economy. Turkey is now a major European automotive producer, a world leader in shipbuilding, and a significant manufacturer of electronics and home appliances (*e.g.* TV, white goods). Its STI system however remains small. BERD was 0.36% of GDP in 2010, well below the OECD median (Panel 1[d]), and is concentrated in a few medium-high-technology manufacturing industries and knowledge services (Panel 2). Connections between industry and academia are good and 13% of public R&D is contracted or subsidised by enterprises (1[o]). Turkey has weak links to international research networks (1[q][r]): a low 7% of PCT patent applications and 18% of scientific articles are produced with international collaboration. Entrepreneurship conditions are poor (1[j]). Product market regulations, particularly employment protection legislation, are restrictive and network monopolies hinder competition. Productivity gains are concentrated in the modern part of the economy; the large informal sector has less access to finance, STI networks and human capital and has limited overall STI potential. Turkish ICT infrastructures need to be improved (1[k][l][m]) and the government makes little use of the Internet to interact with citizens and businesses (1[n]). Skills are weak: 12% of the adult population has tertiary education (1[s]) and 13% of employees are in S&T occupations (1[v]). Turkey has still few researchers (2.9 per thousand employment) but their number has almost tripled in ten years. Moreover, only 1% of 15-year-olds are top performers in the PISA rankings (1[t]), and there are few graduates at doctoral level and fewer in S&E programmes (1[u]).

Recent changes in STI expenditures: GERD was USD 9.6 billion and 0.84% of GDP in 2010. It grew by 10.7% a year between 2005 and 2010 and has been little affected by economic shocks. Implementation of the Turkish Research Area (TARAL) in 2004 gave an impetus to public R&D budgets; government has a sustained commitment to STI and business R&D spending recovers rapidly after crises. In 2010, industry funded 45% of GERD, and government and higher education funded 50%.

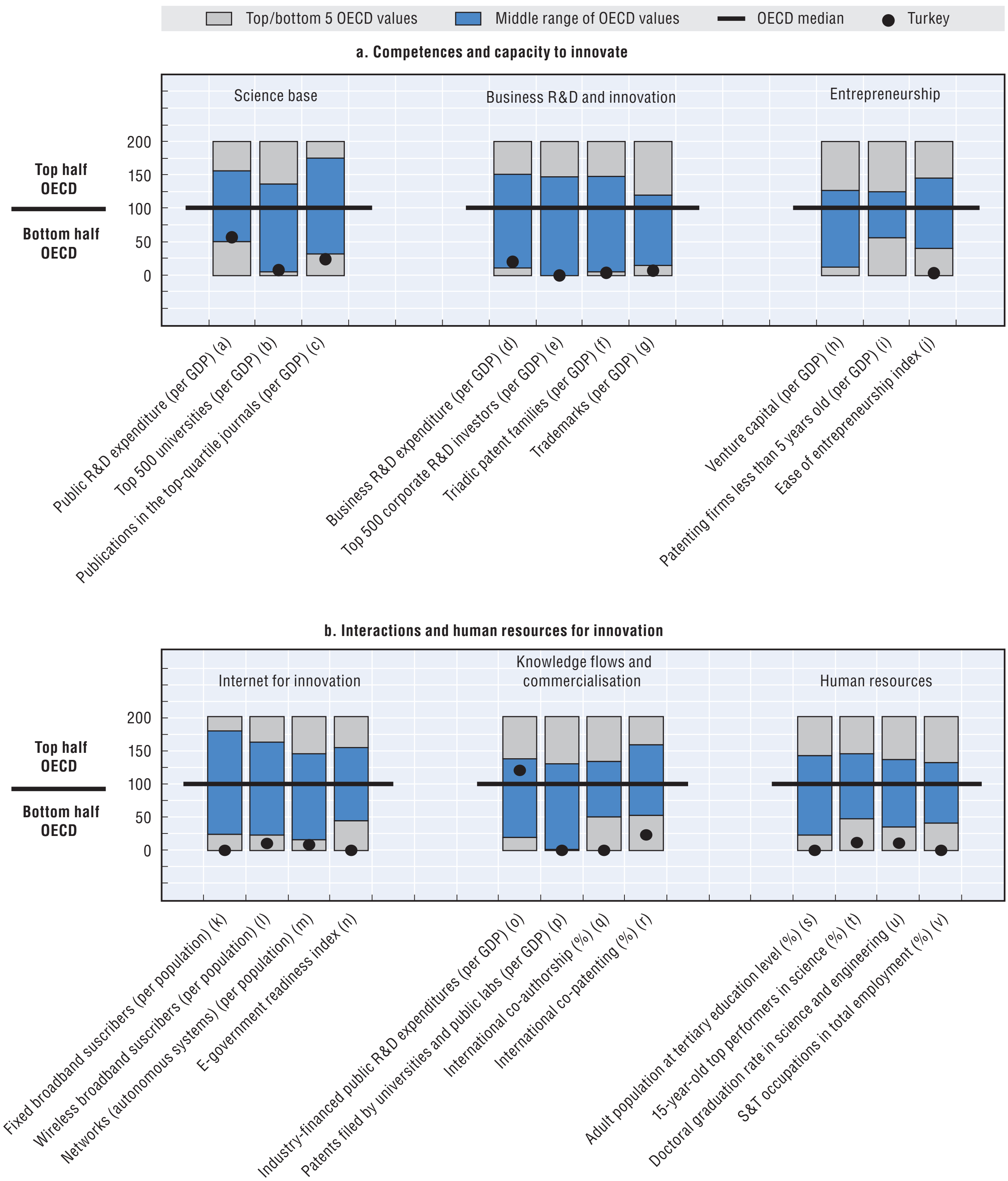
Overall STI strategy: The National Science, Technology and Innovation Strategy (2011-16) (UBTYS) aims to strengthen national R&D and innovation capacities in order to upgrade the industrial structure towards high-technology industries. GERD should reach 3% of GDP by 2023. UBTYS targets competitive sectors with strong STI potential (automotive, machinery, various

Key figures

Labour productivity, GDP per hour worked in USD, 2010	**26.3**	**GERD, as % of GDP, 2010**	**0.84**
(annual growth rate, 2005-10)	(+1.4)	(annual growth rate, 2005-10)	(+10.7)
Environmental productivity, GDP per unit of CO_2 emitted in USD, 2009	**4.06**	**GERD publicly financed, as % of GDP, 2010**	**0.42**
(annual growth rate, 2005-09)	(–2.4)	(annual growth rate, 2006-10)	(+13.1)

Figure 10.41. **Science and innovation in Turkey**

Panel 1. Comparative performance of national science and innovation systems, 2011



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

manufacturing and ICT) and areas of global demand (energy, water, food, security and space). The Turkish Industrial Strategy Document and Action Plan (2011-14) and several sector-centred plans reinforce this targeted approach and the priority of the business sector.

STI policy governance: Since 2011, a new Ministry of Science, Industry and Technology (MoSIT) is in charge of STI policy design, implementation and co-ordination of R&D and innovation activities. The Scientific and Technological Research Council of Turkey (TUBITAK) and the Turkish Academy of Science (TUBA) are affiliated to the Ministry. Evaluation policy has been reinforced and an inter-ministerial co-ordination board has been set up to review all R&D, innovation and entrepreneurship support schemes under the presidency of TUBITAK.

Science base: Turkey's public research system is small (0.48% of GDP in 2010) and universities account for 80% of total expenditures (Panel 4). It has few articles in top scholarly journals (1[(c)]) and only one world-class university (1[(b)]). Public research is currently undergoing major reforms to improve the quality and relevance of public R&D, increase collaboration with the private sector and leverage private funding. Since 2011, a university index has been developed under the responsibility of TUBITAK, the Higher Education Council and TurkStat to evaluate universities' entrepreneurship and innovativeness performance based on criteria such as articles, R&D projects, collaboration, licences and spin-offs.

Business R&D and innovation: Turkey aims to increase BERD to 2% of GDP by 2023. During the 2009 crisis USD 217 million was earmarked to TUBITAK to support STI actors via various grant schemes. TUBITAK's main funding instrument, the Industrial R&D Funding Programme, has increased grants by 10% for certain technology fields (IT, biotechnology, environment-related technologies, advanced materials). A new small business innovation and research support programme was implemented in 2012.

Entrepreneurship: Entrepreneurship is a main STI policy priority. The Techno-Entrepreneurship Grant Programme provides young entrepreneurs with grants in order to steer entrepreneurship towards technology and innovation. The Council for Entrepreneurship was established in 2012 to help entrepreneurs access domestic and foreign financing. The G-43 Developing Anatolian Venture Capital Fund deals with SMEs' financing issues in less developed regions. Efforts are also made to promote entrepreneurship culture in education from primary schools to universities.

Clusters and regional policies: Smart specialisation and clustering have recently attracted policy attention. Province-level innovation platforms were set up in 2010 to transform local knowledge into economic and social benefits by stimulating co-operation. In 2011 TUBITAK launched a competitive funding programme to set up regional innovation platforms and co-operation networks at the local level. The law on technology development zones (TDZ) fosters the creation of technology parks. Financial support is provided through tax incentives for land procurement, infrastructure and buildings.

Knowledge flows and commercialisation: The relative number of patents filed by universities and PRIs per GDP is low (1[(p)]). In 2011 TUBITAK implemented the Technology Transfer Support Programme for SMEs to encourage the commercialisation of public research results in collaboration with SMEs. The Turkish Patent Institute works to raise awareness of IPRs in the business community and collects data on licensing activities in order to increase revenues from patents. A draft Patent Law is currently under debate to improve the Turkish IP system and better align it with EU and international legislation.

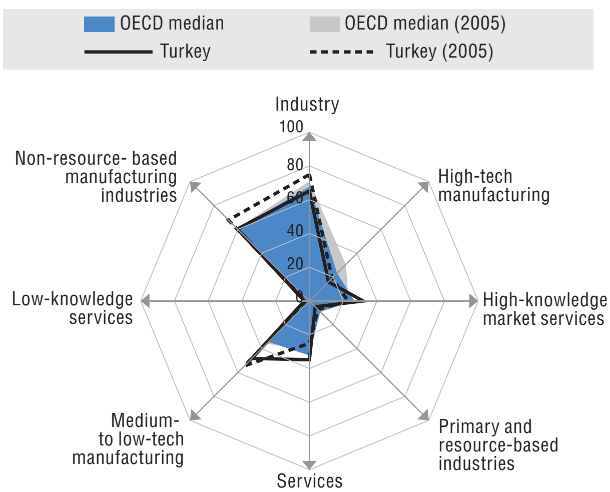
Human resources: Turkey lags behind OECD countries in terms of human resources (1[(s)(t)(u)(v)]). The aim of the Action Plan to Strengthen Links between Vocational Education and Employment, issued in 2010, is to establish a national skills classification, revise curricula and strengthen co-operation with employers. An Initiative for Enhancing Opportunities in Technology (FATIH) has been set up to improve education in STEM and non-S&T fields through new learning practices and new instructional tools. The National Science and Technology Human Resources Strategy and Action

Plan (2011-16) aims to increase R&D personnel, foster a research culture, and develop researchers' skills, mobility and employability.

Green innovation: Owing to its recent industrial boom and rapid urbanisation, Turkey has seen a 2.4% annual decline in environmental productivity over 2005-09. The National Food, Water and Energy R&D and Innovation Strategies 2011-16 are co-ordinated by TÜBITAK and call-based target-oriented support mechanisms have been launched recently. The Turkish Energy Efficiency Strategy (2012-23) has been adopted.

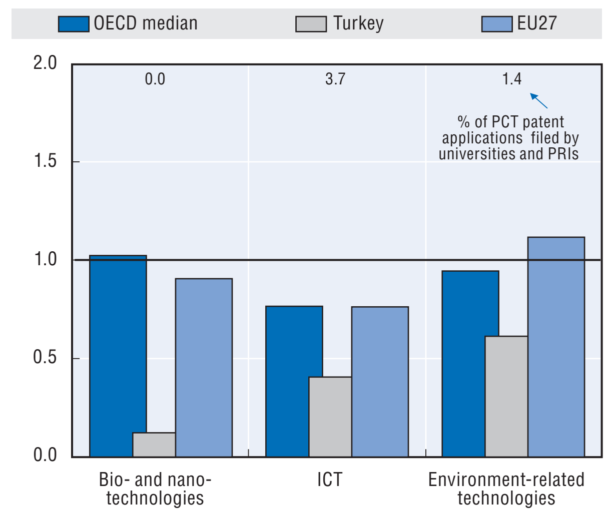
Panel 2. Structural composition of BERD, 2009

As a % of total BERD

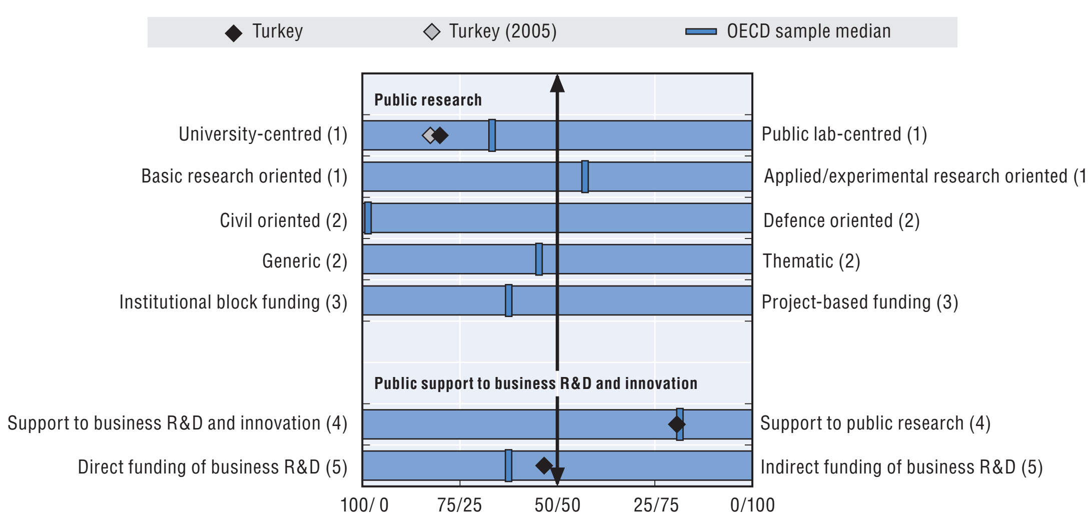


Panel 3. Revealed technology advantage in selected fields, 2007-09

Index based on PCT patent applications



Panel 4. Overview of national innovation policy mix, 2010



1. Balance as a percentage of the sum of HERD and GOVERD.
2. Balance as a percentage of total GBAORD.
3. Balance as a percentage of total funding to national performers.
4. Balance as a percentage of the sum of HERD and GOVERD funded by government and higher education and components of (5).
5. Balance as a percentage of the sum of indirect funding of business R&D and innovation through R&D tax incentives and direct funding of BERD through grants, contracts and loans.

Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888932690909

UNITED KINGDOM

Hot STI issues

- Encouraging closer relations between universities and business.
- Prioritising strategic investments in technology areas able to exploit their potential in global markets.
- Exploiting the potential to transform the public sector into a major driver of innovation.

General features of the STI system: With its large service-based economy, the United Kingdom performs below the OECD median on several headline indicators, including R&D expenditure and patenting. It is a very open economy, and a relatively high proportion of BERD is accounted for by large foreign-owned firms (Panel 2). BERD is below the OECD average at around 1.07% of GDP (Panel 1[(d)]). Almost half is accounted for by high-technology fields: pharmaceuticals (28%), aircraft and spacecraft (9%), and computer and software services (9%). Industry-financed public R&D expenditures as a share of GDP are below the OECD median (1[(o)]). However patents filed by universities and public labs per GDP is well above the OECD median (1[(p)]), an indication of the commercial efforts made by UK universities. The United Kingdom's RTA has remained quite stable over the last decade: it is strong in ICT and biotechnology and weaker in environment-related areas (Panel 3). With 35% of the adult population tertiary-qualified (1[(s)]), the proportion of the labour force employed in S&T occupations is only 28%, below the OECD median (1[(v)]). The 7.6 researchers per thousand employment is close to the OECD median. Researchers are reasonably well integrated in international networks: 45% of scientific articles and 25% of PCT patent applications were produced with international collaboration (1[(q)(r)]). ICT infrastructures are well developed. Fixed broadband subscriptions stand at 33% (1[(k)]); at 44%, subscriptions to wireless networks are around the median (1[(l)]). The e-government readiness index is one of the OECD's highest (1[(n)]).

Recent changes in STI expenditures: The UK GERD (1.76% of GDP in 2010) is below the total OECD and EU27 levels. In 2009 industry funded 45% of total GERD, government funded 32% and 16% was funded from abroad. These figures confirm the relative lack of industrial R&D and the strong presence of international firms. In response to the economic crisis, the government included in its Spending Review 2010 a deficit reduction plan, under which the USD 7 billion science budget will be maintained at its current level until 2014.

Overall STI strategy: In December 2011, the government launched its Innovation and Research Strategy for Growth, with four core objectives: strengthen knowledge transfer; improve research infrastructure; foster business innovation, particularly in services and low- and medium-technology sectors; and make the public sector a major driver of innovation. In a broader context, the government launched its Plan for Growth in March 2011; it includes a number of innovation-related measures such as support of SME innovation and knowledge transfer from the public research system.

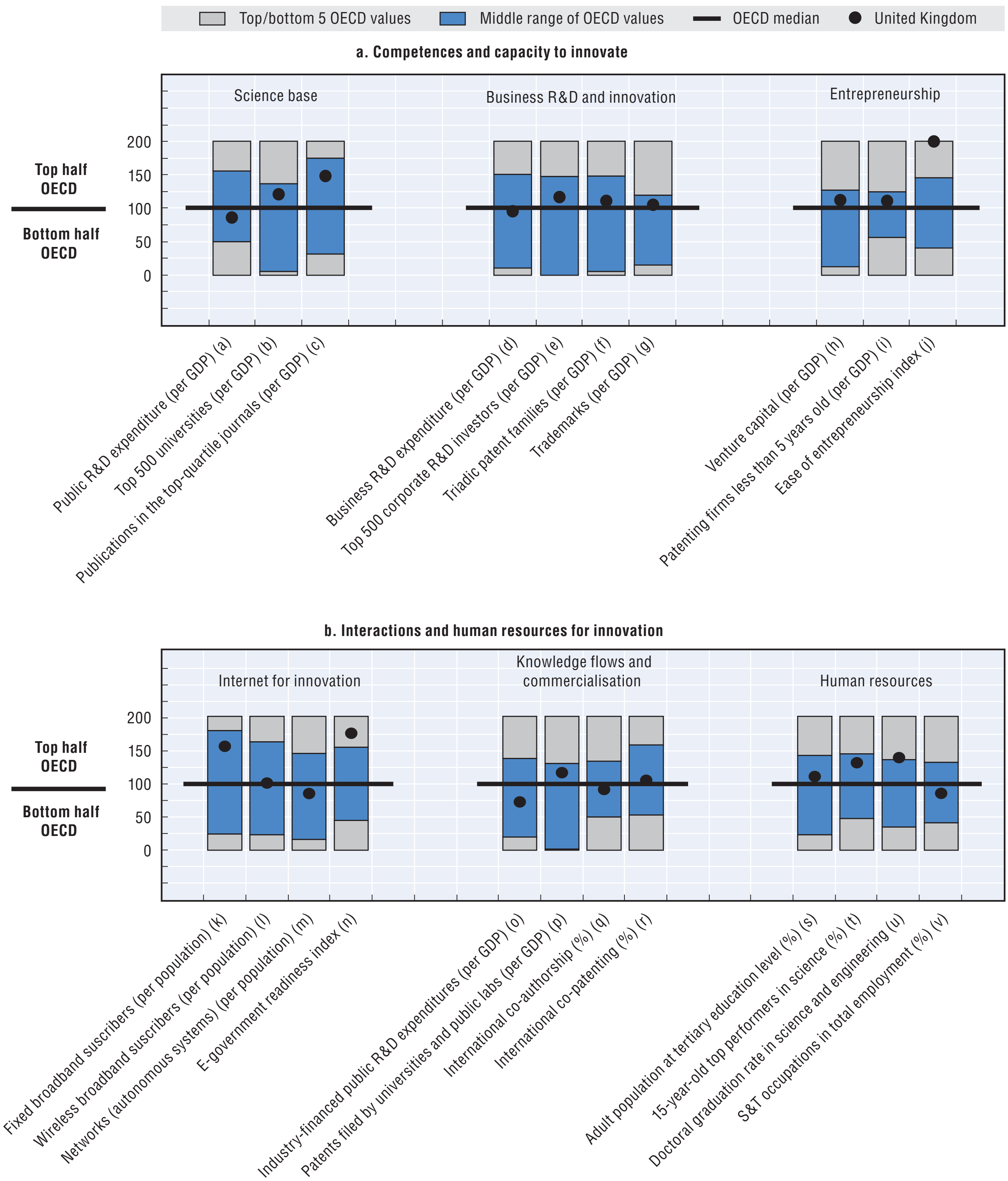
STI policy governance: The Department for Business, Innovation and Skills (BIS) is the main policy-making body in the STI area. In delivering its strategic priorities it is supported by a various partner organisations, including some non-

Key figures

Labour productivity, GDP per hour worked in USD, 2010	**46.2**	**GERD, as % of GDP, 2010**	**1.76**
(annual growth rate, 2005-10)	(+0.5)	(annual growth rate, 2005-10)	(+0.9)
Environmental productivity, GDP per unit of CO_2 emitted in USD, 2009	**4.57**	**GERD publicly financed, as % of GDP, 2010**	**0.59**
(annual growth rate, 2005-09)	(+3.5)	(annual growth rate, 2005-10)	(+0.6)

Figure 10.42. **Science and innovation in the United Kingdom**

Panel 1. Comparative performance of national science and innovation systems, 2011



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

departmental public bodies, such as the Technology Strategy Board, the Higher Education Funding Council for England (HEFCE), and the Research Councils. At sub-national level, the English regional development agencies have been abolished and their innovation responsibilities transferred to the Technology Strategy Board. The devolved administrations in Scotland, Wales and Northern Ireland have their own science and innovation agendas and measures.

Science base: Although levels of public R&D expenditure are below the OECD median (1[(a)]), the United Kingdom is among the top performers in publication counts (1[(c)]) and boasts some of the world's leading research universities (1[(b)]). Although the public research system is university-oriented, most research is applied or experimental development (Panel 4). The government's renewed emphasis on concentrating resources on centres of proven excellence is supported by the Research Excellence Framework (REF), which will be completed in 2014 and replace the Research Assessment Exercise, the system previously used to assess the quality of university research. The new system puts much greater emphasis than its predecessor on measuring research impacts.

Business R&D and innovation: The government provides an increasing proportion of its support to business R&D and innovation through indirect funding (Panel 4). This is set to continue, with an increase in the rate of the SME R&D tax relief to 200% in 2011 and 225% in 2012.

Public-sector innovation: A key focus of the Innovation and Research Strategy for Growth is exploitation of the public sector's potential to drive innovation, particularly through the use of public procurement. Increased funding has been allocated to the Small Business Research Initiative (SBRI), a public procurement scheme that encourages SMEs to develop innovative solutions to challenges in the delivery of public services.

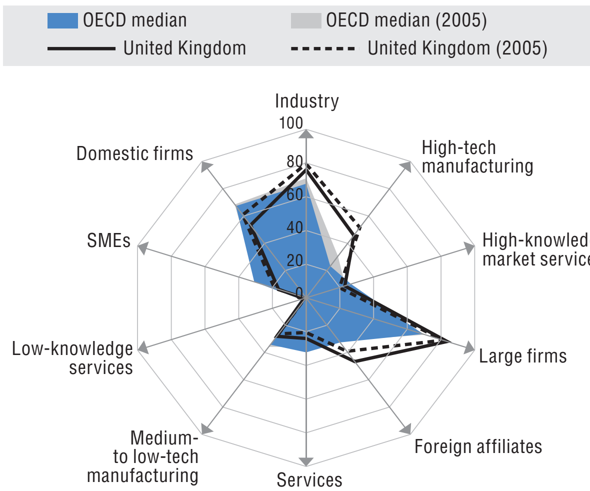
Clusters and regional policies: The regional development agencies have been replaced by consortia of local authorities and businesses in local enterprise partnerships (LEPs) which are expected to work with government to support enterprise, innovation, global trade and inward investment. LEPs cover some of the enterprise zones announced in the Plan for Growth, which offer superfast broadband, lower business tax rates, and low levels of regulation and planning controls, among other benefits.

Knowledge flows and commercialisation: Improving the economic returns to investments in public research is an important policy goal, and a number of Catapult Centres have recently been announced to bridge the perceived gap between businesses and universities. These centres, which are overseen by the Technology Strategy Board with an investment of over USD 300 million, aim to create a critical mass of resources for business and research innovation. They will allow businesses to access equipment and expertise that would otherwise be out of reach. They focus on specific technologies with a potentially large global market and significant UK capability. The government has also announced the creation of an Open Data Institute to exploit the growth opportunities created by its open data policy.

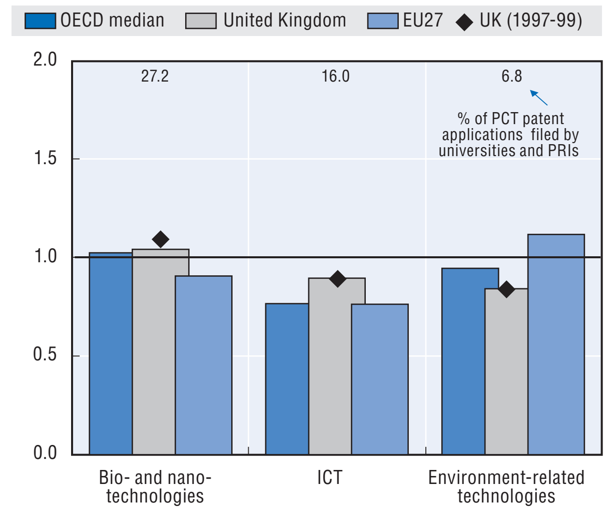
Human resources: Over the period 2011-15, the Department for Education will spend up to USD 200 million to improve education in STEM in schools. Measures include the reform of the primary and secondary school curriculum, with a strong focus on essential knowledge, and incentives to attract the best students to teaching careers.

Green innovation: Efforts are being made to encourage investment in the green economy. The Technology Strategy Board has dedicated around 70% of its total investment to the development of low carbon technologies, and a Green Investment Bank has been set up to accelerate private-sector investment to move towards a green economy.

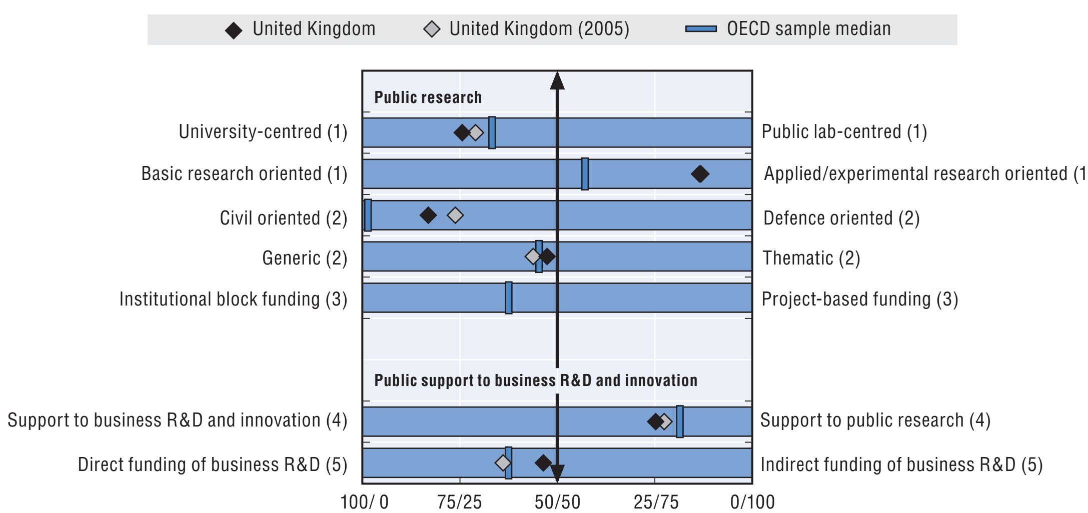
Panel 2. Structural composition of BERD, 2009
As a % of total BERD



Panel 3. Revealed technology advantage in selected fields, 2007-09
Index based on PCT patent applications



Panel 4. Overview of national innovation policy mix, 2010



1. Balance as a percentage of the sum of HERD and GOVERD.
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Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888932690928

UNITED STATES

Hot STI issues

- Creating a 21st century workforce and research infrastructure.
- Catalysing breakthroughs for national priorities through market-based and sustainable innovation.
- Improving innovation governance and co-ordination in a highly decentralised system.

General features of the STI system: The United States has long been at the forefront of cutting-edge innovation. It has excellent higher education institutions, a large and integrated marketplace, and efficient capital and equity markets. It leads the OECD in shares of GERD (41%), triadic patent families (29%) and scientific publications (31%). It hosts nearly a third of the world's largest corporate R&D investors (Panel 1[(e)]). Its research system relies primarily on an R&D-intensive business sector (2.04% of GDP) which accounts for 70% of total GERD (1[(d)]). Large domestic firms are the key actors; SMEs account for 17% of BERD and foreign affiliates for 15% (Panel 2). Most private R&D performers are in high-technology manufacturing (50%), followed by knowledge-intensive services (27%). Triadic patents per GDP are above the OECD median (1[(f)]). Researchers' international linkages are below the OECD median on account of the variety of opportunities offered by domestic linkages: 30% of scientific articles and 12% of PCT patent applications involve international collaboration (1[(q)(r)]). Universities and PRIs are actively filing patents (1[(p)]), especially in bio- and nano-technologies (35%) (Panel 3). While its RTA has slipped in recent years, the United States is strong in these technologies, as well as in ICT; it is relatively weak in environmental technologies (Panel 3). It has a good skills foundation; 41% of the adult population is tertiary-qualified and 35% of those employed are in S&T occupations (1[(s)(v)]). Inflows of new skills are modest. Only 9% of 15-year-olds perform well in science on the PISA test, there is a relative decline in doctoral graduates and low participation in science and engineering (1[(t)(u)]). ICT infrastructure is good, with fair coverage in fixed broadband (1[(k)]) and wide coverage in wireless broadband (1[(l)]). The e-government readiness index is high (1[(n)]).

Recent changes in STI expenditures: GERD was USD 402 billion and 2.90% of GDP in 2009. It grew by a strong 2.9% in real terms during 2005-09, in spite of a sharp USD 5.8 billion decrease in 2009 driven by a contraction in private spending. In response to the economic crisis, the *American Recovery and Reinvestment Act* (ARRA) of 2009 approved R&D funding of USD 18 billion for new discoveries in energy, climate and future technologies.

Overall STI strategy: The 2009 Strategy for American Innovation: Driving towards Sustainable Growth and Quality Jobs was updated in 2011 and is the basis of the government's push to further an innovation-based economy. It has three goals: a world-class workforce with 21st century skills; competitive markets that spur productive entrepreneurship; and breakthroughs in national priorities.

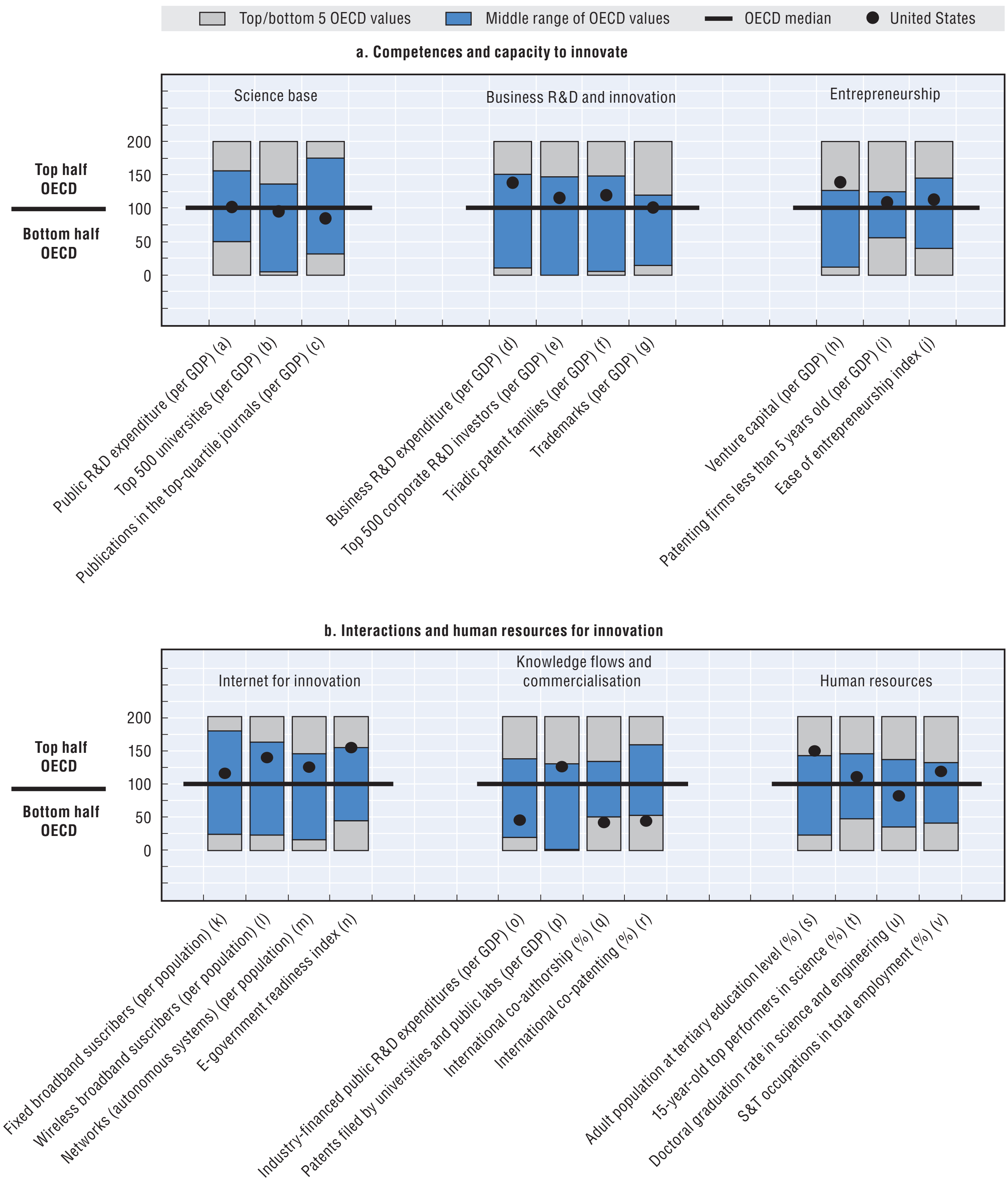
STI policy governance: There is no central administration exclusively in charge of innovation. The Office of Science and Technology Policy gives policy advice and co-ordinates STI policies. Key agencies in the Commerce Department are the National Institute of Standards and Technology and the US Patent and Trademark Office. The Commerce

Key figures

Labour productivity, GDP per hour worked in USD, 2010	**59.0**	**GERD, as % of GDP, 2009**	**2.90**
(annual growth rate, 2005-10)	(+1.6)	(annual growth rate, 2005-09)	(+2.9)
Environmental productivity, GDP per unit of CO_2 emitted in USD, 2009	**2.67**	**GERD publicly financed, as % of GDP, 2009**	**1.01**
(annual growth rate, 2005-09)	(+3.1)	(annual growth rate, 2005-09)	(+4.2)

Figure 10.43. **Science and innovation in the United States**

Panel 1. Comparative performance of national science and innovation systems, 2011



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

Department established an Office of Innovation and Entrepreneurship and a National Advisory Council on Innovation and Entrepreneurship. In January 2012, a COMPETES progress report provided findings on basic research, education, research infrastructure, and support for manufacturing. The National Science Foundation's (NSF) Science of Science and Innovation Policy (SciSIP) and Science of Science Policy (SOSP) are building a knowledge base to improve policy evaluation.

Science base: The United States has a strong science base, but at the aggregate level, selected performance indicators are around the OECD median (1[(a)(b)(c)]). Public R&D expenditures are slightly above the median, and many other OECD countries have caught up with the performance of US universities and researchers.

Business R&D and innovation: To boost business R&D, the Research and Experimentation (R&E) Tax Credit is to be simplified, expanded and extended. The 2013 budget increases non-defence R&D by 5% to USD 64.9 billion. The budgets of three key science agencies – NSF, the Department of Energy Office of Science, and the National Institute of Standards and Technology laboratories – are on a long-term doubling trajectory.

Entrepreneurship: Formal entrepreneurial education programmes have been set up in recent years, and the Kauffman Foundation has allocated USD 20 million for university funding of entrepreneurship research. The Small Business Innovation Research programme offers SMEs government R&D funding opportunities. The proposed changes to the R&E tax credit will extend support for loans and tax credits to SMEs. The Startup America Initiative also encourages entrepreneurship.

ICT and scientific infrastructures: As part of building a 21st century infrastructure, the Wireless Innovation (WIN) Fund will allocate USD 300 million to advance R&D in cutting-edge wireless technologies. This should expand access to high-speed Internet, modernise the electric grid and enhance the wireless spectrum.

Clusters and regional policies: The Economic Development Administration (EDA) promotes incubators and regional cluster development. The Small Business Administration and the EDA encourage regional innovation clusters. The Department of Defense has technology clusters for robotics, energy and cyber-security. A new proof-of-concept centre at the University City Science Center in Philadelphia and the Office of Innovation and Entrepreneurship (OIE) are key recent developments. The OIE also manages the i6 Challenge, a competitive grants programme.

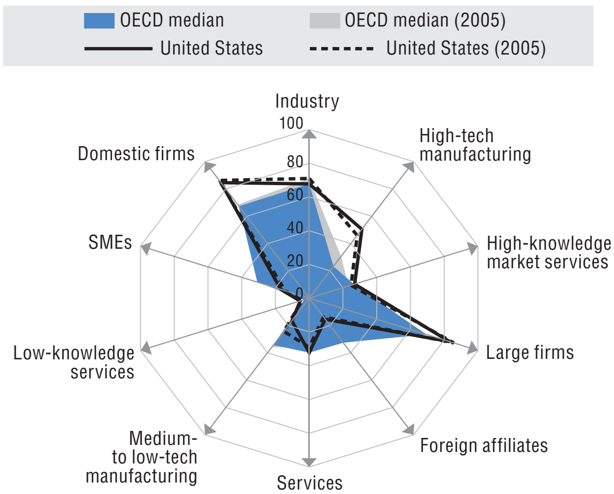
Knowledge flows and commercialisation: The *America Invents Act 2011* is a major policy reform to improve IPR protection and licensing. It aims to reduce patent backlogs, limit litigation, improve patent quality and increase inventors' ability to protect intellectual property abroad. The NSF's Office of Experimental Programs to Stimulate Competitive Research (EPSCoR) aims to strengthen research and education in science and engineering and to prevent undue concentration of research activities.

Human resources: The improvement of STEM education is a national priority, along with the goal to lead in tertiary attainment. The 2013 budget proposes a 2.6% increase to improve post-secondary STEM education as well as the quality of primary and secondary teachers. The five-year strategic plan for STEM education aims to improve co-ordination of STEM-related agencies. Other human capital programmes include Race to the Top (Phase 3), the Early Learning Challenge Fund and the Head Start Program.

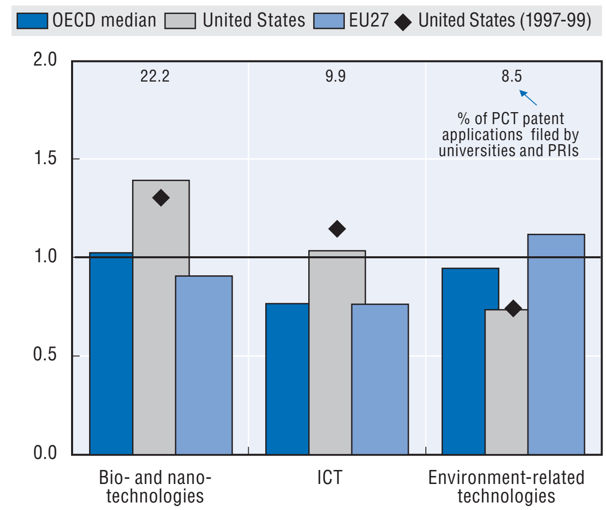
Emerging technologies: The 2013 budget provides USD 2.2 billion for R&D in advanced manufacturing, industrial materials and robotics to create high-quality manufacturing jobs. It also proposes USD 30.7 billion for the National Institutes of Health for biomedical research. Funding for the National Center for Advancing Translational Sciences aims to expedite the development of new diagnostics and treatments; the National Nanotechnology Initiative receives ongoing R&D funding.

Green innovation: The United States intends to lead the world in R&D on clean energy technology. The Clean Energy Standard aims to create a market for clean technologies through tax incentives and the Production Tax Credit. Other R&D funding has been allocated to the Advanced Research Projects Agency-Energy and the Energy Efficiency and Renewable Energy Office for advanced technology vehicles.

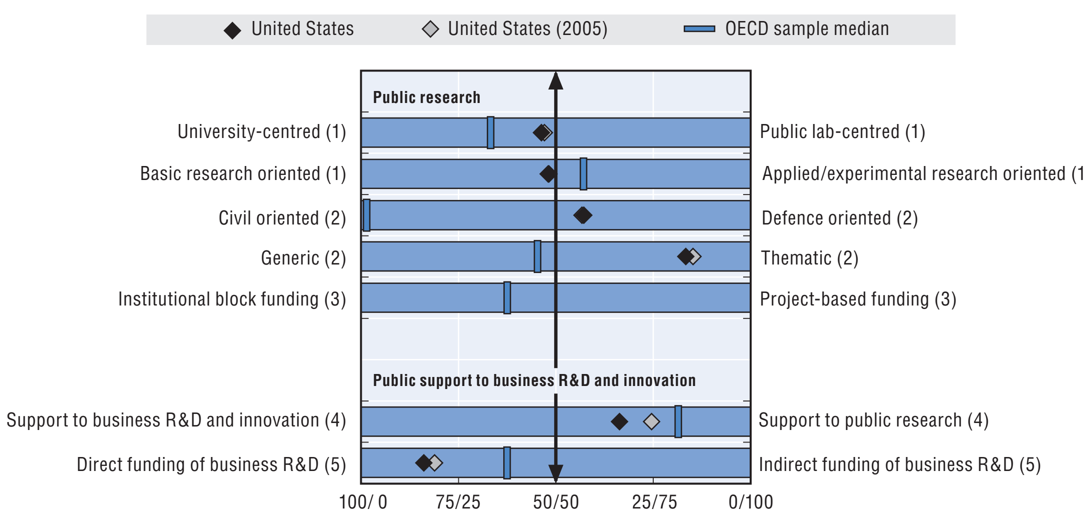
Panel 2. Structural composition of BERD, 2009
As a % of total BERD



Panel 3. Revealed technology advantage in selected fields, 2007-09
Index based on PCT patent applications



Panel 4. Overview of national innovation policy mix, 2010



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Source: See reader's guide and methodological annex.

StatLink http://dx.doi.org/10.1787/888932690947

ANNEX A

Methodological Annex to the 2012 OECD STI Outlook *Country Profiles*

Introduction

Chapter 10 presents, in a series of country profiles, 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.

For the 2012 edition, the country profiles were expanded to include over 300 key indicators in selected STI areas, a radical expansion of the statistical framework from previous editions (which had some 20 indicators). The policy dimension has been also reinforced through a more systematic and comprehensive use of national science, technology and innovation (STI) policy information.

The new 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):

- On the one hand, the policy research conducted by the Working Party on Innovation and Technology Policy (TIP), on the links between innovation and sustainable growth and the evaluation of national STI public support schemes, and the work of the 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 2012 which was circulated to CSTP delegates between January and March 2012. Official documents and external sources, such as the EU Erawatch/TrendChart reports were also used when appropriate.
- On the other hand, the statistical work and empirical research 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).

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 Science, Technology and Industry Outlook 2012*, in particular to relate the policy profiles (thematic approach) to the country profiles (country approach). It served a role in the re-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 improve: the competences and capacity of STI actors to innovate; STI actors' interactions and capacity to connect to knowledge flows; human resources (HR) for innovation; and STI policy governance.

STI actors' competences and capacity to innovate

Science base

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, 2012a). 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. 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. Gross domestic expenditures on R&D (GERD) declined by 1.6% in 2009 in the OECD area, driven by a sharp contraction of business R&D spending (–4.5%), while expenditure by higher education (+4.8%) and government (+3.8%) kept growing (OECD, 2012a). The same occurred in 2002 after the explosion of the IT bubble, although to a lesser extent.

Business R&D and innovation

Firms are major actors in national innovation systems. 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.

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.

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, 2012b). Governments see ICTs and the Internet as a major platform for research and innovation.

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.

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. 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. IPRs are therefore increasingly traded in markets and the number of intermediaries that broker commercialisation activities, notably IP services, has risen. 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.

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.

Human resources for innovation

Education

Because it raises attainment levels and the general level of education, can inspire talented young people to enter innovation-related occupations and equip people with the highest skills, formal education remains the main vehicle for improving the supply of the diverse and complex skills required for innovation. In addition to scientific, technological, engineering and mathematics skills innovation requires soft skills (entrepreneurship, creativity, leadership etc.).

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.

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.

STI policy governance

As the portfolio of innovation policy instruments has broadened, STI policy has become increasingly sophisticated. The sedimentation 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, 2010) which 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 stabilised, 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 Chapters 5, 6, 7, 8 and 9 of this volume.

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 2005 to 2010. 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 welfare 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. Also, value-added measures based on a double-deflation procedure with fixed-weight Laspeyres indices suffer from several theoretical and practical drawbacks. Data are drawn from the OECD Productivity Database which provides estimates of productivity levels and allows for comparison of standards of living and underlying factors across countries (*www.oecd.org/statistics/productivity*).

Environmental productivity levels and annual growth: Environmental outcomes are important determinants of health status and well-being. A central element of green growth is the environmental and natural resource efficiency of production and consumption. A declining asset base and climate change constitute risks for growth and sustainable development. 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

* Compound annual growth rates are calculated based on 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:

$$CAGR^{I}_{t_1, t_0} = \left[(I_{t_1} \mid I_{t_0})^{(1 \mid (t_1 - t_0))} \right] - 1$$

socioeconomic activities that can affect global economic output (OECD, 2011e). Carbon dioxide (CO_2) accounts for the largest share of GHG emissions. The main drivers of climate change and GHG emissions include fuel combustion in economic activities and by households. Environmental 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) based on the IEA energy balances and the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (IEA, 2011).

Size of the research system and public financial commitment to R&D

GERD intensity and annual growth of GERD: 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. Many OECD and non-OECD countries "target" a certain level of GERD intensity to help focus policy decisions and public funding (see Chapter 5). Data are drawn from the OECD Main Science and Technology Indicators (MSTI) Database which aims to reflect the level and structure of efforts in the field of science and technology and is based on harmonised national R&D surveys (*www.oecd.org/sti/msti*).

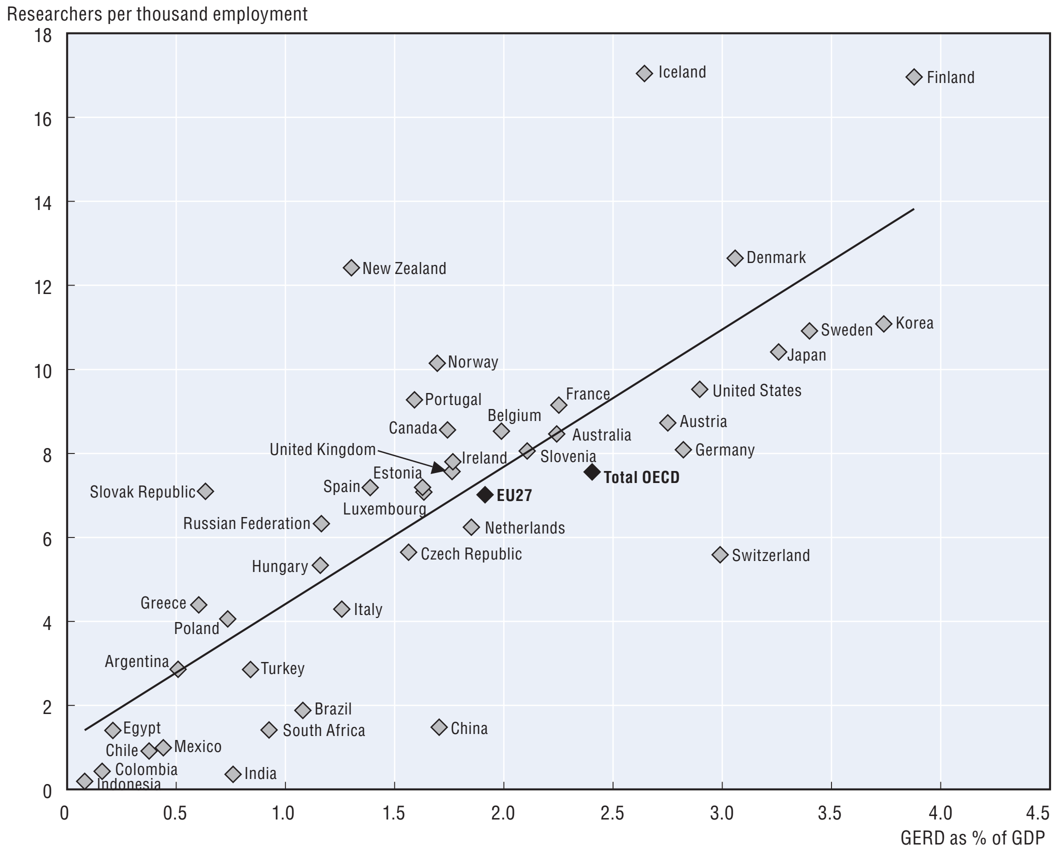
In many economies most R&D expenditures cover personnel costs which includes researcher salaries and compensation. GERD intensity as a percentage of GDP and researchers per thousand employment are therefore closely related (OECD, 2011a). To avoid redundancy, data on researcher density are not always presented in the country profiles but are included when the link between researcher and GERD intensity is more tenuous (*e.g.* Finland, New Zealand) (Figure A.1). The researcher population is estimated in full-time equivalent (FTE). Data are drawn from the OECD MSTI Database.

The size of national research systems in terms of input (GERD) and their relative performance in terms of output (patents and publications) are also reflected in a country's share in OECD totals of GERD, triadic patent families and scientific publications. These data may be used on a case-by-case basis and are drawn from the OECD MSTI Database and the *OECD STI Scoreboard 2011* (OECD, 2011a).

Publicly financed GERD intensity and annual growth: GERD is financed by various sources: business enterprises (industry), government (public), 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*).

The relative shares of the funding sectors in total GERD may be included in the text of the profiles. An average 60.7% of GERD is funded by industry in the OECD area, but governments account for around 50% of total R&D funding in Norway, the Slovak Republic and Spain. The R&D funding structure is reversed in the Russian Federation as the government funds over two-thirds of GERD. These shares reflect the extent to which the research system is supported by and may be leveraged by public funding. They also indicate the potential sensitivity or resilience of domestic R&D investments to market shocks as public R&D spending may serve as a stabiliser in times of economic crisis. Data

Figure A.1. **GERD as a percentage of GDP and researchers per thousand employment, 2010 or latest year available**



Source: OECD *MSTI Database*, June 2012. For Mexico, national sources (Conacyt-INEGI R&D survey).

StatLink http://dx.doi.org/10.1787/888932690966

are based on harmonised national R&D surveys and are drawn from the OECD RDS Database (*www.oecd.org/sti/rds*).

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 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. 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 follows:

$$\text{If } X_t^c > X_t^{Med} \text{ then } I_t^c = 100 + (X_t^c - X_t^{Med}) / (X_t^{Max} - X_t^{Med})*100$$

$$\text{If } X_t^c < X_t^{Med} \text{ then } I_t^c = 100 + (X_t^c - X_t^{Med}) / (X_t^{Min} - X_t^{Med})*100$$

The standard set of indicators includes the following:

Science base

(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.

(b) Top 500 universities (per GDP): Research excellence 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 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. More than 1 000 universities are actually ranked by ARWU every year and the list of the leading 500 are published on the web (*www.arwu.org*). This indicator has certain limits however. The ranking is skewed towards large and English-speaking institutions and emphasises the natural sciences over the social sciences or humanities. It also emphasises research excellence over the quality of teaching. The top 500 universities are expressed per million US dollars of GDP at PPP to take into account the size and the relative wealth of the country. Data for GDP are drawn from the OECD MSTI Database and are based on national accounts.

(c) Publications in top-quartile journals (per GDP): Publication is the main means of disseminating and validating 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 affiliated to an institution, in a given country). This ranking is based on the *SCImago Journal Rank* (SJR) indicator (*www.scimagoir.com*), a size-independent metric that measures the current "average prestige per paper" of journals for use in research evaluation processes and is built on citation data drawn from the *Elsevier's Scopus* database (SCImago, 2007). 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 per million US dollars of GDP at PPP to take into account the size and the relative wealth of the country. Data for GDP are drawn from the OECD MSTI Database and are based on national accounts.

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.

(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 *2011 EU Industrial R&D Investment Scoreboard* (*http://iri.jrc.ec.europa.eu/research/docs/2011/SB2011.pdf*) presents economic and financial information about the world's 1 400 largest companies ranked according to the level of their own-funded R&D investments. The top 500 accounted in 2010 for 87% of the 1 400 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 400 European and 1 000 non-European firms that invested more than EUR 30 million in R&D in 2010. 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, 2011). 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. Data for GDP are drawn from the OECD MSTI Database and are based on national accounts.

(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 2008-10 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*) and data for GDP are drawn from the OECD MSTI Database and are based on national accounts.

(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, 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. The number of trademarks applied for over the 2007-09 period is expressed per billion US dollars of GDP at PPP. Data for trademarks are drawn from OECD calculations based on World Intellectual Property Organization (WIPO) Trademark Statistics and data for GDP are drawn from the OECD MSTI Database and are based on national accounts.

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, 2011b) and data for GDP are drawn from the OECD MSTI Database and are based on national accounts.

(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 2010. 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 2007 and 2010. 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). Data for GDP are drawn from the OECD MSTI Database based on national accounts.

(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 barriers to competition (*e.g.* legal barriers, antitrust exemptions, barriers in network sectors and in retail and professional services); regulatory and administrative opacity (*e.g.* licences, permits, simplicity of procedures); and administrative burdens for creating new firms. However, the PMR indicators were last updated in 2008 and the data may no longer fully reflect the situation in rapidly reforming countries. 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 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) Fixed broadband subscribers (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). Recent 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, 2012b). 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 subscribers includes business and residential connections and is expressed per 100 inhabitants. Data for fixed broadband subscriptions are drawn from the OECD Broadband Statistics (*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 2011 Database and population data come from the UNESCO Institute for Statistics.

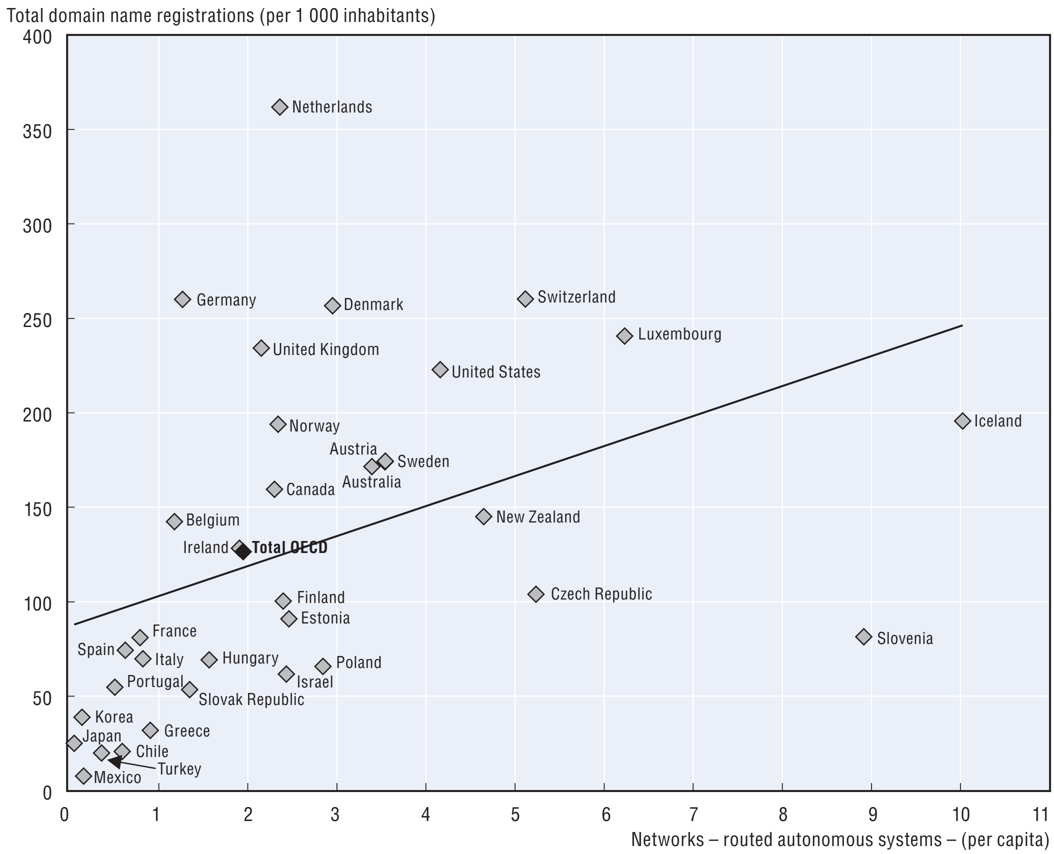
(l) Wireless broadband subscribers (per population): Wireless broadband includes subscriptions with advertised download speeds of at least 256 kbit/s through satellites, terrestrial fixed wireless, terrestrial mobile wireless (including standard mobile subscriptions and dedicated data subscriptions). It does not include Wi-Fi. The number of wireless broadband subscribers includes business and residential connections and is expressed per 100 inhabitants. Data for wireless 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 2011 Database and population data come from the UNESCO Institute for Statistics. Satellite subscriptions which tend to be null are not included.

(m) Networks (autonomous systems) (per population): The deployment of Internet infrastructures, *e.g.* individual networks, is linked to the use made of them, *e.g.* the registration of new domain names (Figure A.2). The Internet is composed of individual networks under single administrative control. These networks are called autonomous systems (AS). They can be Internet service providers (ISPs), academic or government networks, or firms with a particular need for some independence of networking (*e.g.* AT&T, France Telecom, Google, NTT). A unique number is assigned to each autonomous system in order to identify it and each AS is given an aggregated block of Internet Protocol (IP) addresses. Regional Internet registries (RIRs) are non-profit corporations which administer and register Internet Protocol (IP) address space and AS networks. ASs use the Border Gateway Protocol (BGP) routing protocol to announce (*i.e.* advertise) the aggregated IP addresses to which they can deliver traffic.

Domain names are one of the best available indicators of the spread of the Internet and e-commerce (OECD, 2011c). The domain name system (DNS) translates user-friendly domain names into IP addresses. The DNS servers handle billions of requests daily and are essential for the smooth functioning of the Internet. Top-level domains (TLDs) are divided into two classes: generic top-level domains (gTLDs) such as ".com" or ".org", and country code top-level domains (ccTLDs) which consist of two-letter codes generally reserved for a country or dependent territory (*e.g.* ".au" for Australia or ".fr" for France). Between 2000 and 2010, registrations under all ccTLDs worldwide grew by 24.3% a year and registrations under major gTLDs grew by 19.8% a year. Domain name registrations are an indicator of interest in having a web presence. Creating a new TLD can be attractive for brand holders and organisations potentially interested in managing their own name as a top-level domain for branding purposes.

The number of routed/advertised autonomous systems (RAS) is expressed per million inhabitants. Data from the *OECD Communications Outlook 2011* (OECD, 2011c) have been updated based on information compiled by *www.zooknic.com*. For non-OECD countries, population data come from the UNESCO Institute for Statistics.

Figure A.2. **Networks infrastructures and spread of the Internet use, 2010**



Source: OECD (2011), *OECD Communications Outlook 2011*, OECD, Paris. Based on *www.zooknic.com* and *www.potaroo.net/reports/oecd*.

StatLink http://dx.doi.org/10.1787/888932690985

(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, 2012b). 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 2012.

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.

(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 between 2005 and 2009 under the PCT, at international phase, by priority date and applicant's country of residence. Patent applicant names are allocated to institutional sectors using a methodology developed by Eurostat and Katholieke Universiteit Leuven (KUL). Only countries having filed at least 250 patents over the period are included. 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. Data are drawn from the OECD Patent Database. Patent counts by universities and PRIs are expressed per billion USD GDP (PPPs). GDP data are drawn from OECD MSTI Database based on OECD National Accounts.

(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 2008 and 2010. The values are computed on the basis of the share of an institution's output which includes addresses in more than one country over the period. Data are drawn from the *SCImago Journal and Country Rank (SJR)* (*www.scimagojr.com*) by the SCImago Research Group (CSIC).

(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 2007 and 2009 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) 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 Level 5 of the International Standard Classification of Education (ISCED) 1997. The adult population is defined as those aged from 25 to 64 years old. Data on population and educational attainment are compiled from national labour force surveys (LFS). For European countries, Iceland, Norway, Switzerland and Turkey, data are from Eurostat. Otherwise they are drawn from *OECD Education at a Glance 2011* (*www.oecd.org/edu/eag2011*) (OECD, 2011d).

(t) 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) 2009 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 2009 Database (*www.pisa.oecd.org*).

(u) 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 2011* (OECD, 2011d) and the OECD Education Database (*www.oecd.org/education/database*).

(v) S&T occupations in total employment (%): Human resources in science and technology are major actors in innovation. HRST are defined as persons having graduated at the tertiary level of education (ISCED Level 5 or 6) or employed in a science and technology occupation for which a high qualification is normally required and the innovation potential is high. HRST occupations refer to professionals and technicians. Professionals include: physical, mathematical and engineering science professionals (physicists, chemists, mathematicians, statisticians, computing professionals, architects, engineers); life science and health professionals (biologists, agronomists, doctors, dentist, veterinarians, pharmacists, nursing); teaching professionals; and other professionals (business, legal, information, social science, creative, religious, public service administrative). Technicians and associate professionals include: physical and engineering science associate professionals; life science and health associate professionals; teaching associate professionals; other associate professionals (finance, sales, business services, trade brokers, administrative, government, police inspectors, social work, artistic entertainment and sport, religious). Data are drawn from the OECD ANSKILL Database.

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. 3. 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 is in the process of moving to the new sectoral classification, ISIC Rev. 4, in line with the OECD STAN family of sectoral databases. In the meantime, for some countries, despite the fact that more recent data are available according to the new classification, sectoral grouping refer to earlier years.

The sectoral groupings are defined as:

Industry includes Mining (ISIC 10-14), Manufacturing (ISIC 15-37) and Utilities (ISIC 40-41) while *Services* include market sector services (ISIC 50-74) and non-market sector services (ISIC 75-99).

High-technology manufacturing include Pharmaceuticals (ISIC 2423), Office, accounting and computing machinery (ISIC 30), radio, TV and communication equipments (ISIC 32), Medical, precision and optical instruments, watches and clocks (ISIC 33), while *medium- to low-technology industries* include all other manufacturing industries.

High-knowledge market services include Post and telecommunications (ISIC 642), Financial intermediation (ISIC 65-67) and some knowledge-intensive business activities (ISIC 72-74), including Computer and related activities (ISIC 72) and Research and development (ISIC 73). *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, hunting, forestry and fishing (ISIC 01-05), Mining and quarrying (ISIC 10-14), Food products, beverages and tobacco (ISIC 15-16), Wood and products of wood and cork (ISIC 20), Pulp, paper and paper products (ISIC 21), Coke, refined petroleum products and nuclear fuel (ISIC 23), Other non-metallic mineral products (ISIC 26), Basic metals (ISIC 27) and Electricity, gas and water supply (ISIC 40-41). Owing to their low contribution to total BERD and issues of data availability, Wearing apparel, dressing and dying of fur (ISIC 18) and Leather, leather products and footwear (ISIC 19) are not included. This sectoral grouping is not represented in the charts for countries in which these industries contribute marginally to business R&D expenditure.

Firm population

Firm size: 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 AFA and FATS Databases.

Revealed technology advantage in selected fields (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 500 patents over the period reviewed are included. Data are drawn from the OECD Patent Database.

Overview of national research and innovation policy mix (Panel 4 of the country profiles)

This figure shows several features of national research and innovation systems that are areas of direct or indirect public intervention.

Public research

By sector of performance: Public research is traditionally performed by universities and PRIs. 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 (university-centred public research) and R&D performed by PRIs (public lab-centred public research), as a percentage of total public expenditure 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.

By mission/orientation: Most basic research is performed by universities and PRIs. 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 (basic-research-oriented public 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.

By socioeconomic objective: Government budget appropriations or outlays for R&D (GBAORD) by socioeconomic objective indicate the relative importance of various socioeconomic 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 socioeconomic 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*). 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". Data are drawn from the OECD RDS Database and based on budget data assembled by national authorities using statistics collected for budgets.

Civil GBAORD includes total GBAORD less defence. Defence R&D financed by government includes military nuclear and space but excludes civilian R&D financed by ministries of defence (*e.g.* meteorology).

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.

By funding mechanism: Governments support public research by means of institutional and project-based funding. 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. Data are based on an exploratory project carried out by NESTI on public R&D funding (Van Steen, 2012).

Public support to business R&D and innovation

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. 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) (Colecchia, 2007).

In relative terms with 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 data on R&D tax incentives collected by NESTI in 2010 and 2011.

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 data on R&D tax incentives collected by NESTI in 2010 and 2011.

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ANNEX B

Statistical Annex to the 2012 *OECD* STI Outlook *Country Profiles*[*]

[*] 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."

Panel 1. **Comparative performance of national science and innovation systems**

	Science Base											
	Public R&D expenditure (as a % of GDP)				Top 500 universities (per million USD GDP)				Publications in the top-quartile journals (per million USD GDP)			
	(a)				(b)				(c)			
	Year (2010)	Value	Note	Rank (42)	Year (2010)	Value	Note	Rank (43)	Year (2009)	Value	Note	Rank (40)
Argentina		0.46		33		0.00		33	..	..	..	..
Australia	2008	0.81		13		0.02		6		0.03		10
Austria		0.87	(1)	8		0.02		5		0.02		17
Belgium		0.65	(2)	22		0.02		11		0.03		12
Brazil	2004	0.54	(3)	28		0.00	(1)	30		0.01	(1)	36
Canada	2011	0.82	(2)	12		0.02		14		0.03		11
Chile		0.16	(4)	40		0.01		24		0.01		30
China		0.47		32		0.00		29		0.01		34
Colombia	2009	0.09	(3)	41		0.00	(2)	38	..	..	..	..
Czech Republic		0.59		25		0.00		28		0.02		26
Denmark		0.96	(5)	5		0.02		10		0.04		5
Egypt	..	..	..	..		0.00	(1)	32	..	..	..	..
Estonia		0.79		14		0.00		38		0.03		15
Finland		1.15		1		0.03		4		0.04		7
France		0.85	(2)	9		0.01		20		0.02		21
Germany		0.93	(6)	6		0.01		16		0.02		20
Greece	2007	0.42	(5)	36		0.01		25		0.02		18
Hungary		0.45	(7)	35		0.01		19		0.02		27
Iceland	2008	1.14	(2)	2		0.00		38		0.04		3
India	2007	0.50	(8)	29		0.00	(1)	37		0.01	(1)	37
Indonesia	2001	0.04	(9)	42		0.00	(1)	38		0.00	(1)	40
Ireland		0.59	(10)	24		0.02		13		0.02		16
Israel		0.75	(11)	16		0.03		2		0.04		4
Italy		0.54	(2)	26		0.01		17		0.02		24
Japan		0.71		18		0.01		27		0.01		28
Korea		0.88		7		0.01		21		0.02		25
Luxembourg		0.48	(2)	31		0.00		38		0.01		35
Mexico	2009	0.25	(12)	39		0.00		36		0.00		38
Netherlands		0.96	(13)	4		0.02		8		0.04		8
New Zealand	2009	0.76		15		0.04		1		0.04		6
Norway		0.83		11		0.01		15		0.03		14
Poland		0.54		27		0.00		31		0.01		29
Portugal		0.70	(2)	19		0.01		23		0.02		19
Russian Federation		0.46		34		0.00		35		0.00		39
Slovak Republic		0.36	(14)	38		0.00		38		0.01		31
Slovenia		0.68		20		0.02		9		0.03		13
South Africa	2008	0.37		37		0.01		26		0.01		32
Spain		0.67	(2)	21		0.01		22		0.02		23
Sweden		1.06	(5)	3		0.03		3		0.04		2
Switzerland		0.83	(15)	10		0.02		7		0.05		1
Turkey		0.48		30		0.00		34		0.01		33
United Kingdom		0.65	(2)	23		0.02		12		0.04		9
United States	2009	0.73	(16)	17		0.01		18		0.02		22
OECD sample average		**0.71**				**0.01**				**0.02**		
OECD sample median		**0.72**				**0.01**				**0.02**		

Notes:

Public R&D expenditure (as a % of GDP)

1. Provisional national estimate or projection.
2. Provisional.
3. *Source:* UNESCO Institute of Statistics, April 2012.
4. Provisional and based on national sources.
5. National estimate or projection.
6. HERD is a national estimate or projection.
   GOVERD may be overestimated.
7. The breakdown of R&D expenditures by sector of performance does not add to the total.
8. *Source:* UNESCO Institute of Statistics, April 2012.
   GERD is a national estimation or based on national estimation.
9. *Source:* UNESCO Institute of Statistics, April 2012.
   GERD is partial and extracted from a regional publication.
10. HERD is a national estimate or projection.
11. HERD excludes R&D in the social sciences and humanities and is provisional.
    GOVERD excludes defence (all or mostly) and is provisional.
12. National sources (INEGI-Conacyt 2010).
13. GOVERD may be overestimated.
14. GOVERD excludes defence (all or mostly).
15. GOVERD is for federal or central government only.
16. HERD excludes most or all capital expenditure.
    GOVERD is for federal or central government only.

Top 500 universities (per million USD GDP)

1. *Source:* IMF World Economic Outlook, April 2012 (GDP).
2. GDP is an IMF estimate based on IMF World Economic Outlook, April 2012.

Publications in the top-quartile journals (per million USD GDP)

1. *Source:* IMF World Economic Outlook, April 2012 (GDP per capita).

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Panel 1. **Comparative performance of national science and innovation systems**

	Business R&D and innovation							
	Business R&D expenditure (as a % of GDP)				Top 500 corporate R&D investors (per billion USD GDP)			
	(d)				(e)			
	Year (2010)	Value	Note	Rank (42)	Year (2010)	Value	Note	Rank (43)
Argentina		0.14		40		0.00		26
Australia	2009	1.30		16		0.01		17
Austria		1.88	(1)	10		0.00		26
Belgium		1.32	(2)	14		0.01		13
Brazil	2004	0.36	(3)	32		0.00	(1)	24
Canada	2011	0.91	(2)	21		0.00		21
Chile		0.16	(4)	39		0.00		26
China		1.30		15		0.00		22
Colombia	2009	0.03	(3)	41		0.00	(2)	26
Czech Republic		0.97		20		0.00		26
Denmark		2.08	(5)	7		0.03		4
Egypt	..	..	..	..		0.00	(1)	26
Estonia		0.82		24		0.00		26
Finland		2.70		3		0.01		12
France		1.38	(2)	13		0.01		8
Germany	2011	1.92	(2)	9		0.01		9
Greece	2007	0.17		38		0.00		26
Hungary		0.69	(6)	28		0.00		26
Iceland	2008	1.44	(2)	11		0.00		26
India	2007	0.26	(7)	35		0.00	(1)	23
Indonesia	2001	0.01	(8)	42		0.00	(1)	26
Ireland		1.18	(5)	17		0.03		3
Israel		3.51	(9)	1		0.01		14
Italy	2011	0.66	(2)	29		0.00		18
Japan		2.49		4		0.02		5
Korea		2.80		2		0.01		15
Luxembourg		1.16	(2)	18		0.05		1
Mexico	2009	0.18		37		0.00		26
Netherlands		0.89		22		0.02		7
New Zealand	2009	0.54		31		0.00		26
Norway		0.87		23		0.01		16
Poland		0.20		36		0.00		26
Portugal		0.72	(2)	25		0.00		19
Russian Federation		0.70		27		0.00		25
Slovak Republic		0.27		34		0.00		26
Slovenia		1.43		12		0.00		26
South Africa	2008	0.54		30		0.00		26
Spain		0.71	(2)	26		0.00		20
Sweden		2.34	(5)	5		0.02		6
Switzerland	2008	2.20		6		0.04		2
Turkey		0.36		33		0.00		26
United Kingdom		1.07	(2)	19		0.01		10
United States	2009	2.04	(10)	8		0.01		11
OECD sample average		**1.27**				**0.01**		
OECD sample median		**1.12**				**0.00**		

Panel 1. **Comparative performance of national science and innovation systems**

	Business R&D and innovation							
	Triadic patents families (per billion USD GDP)				Trademarks (per billion USD GDP)			
	(f)				(g)			
	Year (2008-10)	Value	Note	Rank (43)	Year (2007-09)	Value	Note	Rank (41)
Argentina		0.01		39		0.65		31
Australia		0.33		22		3.15		11
Austria		1.21		10		2.62	(1)	17
Belgium		1.00		12		2.06	(1)	20
Brazil	2007-09	0.03	(1)	33		0.37	(2)	37
Canada		0.48		15		5.77		4
Chile		0.03		36		1.28		25
China		0.08		29		0.39		36
Colombia	2005-07	0.00	(1)	41	..	..	..	..
Czech Republic		0.08		28		0.63	(1)	32
Denmark		1.39		8		4.16	(1)	7
Egypt	2004-06	0.00	(1)	42	..	..	..	..
Estonia		0.26		23		1.16	(1)	28
Finland		1.78		5		2.29	(1)	18
France		1.12		11		2.71	(1)	15
Germany		1.88		4		3.18	(1)	10
Greece		0.03		32		0.45	(1)	35
Hungary		0.22		25		0.57	(1)	33
Iceland		0.34		21		9.75		3
India		0.05	(1)	31		0.17	(2)	39
Indonesia		0.00	(1)	43		0.10	(2)	41
Ireland		0.43		16		3.11	(1)	13
Israel		1.68		6		4.44		6
Italy		0.37		20		2.20	(1)	19
Japan		3.25		1		1.44	(3)	23
Korea		1.49		7		1.71		21
Luxembourg		0.43		17		9.98	(1)	2
Mexico		0.01		40		0.95		29
Netherlands		1.27		9		3.08	(1)	14
New Zealand		0.39		19		4.91		5
Norway		0.42		18		1.71		22
Poland		0.03		34		0.31	(1)	38
Portugal		0.10		27		1.18	(1)	26
Russian Federation		0.02		38		0.14		40
Slovak Republic		0.03		35		1.16	(1)	27
Slovenia		0.26		24		3.21	(1)	9
South Africa		0.05		30		0.77		30
Spain		0.16		26		1.31	(1)	24
Sweden		2.46		2		3.82	(1)	8
Switzerland		2.38		3		14.94		1
Turkey		0.03		37		0.46		34
United Kingdom		0.74		14		3.12	(1)	12
United States		0.98		13		2.63	(4)	16
OECD sample average		**0.80**				**3.10**		
OECD sample median		**0.42**				**2.45**		

Notes:

Business R&D expenditure (as a % of GDP)

1. Provisional national estimate or projection.
2. Provisional.
3. *Source:* UNESCO Institute of Statistics, April 2012.
4. Provisional and based on national sources.
5. National estimate or projection.
6. The breakdown of R&D expenditures by sector of performance does not add to the total.
7. *Source:* UNESCO Institute of Statistics, April 2012.
   GERD is a national estimation or based on national estimation.
   BERD includes private non-profit.
8. *Source:* UNESCO Institute of Statistics, April 2012.
   Partial data.
   GERD is extracted from a regional publication.
9. Defence excluded (all or mostly) and provisional.
10. Excludes most or all capital expenditure.

Top 500 corporate R&D investors (per billion USD GDP)

1. *Source:* IMF World Economic Outlook, April 2012 (GDP).
2. GDP is an estimate from IMF World Economic Outlook, April 2012.

Triadic patent families (per billion USD GDP)

1. *Source:* IMF World Economic Outlook, April 2012 (GDP).

Trademarks (per billion USD GDP)

1. The number of trademarks abroad per country is calculated based on the trademarks filed in the two other foreign offices (USPTO and JPO).
2. *Source:* IMF World Economic Outlook, April 2012 (GDP).
3. The number of trademarks abroad per country is calculated based on the trademarks filed in the two other foreign offices (USPTO and OHIM).
4. The number of trademarks abroad per country is calculated based on the trademarks filed in the two other foreign offices (OHIM and JPO).

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Panel 1. **Comparative performance of national science and innovation systems**

	Entrepreneurship											
	Venture capital (as a % of GDP)				Patenting firms less than 5-year old (per billion USD GDP)				Ease of entrepreneurship index			
	(h)				(i)				(j)			
	Year (2009)	Value	Note	Rank (27)	Year (2007-10)	Value	Note	Rank (22)	Year (2008)	Value	Note	Rank (39)
Argentina	..	..	..	..	..	..	..	..	..	..	..	..
Australia		0.06	(1)	9	..	..	..	..		4.9		9
Austria		0.03	(2)	14		1.24		7		4.8		13
Belgium		0.07	(2)	6		0.62		14		4.6		22
Brazil	..	..	..	..	..	..	..	..		4.1		31
Canada		0.03		15		0.63		13		4.9		7
Chile	..	..	..	..	..	..	..	..		4.4		25
China	..	..	..	..		0.04		20		3.1		39
Colombia	..	..	..	..	..	..	..	..	..	..	..	..
Czech Republic		0.01	(2)	20		0.29		17		4.5		24
Denmark		0.06	(2)	10		3.19		1		4.9		8
Egypt	..	..	..	..	..	..	..	..	..	..	..	..
Estonia		0.01	(2)	21	..	..	..	..		4.6		21
Finland		0.07	(2)	7		1.93		3		4.7		19
France		0.05	(2)	11		0.72		12		4.7		17
Germany		0.03	(2)	16		0.94		10		4.7		18
Greece		0.01	(2)	22	..	..	..	..		4.1		30
Hungary		0.00	(2)	26	..	..	..	..		4.3		28
Iceland	..	..	..	..	..	..	..	..		4.0		32
India	..	..	..	..		0.00		21		3.3		38
Indonesia	..	..	..	..	..	..	..	..	..	..	..	..
Ireland		0.07	(2)	5		1.42		6		4.8		10
Israel		0.18		1	..	..	..	..		3.5		37
Italy		0.00	(2)	23		0.62		15		4.9		4
Japan	..	..	..	..		0.18		19		4.6		20
Korea		0.03		17	..	..	..	..		4.9		6
Luxembourg		0.00	(2)	25	..	..	..	..		4.3		27
Mexico	..	..	..	..		0.00		22		3.7		34
Netherlands		0.03	(2)	13		1.44		5		5.1		2
New Zealand	..	..	..	..	..	..	..	..		4.4		26
Norway		0.06		8		1.61		4		4.8		14
Poland		0.00	(2)	27	..	..	..	..		3.7		35
Portugal		0.02	(2)	18	..	..	..	..		4.8		11
Russian Federation	..	..	..	..	..	..	..	..		4.2		29
Slovak Republic	..	..	..	..		0.20		18		4.5		23
Slovenia		0.00	(2)	24	..	..	..	..		4.9		5
South Africa	..	..	..	..	..	..	..	..		3.9		33
Spain		0.02	(2)	19		0.49		16		4.8		15
Sweden		0.08	(2)	3		2.13		2		5.1		3
Switzerland		0.08		4		0.79		11		4.8		12
Turkey	..	..	..	..	..	..	..	..		3.6		36
United Kingdom		0.05	(2)	12		1.12		8		5.2		1
United States		0.09	(3)	2		1.08		9		4.8		16
OECD sample average		**0.04**				**1.03**				**4.6**		
OECD sample median		**0.03**				**0.87**				**4.7**		

Notes:

Venture capital (as a % of GDP)

1. Includes pre-seed stage and early expansion.
2. Includes later stage except bridge financing.
3. Includes expansion.

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Panel 1. **Comparative performance of national science and innovation systems**

	Internet use for innovation							
	Fixed broadband subscribers (per 100 population)				Wireless broadband subscribers (per 100 population)			
	(k)				(l)			
	Year (Jun 11)	Value	Note	Rank (43)	Year (Jun 11)	Value	Note	Rank (37)
Argentina	2010	10	(1)	36	..	..	..	..
Australia		24	(2)	21		65	(1)	8
Austria		25	(3)	18		33	(1)	23
Belgium		32	(3)	12		11	(1)	32
Brazil	2010	7	(1)	38	2010	21	(2)	31
Canada		31	(3)	13		32	(1)	26
Chile		11	(4)	32		10	(3)	34
China	2010	9	(1)	37	..	..	..	..
Colombia	2010	6	(1)	39	2010	5	(2)	36
Czech Republic		15	(3)	29		55	(4)	10
Denmark		38	(3)	3		74	(5)	6
Egypt	2010	2	(1)	40	2010	21	(2)	30
Estonia		24	(3)	20		33	(1)	24
Finland		29	(3)	14		79	(4)	4
France		34	(5)	6		38	(6)	22
Germany		33	(3)	9		29	(1)	28
Greece		21	(3)	26		30	(1)	27
Hungary		20	(3)	27		10	(1)	33
Iceland		34	(3)	7		54	(1)	14
India	2010	1	(1)	42	..	..	..	..
Indonesia	2010	1	(1)	43	..	..	..	..
Ireland		21	(3)	25		54	(1)	13
Israel		24	(3)	19		40	(4)	21
Italy		22	(3)	24		42	(1)	20
Japan		27	(3)	16		80	(6)	3
Korea		36	(3)	4		99	(7)	1
Luxembourg		32	(6)	11		55	(1)	11
Mexico		11	(3)	34		0	(6)	37
Netherlands		38	(3)	1		44	(1)	18
New Zealand		26	(3)	17		54	(1)	12
Norway		35	(3)	5		76	(1)	5
Poland		14	(3)	30		51	(1)	15
Portugal		20	(3)	28		65	(8)	9
Russian Federation	2010	11	(1)	33	..	..	..	..
Slovak Republic		13	(3)	31		33	(1)	25
Slovenia		23	(7)	23		29	(9)	29
South Africa	2010	1	(1)	41	..	..	..	..
Spain		24	(3)	22		42	(1)	19
Sweden		32	(3)	10		94	(1)	2
Switzerland		38	(8)	2		49	(10)	16
Turkey		10	(3)	35		5	(6)	35
United Kingdom		33	(3)	8		44	(1)	17
United States		27	(9)	15		66	(10)	7
OECD sample average		**26**				**46**		
OECD sample median		**25**				**44**		

Panel 1. Comparative performance of national science and innovation systems

	Internet use for innovation							
	Networks (autonomous systems) (per million population)				E-government readiness index			
	(m)				(n)			
	Year (2010)	Value	Note	Rank (43)	Year (2012)	Value	Note	Rank (43)
Argentina		5	(1)	32		0.6		36
Australia		37	(1)	10		0.8		11
Austria		38		8		0.8		19
Belgium		12		26		0.8		22
Brazil		4	(2)	35		0.6		37
Canada		25	(3)	15		0.8		10
Chile		6		31		0.7		30
China		0	(3)	43		0.5		38
Colombia		1	(2)	40		0.7		31
Czech Republic		71		3		0.6		32
Denmark		28		12		0.9		4
Egypt		1	(2)	41		0.5		42
Estonia		24		18		0.8		18
Finland		25		17		0.9		9
France		8		29		0.9		6
Germany		13		25		0.8		15
Greece		8		27		0.7		29
Hungary		16	(3)	22		0.7		25
Iceland		110	(3)	1		0.8		20
India		0	(2)	42		0.4		43
Indonesia		2	(2)	38		0.5		40
Ireland		20		21		0.7		28
Israel		25	(1)	14		0.8		14
Italy		8		28		0.7		26
Japan		4	(1)	34		0.8		16
Korea		14	(1)	24		0.9		1
Luxembourg		68		4		0.8		17
Mexico		2	(1)	39		0.6		35
Netherlands		25		16		0.9		2
New Zealand		47	(3)	6		0.8		12
Norway		25	(3)	13		0.9		8
Poland		29	(3)	11		0.6		33
Portugal		5		33		0.7		27
Russian Federation		21	(1)	19		0.7		24
Slovak Republic		15		23		0.6		34
Slovenia		93		2		0.7		23
South Africa		2	(1)	37		0.5		41
Spain		7		30		0.8		21
Sweden		37		9		0.9		7
Switzerland		50		5		0.8		13
Turkey		3	(3)	36		0.5		39
United Kingdom		21		20		0.9		3
United States		45	(3)	7		0.9		5
OECD sample average		**28**				**0.8**		
OECD sample median		**24**				**0.8**		

Notes:

Fixed broadband subscribers (per 100 population)

1. *Source:* ITU / World telecommunications indicators 2011, January 2012.
2. Government supplied estimates. Cables subscriptions include other data.
3. Government supplied estimates.
4. OECD estimates.
5. Government supplied estimates. Cable data are estimates based on data reported by publicly listed companies.
6. Government supplied estimates. The methodology to collect cable modem subscriptions changed for the June 2011 data collection.
7. Government supplied estimates. Fibre data include only fiber-to-the-home (FTTH).
8. Government supplied estimates and preliminary data.
9. OECD estimates based on data reported by publicly listed companies, and government supplied estimates.

Wireless broadband subscribers (per 100 population)

1. Government supplied estimates.
2. *Source:* ITU / World telecommunications indicators 2011, January 2012.
   Satellite subscriptions are not available.
3. OECD estimates.
4. Government supplied estimates. Due to a change in methodology for June 2011 data collection, no comparison should be made with previous data.
5. Government supplied estimates. Satellite subscriptions data are not available.
6. Government supplied estimates. Standard mobile broadband subscriptions include dedicated mobile data subscriptions.
7. Government supplied estimates. Terrestrial fixed wireless data are not available.
8. Government supplied estimates. Standard mobile broadband subscriptions include subscriptions used to make an Internet data connection via IP in the previous 30 days.
9. Government supplied estimates. Standard mobile broadband subscriptions include subscriptions to dedicated data services purchased separately from voice services. Dedicated mobile data subscriptions include dedicated services cards/modems/keys only.
10. Government supplied estimates based on preliminary data.

Networks (autonomous systems) (per million population)

1. Population data are for 2010.
2. *Source:* UNESCO Institute of Statistics, April 2012 (population data).
3. Population data are OECD estimates or projections based on national sources.

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Panel 1. **Comparative performance of national science and innovation systems**

	Knowledge flows and commercialisation							
	Industry-financed public R&D expenditures (as a % of GDP)				Patents filed by universities and public labs (per billion USD GDP)			
	(o)				(p)			
	Year (2010)	Value	Note	Rank (38)	Year (2005-09)	Value	Note	Rank (36)
Argentina		0.00		38				
Australia	2008	0.06		15		0.91		12
Austria	2009	0.05		20		0.74		14
Belgium	2009	0.07		8		1.11		10
Brazil	..	..	..	..		0.10	(1)	28
Canada	2011	0.06	(1)	13		1.02		11
Chile		0.01	(2)	34				
China		0.06	(3)	11		0.17		24
Colombia	..	..	..	..				
Czech Republic		0.02		31		0.21		23
Denmark		0.03	(4)	23		1.76		4
Egypt	..	..	..	..				
Estonia		0.03		24				
Finland		0.08		5		0.22		22
France		0.04	(1)	21		1.76		5
Germany	2009	0.11	(5)	3		0.69		16
Greece	2005	0.03		26		0.03		34
Hungary		0.06	(3)	14		0.12		26
Iceland	2008	0.13	(1)	2		0.07		29
India	..	..	..	..		0.11	(1)	27
Indonesia	..	..	..	..				
Ireland		0.02	(6)	30		1.90		2
Israel	2008	0.06	(7)	16		4.52		1
Italy	2009	0.01		33		0.36		18
Japan		0.01		32		1.51		7
Korea		0.06		12		1.90		3
Luxembourg		0.01	(1)	35		0.03		32
Mexico	2007	0.00		37		0.04		31
Netherlands	2009	0.14	(5)	1		0.80		13
New Zealand	2009	0.07		9		0.14		25
Norway	2009	0.05		17		0.29		20
Poland		0.02	(5)	28		0.04		30
Portugal	2009	0.01		36		0.50		17
Russian Federation		0.07		7		0.02		36
Slovak Republic		0.03	(8)	25				
Slovenia		0.09		4		0.27		21
South Africa	2008	0.03		27		0.33		19
Spain	2009	0.05		18		0.69		15
Sweden	2009	0.05		19		0.03		33
Switzerland		0.07	(9)	6		1.14		9
Turkey		0.06		10		0.02		35
United Kingdom		0.04	(1)	22		1.22		8
United States	2009	0.02	(10)	29		1.58		6
OECD sample average		**0.05**				**0.83**		
OECD sample median		**0.05**				**0.69**		

Panel 1. **Comparative performance of national science and innovation systems**

	Knowledge flows and commercialisation							
	International co-authorship (as a % of total scientific articles)				International co-patenting (as a % of total PCT patent applications)			
	(q)				(r)			
	Year (2008-10)	Value	Note	Rank (43)	Year (2007-09)	Value	Note	Rank (43)
Argentina		44.1		27		46.8		4
Australia		44.2		26		15.7		34
Austria		56.8		6		25.6		18
Belgium		57.5		5		43.1		5
Brazil		27.4		38		17.1		32
Canada		45.2		23		30.2		15
Chile		54.6		9		31.1		13
China		15.0		43		10.5		40
Colombia		50.4		12		29.8		16
Czech Republic		40.8		31		31.0		14
Denmark		56.1		7		21.9		23
Egypt		39.4		33		24.4		22
Estonia		49.6		15		29.5		17
Finland		49.6		15		19.2		29
France		47.6		20		20.6		26
Germany		47.2		21		16.9		33
Greece		38.1		34		32.0		12
Hungary		47.9		19		32.4		11
Iceland		72.4		2		42.2		7
India		19.0		41		24.5		20
Indonesia		70.0		3		49.9		2
Ireland		50.4		13		33.9		9
Israel		44.6		25		14.2		35
Italy		40.9		30		13.5		38
Japan		25.4		40		2.7		43
Korea		26.3		39		3.7		42
Luxembourg		75.5		1		56.3		1
Mexico		42.8		28		24.5		21
Netherlands		51.5		11		19.3		28
New Zealand		50.3		14		20.1		27
Norway		52.6		10		21.2		25
Poland		32.7		35		34.6		8
Portugal		48.8		17		32.7		10
Russian Federation		31.3		36		21.6		24
Slovak Republic		48.3		18		48.4		3
Slovenia		42.0		29		14.1		36
South Africa		46.0		22		13.7		37
Spain		40.2		32		17.6		31
Sweden		55.0		8		18.9		30
Switzerland		62.9		4		43.0		6
Turkey		17.8		42		7.4		41
United Kingdom		44.9		24		24.7		19
United States		30.2		37		11.7		39
OECD sample average		**46.8**				**25.1**		
OECD sample median		**47.7**				**23.2**		

Notes:

Industry-financed public R&D expenditures (as a % of GDP)

1. Provisional.
2. Provisional and based on national sources.
3. The breakdown of R&D expenditures by sector of performance does not add to the total.
4. National estimate or projection.
5. Industry-financed GOVERD may be overestimated.
6. Industry-financed HERD is a national estimate or projection.
7. Industry-financed HERD excludes R&D in the social sciences and humanities.
   Industry-financed GOVERD excludes defence (all or mostly).
8. Industry-financed GOVERD excludes defence (all or mostly).
9. Excludes industry-financed GOVERD.
10. Excludes industry-financed GOVERD and most or all capital expenditure.

Patents filed by universities and public labs (per billion USD GDP)

1. *Source:* IMF World Economic Outlook, April 2012 (GDP).

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Panel 1. **Comparative performance of national science and innovation systems**

	Human resources for innovation							
	Adult population at tertiary education level (as a % of total adult population)				15-year-old top performers in science (as a % of total population at 15)			
	(s)				(t)			
	Year (2010)	Value	Note	Rank (40)	Year (2009)	Value	Note	Rank (39)
Argentina	2003	13.7	(1)	35		0.7		35
Australia	2009	36.9		11		14.5		4
Austria		19.3	(2)	29		8.0		19
Belgium		35.0	(2)	15		10.1		12
Brazil	2009	10.9		37		0.6		36
Canada	2009	49.5	(3)	2		12.1		7
Chile	2009	24.4		24		1.1		34
China	2000	4.6	(4)	38	..	..	..	..
Colombia	..	..	..	..		0.1		38
Czech Republic		16.8	(2)	31		8.4		16
Denmark		34.2	(2)	17		6.7		22
Egypt	..	..	..	..	..	..	..	..
Estonia		35.3	(2)	13		10.4		11
Finland		38.1	(2)	8		18.7		1
France		29.0	(2)	22		8.1		17
Germany		26.6	(2)	23		12.8		5
Greece		23.9	(2)	25		3.1		32
Hungary		20.1	(2)	28		5.4		27
Iceland		32.5	(2)	19		7.0		21
India	..	..	..	..	..	..	..	..
Indonesia	2007	4.5	(1)	39		0.0		39
Ireland		37.3	(2)	9		8.7		15
Israel	2009	44.9		3		3.9		31
Italy		14.8	(2)	34		5.8		26
Japan	2009	43.8		4		16.9		3
Korea	2009	38.8		7		11.6		8
Luxembourg		35.5	(2)	12		6.7		23
Mexico	2009	15.9		32		0.2		37
Netherlands		31.9	(2)	20		12.7		6
New Zealand	2009	40.1		6		17.6		2
Norway		36.9	(2)	10		6.4		24
Poland		22.9	(2)	27		7.5		20
Portugal		15.4	(2)	33		4.2		29
Russian Federation	2002	54.0		1		4.4		28
Slovak Republic		17.3	(2)	30		6.2		25
Slovenia		23.7	(2)	26		9.9		13
South Africa	2007	4.3	(1)	40	..	..	..	..
Spain		30.7	(2)	21		4.0		30
Sweden		34.2	(2)	17		8.1		18
Switzerland		35.3	(2)	13		10.7		10
Turkey		11.9	(2)	36		1.1		33
United Kingdom		35.0	(2)	15		11.4		9
United States	2009	41.2		5		9.2		14
OECD sample average		**30.3**				**8.5**		
OECD sample median		**33.4**				**8.1**		

Panel 1. **Comparative performance of national science and innovation systems**

	Human resources for innovation							
	Doctoral graduation rate in science and engineering				S&T occupations (as a % of total employment)			
	(u)				(v)			
	Year (2009)	Value	Note	Rank (34)	Year (2011)	Value	Note	Rank (43)
Argentina	..	..	..	..	2006	17.5	(1)	34
Australia		0.7	(1)	11	2010	36.7	(2)	11
Austria		0.9		6		31.4		17
Belgium		0.6		18		36.5		12
Brazil		0.1	(2)	31	2007	14.4	(3)	38
Canada		0.7	(1)	16		30.0		22
Chile		0.1		33	2002	22.4		30
China	..	..	..	..	2009	5.8		42
Colombia	..	..	..	..	2008	9.8	(4)	40
Czech Republic		0.7		13		31.1		18
Denmark		0.6		17		40.6		4
Egypt	..	..	..	..	2007	22.1		31
Estonia		0.4		23		27.4		26
Finland		1.0		3		36.8		10
France		0.9	(3)	7		37.0		9
Germany		0.9		5		37.3		8
Greece		0.3	(4)	27		24.0		29
Hungary		0.3		28		28.2		24
Iceland		0.2		30		38.7		5
India	..	..	..	..	2009	7.0		41
Indonesia	..	..	..	..	2008	5.7		43
Ireland		0.8	(3)	10		32.3		15
Israel		0.7		15	2010	30.4		21
Italy		0.6	(4)	19		30.6		19
Japan		0.4	(3)	24	2008	14.9		37
Korea		0.4		26		19.3		33
Luxembourg	..	..	..	..		56.0		1
Mexico		0.1	(3)	34	2008	16.5		35
Netherlands		0.6	(3)	21		38.5		6
New Zealand		0.7		14		30.4		20
Norway		0.6	(5)	20		37.4		7
Poland		0.3	(3)	29		26.7		27
Portugal		0.8		9		20.2		32
Russian Federation	..	..	..	..	2008	33.7		14
Slovak Republic		0.8		8		28.5		23
Slovenia		0.7		12		31.9		16
South Africa	..	..	..	..	2008	16.2		36
Spain		0.4		25		25.8		28
Sweden		1.4		1		41.5		2
Switzerland		1.4		2		41.1		3
Turkey		0.1		32	2010	12.9		39
United Kingdom		0.9		4	2010	28.1		25
United States		0.5	(3)	22		35.4		13
OECD sample average		**0.6**				**31.1**		
OECD sample median		**0.6**				**30.8**		

Notes:

Adult population at tertiary level (as a % of total adult population)

1. *Source:* UNESCO Institute of Statistics, August 2011.
   Includes 25-year-olds and older.
2. *Source:* Eurostat (2012), Attainment, outcomes and returns of education Database.
3. The Canadian Labour Force Survey does not allow for a clear delineation of attainment at ISCED 4 and at ISCED 5B; as a result, some credentials that should be classified as ISCED 4 cannot be identified and are therefore included in ISCED 5B. Thus, the proportion of the population with tertiary-type B education is inflated.
4. *Source:* Census carried out by the Chinese National Bureau of Statistics in 2000. Includes 25-years-olds and older.

Doctoral graduation rate in science and engineering

1. Doctoral graduation rate in S&E is an estimate based on the share of S&E graduates in all new degrees at doctoral level in 2008 and doctoral graduation rate in 2009.
2. *Source:* Ibero-American and Inter-American Network for Science and Technology Indicators (Red de Indicadores de Ciencia y Tecnología RICYT), May 2011.
   Available breakdowns by field of study were adapted in order to map as much as possible ISCED-1997 fields of study.
   Doctoral graduation rate in S&E is an estimate based on the share of S&E graduates in all new degrees at doctoral level in 2008 and doctoral graduation rate in 2009.
3. Gross graduation rates at doctoral level.
4. Doctoral graduation rate in S&E is an estimate based on the share of S&E graduates in all new degrees at doctoral level in 2007 and doctoral graduation rate in 2009.
5. *Source:* The Nordic Institute for Studies in Innovation (NIFU), Research and Education, May 2011.
   Data are based upon NIFU's Doctoral Degree Register which includes all doctoral and licentiate degrees (equivalent to a PhD degree).

S&T occupations (as a % of total employment)

1. Data cover 31 urban agglomerations.
2. Technicians and associate professionals include trade workers.
3. Data exclude rural population of Rondõnia, Acre, Amazonas, Roraima, Pará and Amapá.
4. Estimates are based on ISCO-68 breakdown.

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Panel 2. Structural composition of BERD, as a percentage of BERD

	Industry			Services			High-tech manufacturing			Medium- to low-tech manufacturing		
	Year (2009)	Value	Note	Year (2009)	Value	Note	Year (2009)	Value	Note	Year (2009)	Value	Note
Argentina	..	..	..	..	..	..	..	..	..	..	..	..
Australia	2008	57.7		2008	42.3		2008	7.0		2008	19.6	
Austria		68.4			31.6		2009	16.5			51.0	
Belgium		76.5			23.5		2009	39.7			33.7	
Brazil	..	..	..	..	..	..	..	..	..	..	..	..
Canada	2008	55.5		2008	44.5		2008	18.7		2008	27.8	
Chile	2008	28.3		2008	71.7		..	..	..	..	..	..
China		92.7			7.3		..	..	..	..	..	..
Colombia	..	..	..	..	..	..	..	..	..	..	..	..
Czech Republic	2010	65.2		2010	34.8		2010	14.4		2010	48.9	
Denmark	2006	66.5		2006	33.5		2006	39.9	(1)	2006	25.2	
Egypt	..	..	..	..	..	..	..	..	..	..	..	..
Estonia		24.1			75.9			4.9			15.6	
Finland		82.0			18.0			55.3	(2)		24.7	
France	2007	87.7		2007	12.3		2007	42.5		2007	41.1	
Germany	2008	89.7		2008	10.3		2008	27.7	(2)	2008	61.3	
Greece	2007	47.3		2007	52.7		2007	17.6		2007	28.4	
Hungary		70.9			29.1			42.0			26.1	
Iceland		46.1			53.9			32.0			11.7	
India	..	..	..	..	..	..	..	..	..	..	..	..
Indonesia	..	..	..	..	..	..	..	..	..	..	..	..
Ireland		40.0	(1)		60.0	(1)	2008	23.2	(1)	2008	31.0	
Israel	2010	30.7		2010	69.3		..	..	..	..	..	..
Italy	2010	76.3		2010	23.7		2010	29.1		2010	43.8	
Japan		88.8			11.2			35.9			51.3	
Korea	2010	91.0		2010	9.0		2010	53.4		2010	34.3	
Luxembourg	2007	42.0		2007	58.0		..	..	..	..	..	..
Mexico	2007	70.5		2007	29.5		2007	8.3		2007	61.0	
Netherlands	2007	76.6		2007	23.4		2007	33.8		2007	39.2	
New Zealand		52.5			47.5		..	..	..	..	..	..
Norway	2008	59.1		2008	40.9		2008	11.2		2008	32.0	
Poland		69.7			30.3			14.7	(2)		51.3	
Portugal		40.4			59.6			8.8			24.1	
Russian Federation		14.2			85.8			6.2			5.7	
Slovak Republic		68.5			31.5		2007	15.0	(1)	2007	36.1	
Slovenia		84.9			15.1			44.5			39.2	
South Africa	2008	64.5		2008	35.5		..	..	..	..	..	..
Spain		60.6			39.4			18.5			35.4	
Sweden	2007	84.7		2007	15.3		2007	43.7		2007	39.3	
Switzerland	2008	86.8		2008	13.2		2008	53.7	(3)	2008	23.4	
Turkey	2008	65.2		2008	34.8		2008	16.0		2008	48.1	
United Kingdom		75.9			24.1			45.8			28.1	
United States	2008	67.7		2008	32.3		2008	50.5	(2)	2008	16.6	(1)
OECD sample median		**67.7**			**32.3**			**27.7**			**33.7**	

Notes:

Industry

1 OECD estimate.

Services

1. OECD estimate.

High-tech manufacturing

1. Underestimated: does not include aircraft and spacecraft (ISIC 353).
2. OECD estimate.
3. Underestimated: does not include office, accounting computing machinery (ISIC 30) and aircraft and spacecraft (ISIC 353).

Medium- to low-tech manufacturing

1. OECD estimate.

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Panel 2. **Structural composition of BERD, as a percentage of BERD**

	High-knowledge market services			Low-knowledge services			Primary and resource-based industries			Non-resource-based manufacturing industries		
	Year (2009)	Value	Note	Year (2009)	Value	Note	Year (2009)	Value	Note	Year (2009)	Value	Note
Argentina	..	..		..	..		..	..		..	..	
Australia	2008	32.7		2008	9.6		2008	34.2		2008	23.4	
Austria		26.4			5.3			5.8			62.6	
Belgium		21.6			1.9			9.1			67.3	
Brazil	..	..		..	..		..	..		..	..	
Canada	2008	33.2	(1)	2008	11.3		2008	14.3	(1)	2007	45.0	
Chile	..	..		..	..		2008	15.8		2008	12.5	
China	..	..		..	..			24.8			67.8	
Colombia	..	..		..	..		..	..		..	..	
Czech Republic	2010	32.1		2010	2.7		2010	3.2		2010	62.0	
Denmark	2006	30.5		2006	3.1		2006	4.5	(2)	2006	62.0	
Egypt	..	..		..	..		..	..		..	..	
Estonia		64.9			11.0			8.9	(2)	2007	19.0	
Finland		16.1	(1)		1.9		..	..		2008	23.4	
France	2007	12.0	(2)	2007	0.3		2007	9.5		2007	78.3	
Germany	2008	10.0	(1)	2008	0.3		2008	3.1		2008	86.6	
Greece	2007	50.0		2007	2.7		2007	7.2		2007	40.1	
Hungary		19.0			10.1			6.6			64.3	
Iceland		52.3			1.6		..	..		..	..	
India	..	..		..	..		..	..		..	..	
Indonesia	..	..		..	..		..	..		..	..	
Ireland	2008	41.1		2008	4.6		2005	7.0		2005	59.4	
Israel	2010	69.3	(3)	2010	0.0		..	..		..	..	
Italy	2010	20.9		2010	2.8		2010	6.3		2010	70.0	
Japan		8.2	(3)		3.0		..	..		..	..	
Korea	2010	6.7		2010	2.3		2010	5.1		2010	85.9	
Luxembourg	..	..		..	..		..	..		..	..	
Mexico	2007	7.7		2007	21.8		2007	23.4		2007	47.1	
Netherlands	2007	19.0		2007	4.3		2007	9.9		2007	66.7	
New Zealand	..	..		..	..		..	..		..	..	
Norway	2008	37.4		2008	3.6		2008	22.1		2008	37.0	
Poland		16.7	(3)		13.6			14.1		..	..	
Portugal		53.4			6.2			14.4	(3)	..	..	
Russian Federation		84.6			1.2			2.5			11.7	
Slovak Republic		29.7	(3)		1.8		..	..		..	..	
Slovenia		13.1			2.1			5.2			79.6	
South Africa	..	..		..	..		..	..		..	..	
Spain		29.7			9.7			10.4			50.2	
Sweden	2007	12.7		2007	2.6		..	..		..	..	
Switzerland	2008	14.6	(4)	2008	0.0		..	..		..	..	
Turkey	2008	31.8		2008	3.0		2008	4.9		2008	60.3	
United Kingdom		22.9	(5)		1.1		..	..		..	..	
United States	2008	26.9	(4)	2008	5.4		..	..		..	..	
OECD sample median		**26.6**			**2.9**			**8.9**			**61.2**	

Notes:

High-knowledge market services

1. Overestimated: includes transport, storage and communications (ISIC 60-64x).
2. Underestimated: does not include financial intermediation (ISIC 65-67).
3. Underestimated: does not include telecommunications (ISIC 642).
4. OECD estimate.
5. Underestimated: does not include other business activities (ISIC 74).

Primary and resource-based industries

1. Underestimated: does not include other non-metallic metals (ISIC26).
2. Underestimated: does not include agriculture, hunting, forestry and fishing (ISIC 01-05) and mining and quarrying (ISIC 10-14).
3. Overestimated: includes rubber and plastic products (ISIC 25).

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Panel 2. **Structural composition of BERD, as a percentage of BERD**

	Large firms			SMEs			Foreign affiliates			Domestic firms		
	Year (2009)	Value	Note	Year (2009)	Value	Note	Year (2009)	Value	Note	Year (2009)	Value	Note
Argentina	..	..	..	..	..	..	..	..	..	..	..	
Australia		66.3			33.7			32.1	(1)		67.9	
Austria		71.3			28.7			52.3	(1)		47.7	
Belgium		65.8			34.2			53.8	(1)		46.2	
Brazil	..	..	..	..	..	..	..	..	..	..	..	
Canada	2008	61.6		2008	38.4			32.6	(1)		67.4	
Chile	2008	67.5		2008	32.5	(1)	..	..	..	..	..	
China	..	..	..	..	..	..	..	..	..	..	..	
Colombia	..	..	..	..	..	..	..	..	..	..	..	
Czech Republic	2010	62.0		2010	38.0			58.0	(1)		42.0	
Denmark		71.4			28.6		..	..	..	..	..	
Egypt	..	..	..	..	..	..	..	..	..	..	..	
Estonia		39.3			60.7		..	..	..	..	..	
Finland		81.5			18.5		2008	16.0	(1)	2008	84.0	
France		78.6			21.4	(1)		19.6	(1)		80.4	
Germany		89.0			11.0	(1)		27.3	(1)		72.7	
Greece	2005	40.3		2005	59.7	(1)	..	..	..	..	..	
Hungary		61.8			38.2			52.6	(1)		47.4	
Iceland	..	..	..	..	..	..	..	..	..	..	..	
India	..	..	..	..	..	..	..	..	..	..	..	
Indonesia	..	..	..	..	..	..	..	..	..	..	..	
Ireland	2006	50.9		2006	49.1	(3)		69.9	(1)		30.1	
Israel	..	..	..	..	..	..	2007	61.8		2007	38.2	
Italy	2007	78.2		2007	21.8	(1)		24.5	(1)		75.5	
Japan		93.7			6.3	(4)	2007	5.1	(1)	2007	94.9	
Korea	2010	76.9		2010	23.1	(1)	..	..	..	..	..	
Luxembourg		83.4			16.6	(5)	..	..	..	..	..	
Mexico	..	..	..	..	..	..	..	..	..	..	..	
Netherlands		72.3			27.7	(5)	2008	32.6		2008	67.4	
New Zealand		20.5			79.5		..	..	..	..	..	
Norway		49.5			50.5	(5)	2007	30.5		2007	69.5	
Poland		76.0			24.0	(5)		50.5			49.5	
Portugal		64.5			35.5	(1)	2007	23.1	(1)	2007	76.9	
Russian Federation	..	..	..	..	..	..	..	..	..	..	..	
Slovak Republic	2010	59.2		2010	40.8		2007	37.5	(1)	2007	62.5	
Slovenia		62.5			37.5		..	..	..	..	..	
South Africa	..	..	..	..	..	..	..	..	..	..	..	
Spain		48.9			51.1	(1)	2007	34.3		2007	65.7	
Sweden		81.5			18.5	(5)		29.6	(1)		70.4	
Switzerland	2008	71.0		2008	29.0	(1)	..	..	..	..	..	
Turkey	..	..	..	..	..	..	..	..	..	..	..	
United Kingdom		83.6			16.4			46.7	(1)		53.3	
United States		83.2			16.8	(6)		15.4	(1)		84.6	
OECD sample median		**69.2**			**30.8**			**32.6**			**67.4**	

Notes:

SMEs

1. Does not include firms with no employee.
2. Provisional.
3. Does not include firms with no employee. The unrevised breakdown of BERD by size class does not add to the revised total.
4. Data do not include firms with less than 50 employees and are underestimated or based on underestimated data.
5. Does not include firms with less than 10 employees.
6. Excludes most or all capital expenditures and firms with less than 10 employees.

Foreign affiliates

1. Provisional.

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Panel 3. **Revealed technology advantage in selected fields**

	Bio- and nano-technologies			ICT			Environment-related technologies		
	RTA (1997-99)	RTA (2007-09)	Share of patents filed by PRIs (2005-09)	RTA (1997-99)	RTA (2007-09)	Share of patents filed by PRIs (2005-09)	RTA (1997-99)	RTA (2007-09)	Share of patents filed by PRIs (2005-09)
Argentina	..	..	..	..	..	..	..	..	..
Australia	1.0	1.4	22.2	0.8	0.8	9.9	1.3	1.1	8.5
Austria	0.7	1.0	18.2	0.6	0.7	8.0	1.5	1.3	2.2
Belgium	1.7	1.7	20.4	0.5	0.6	17.4	0.8	0.8	5.6
Brazil	..	1.0	35.0	..	0.3	10.1	..	1.0	6.1
Canada	1.6	1.5	39.7	0.9	1.1	9.1	1.5	1.1	8.4
Chile	..	..	..	..	..	..	..	..	..
China	2.8	0.4	28.9	0.5	1.3	2.8	0.9	0.6	5.0
Colombia	..	..	..	..	..	..	..	..	..
Czech Republic	..	0.8	19.0	..	0.5	9.2	..	1.3	9.1
Denmark	1.5	2.0	13.8	0.6	0.6	10.0	1.3	1.7	5.6
Egypt	..	..	..	..	..	..	..	..	..
Estonia	..	..	..	..	..	..	..	..	..
Finland	0.3	0.6	3.1	1.3	1.3	0.4	0.6	0.7	1.2
France	0.9	1.0	38.5	0.8	0.8	13.3	1.0	1.1	14.0
Germany	0.5	0.7	14.3	0.8	0.6	3.5	1.6	1.3	1.5
Greece	..	..	..	..	..	..	..	..	..
Hungary	..	1.0	23.5	..	0.8	6.7	..	1.5	0.4
Iceland	..	..	..	..	..	..	..	..	..
India	..	1.0	17.5	..	0.7	6.4	..	0.7	11.2
Indonesia	..	..	..	..	..	..	..	..	..
Ireland	..	1.4	56.9	..	1.1	20.8	..	0.8	7.3
Israel	1.1	1.3	35.8	1.4	1.1	8.7	0.6	0.7	14.5
Italy	0.6	0.8	25.3	0.4	0.5	9.0	0.7	0.9	4.8
Japan	0.8	0.7	26.2	1.1	1.2	4.0	1.4	1.4	2.9
Korea	0.8	0.7	28.4	1.1	1.3	5.5	1.2	0.9	8.8
Luxembourg	..	..	..	..	..	..	..	..	..
Mexico	..	0.7	22.2	..	0.3	7.9	..	0.9	6.7
Netherlands	0.6	1.2	14.6	1.4	1.0	1.7	1.1	1.0	2.2
New Zealand	0.9	1.7	2.9	0.6	0.6	1.9	0.8	0.9	0.0
Norway	0.5	0.6	17.8	0.7	0.7	3.1	1.2	1.5	2.0
Poland	..	1.2	2.2	..	0.7	3.0	..	1.4	6.6
Portugal	..	..	..	..	..	..	..	..	..
Russian Federation	0.6	1.0	1.1	0.8	0.6	1.8	1.5	1.1	0.4
Slovak Republic	..	..	..	..	..	..	..	..	..
Slovenia	..	..	..	..	..	..	..	..	..
South Africa	0.2	0.7	53.0	0.5	0.6	6.2	1.1	0.9	11.8
Spain	0.7	1.5	30.9	0.4	0.6	24.3	1.1	1.2	12.6
Sweden	0.5	0.6	0.5	1.1	1.1	0.0	0.9	0.8	0.0
Switzerland	0.7	1.2	7.8	0.6	0.6	3.8	0.7	0.7	3.5
Turkey	..	0.1	..	..	0.4	3.7	..	0.6	1.4
United Kingdom	1.1	1.0	27.2	0.9	0.9	16.0	0.8	0.8	6.8
United States	1.3	1.4	35.2	1.1	1.0	7.3	0.7	0.7	9.2
BRIICS	**1.1**	**0.6**	**..**	**0.6**	**1.1**	**..**	**1.1**	**0.7**	**..**
EU27	**0.7**	**0.9**	**21.4**	**0.9**	**0.8**	**6.8**	**1.2**	**1.1**	**4.6**
OECD sample median	**0.8**	**1.0**	**22.2**	**0.8**	**0.8**	**7.6**	**1.0**	**0.9**	**5.6**

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Panel 4. **Overview of national innovation policy mix, 2010**

	Public Research					
	University-centred			Basic research oriented		
	(as a percentage of the sum of HERD and GOVERD)					
	Year (2010)	Value	Note	Year (2010)	Value	Note
Argentina		41.1			41.7	
Australia	2008	66.3		2008	43.1	
Austria		83.0	(1)	2009	46.8	(1)
Belgium		71.3	(2)	..	..	..
Brazil	2004	64.3	(3)	..	..	..
Canada	2011	79.4	(2)	..	..	..
Chile	2008	80.8		2008	34.1	(2)
China		31.8			17.1	
Colombia	2009	91.3	(3)	..	..	..
Czech Republic		48.1			65.2	
Denmark		93.4	(4)	2009	43.8	(3)
Egypt	..	..	..	..	..	..
Estonia		78.3			54.0	
Finland		68.9		..	..	..
France		56.6	(2)	2009	58.6	
Germany		54.9	(5)	2006	24.6	(4)
Greece	2007	70.2	(4)	..	..	..
Hungary		51.8			51.0	(5)
Iceland	2008	58.5	(2)	2008	38.8	
India	2007	6.7	(3)	..	..	..
Indonesia	2001	5.4	(3)	..	..	..
Ireland		86.9	(6)		55.3	(6)
Israel		77.0	(7)		57.1	(7)
Italy		67.0	(2)	2009	47.8	
Japan		58.8			29.9	
Korea		46.1			32.7	
Luxembourg		39.2	(2)	..	..	..
Mexico	2007	50.9		2003	35.2	
Netherlands		77.5		..	..	..
New Zealand	2009	56.0		2009	42.4	
Norway		66.3		2009	36.3	(2)
Poland		50.9			37.2	
Portugal		83.8	(2)	2009	36.9	
Russian Federation		21.3			40.5	(2)
Slovak Republic		48.0	(8)		77.1	(8)
Slovenia		43.3			27.1	
South Africa	2008	49.5		2008	36.6	
Spain		58.5	(2)	2009	41.7	(2)
Sweden		84.4	(4)	..	..	..
Switzerland		97.3	(9)	2008	77.0	(9)
Turkey		80.1		..	..	..
United Kingdom		74.3	(2)	2009	12.9	(5)
United States	2009	53.6	(10)	2009	51.6	(10)
OECD sample median		**66.7**			**42.7**	

Notes:

University-centred

1. Provisional national estimate or projection.
2. Provisional
3. *Source:* UNESCO Institute of Statistics, April 2012.
4. National estimate or projection.
5. HERD is a national estimate or projection.
   GOVERD may be overestimated.
6. HERD is a national estimate or projection.
7. HERD excludes R&D in the social sciences and humanities and is provisional.
   GOVERD excludes defence (all or mostly) and is provisional.
8. GOVERD excludes defence (all or mostly).
9. GOVERD is for federal or central government only.
10. HERD excludes most or all capital expenditure.
    GOVERD is for federal or central government only.

Basic research oriented

1. Public expenditure on basic research performed by government is underestimated or based on underestimated data.
2. Estimations based on current costs only.
3. Provisional.
4. Estimations based on current costs only.
   Public expenditure on basic research performed by the government sector only.
5. Public expenditure on basic research is a national estimate or projection.
6. HERD is a national estimate or projection.
7. HERD excludes R&D in the social sciences and humanities and is provisional.
   GOVERD excludes defence (all or mostly) and is provisional.
8. Public expenditure on basic research is a national estimate or projection.
   GOVERD excludes defence (all or mostly).
9. GOVERD is for federal or central government only.
10. Estimations based on current costs only.
    GOVERD is for federal and central government only.

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Panel 4. **Overview of national innovation policy mix, 2010**

	Public Research								
	Civil oriented			Generic research			Funded through institutional "block" funding		
	(as a percentage of GBAORD)						(as a percentage of total funding to national performers)		
	Year (2010)	Value	Note	Year (2010)	Value	Note	Year (2010)	Value	Note
Argentina		98.7	(1)		20.4	(1)	..	..	..
Australia	2011	93.8	(2)	2011	35.3	(2)	2008	52.9	
Austria	2012	100.0	(2)	2012	69.0	(2)	2008	71.1	
Belgium		99.8			39.3		2008	44.3	
Brazil	..	..	..	..	..	..	..	..	..
Canada	2008	96.8	(1)	2008	42.3	(3)	2008	65.4	
Chile	..	..	..	..	..	..	..	..	..
China	..	..	..	..	..	..	..	..	..
Colombia	..	..	..	..	..	..	..	..	..
Czech Republic	2011	98.2	(3)	2011	62.1	(4)	2008	53.3	
Denmark	2011	99.7	(3)	2011	62.5	(4)	2008	68.1	
Egypt	..	..	..	..	..	..	..	..	..
Estonia	2011	100.0	(3)	2011	22.7	(4)	..	..	..
Finland	2012	97.4	(3)	2012	47.2	(4)	2008	47.2	
France	2011	93.2		2011	42.3		2008	74.0	(1)
Germany	2011	96.0	(3)	2011	56.7	(4)	2008	65.4	
Greece	2008	99.5	(3)	2008	61.6	(4)	..	..	..
Hungary	2011	100.0	(3)	2011	62.2	(4)	..	..	..
Iceland	2009	100.0		2009	12.8		..	..	..
India	..	..	..	..	..	..	..	..	..
Indonesia	..	..	..	..	..	..	..	..	..
Ireland	2011	100.0	(3)	2011	49.8	(4)	2008	47.8	
Israel	..	..	..		48.6	(4)	2008	64.3	
Italy	2011	99.3		2011	35.9		..	..	..
Japan	2012	97.1	(2)	2012	59.8	(2)	..	..	..
Korea	2011	83.7	(4)	..	..	..	2008	31.1	
Luxembourg	2011	100.0	(3)	2011	64.1	(4)	..	..	..
Mexico	2006	100.0		..	..	..	..	..	..
Netherlands	2012	98.4	(3)	2012	73.1	(4)	2008	72.2	
New Zealand		100.0	(3)		71.3	(4)	2008	28.1	
Norway	2011	95.6	(3)	2011	48.3	(4)	2008	58.5	
Poland	2008	96.8		2008	58.2		2008	68.6	
Portugal	2012	99.8	(3)	2012	61.9	(4)	..	..	..
Russian Federation	..	..	..	2001	24.8	(4)	..	..	..
Slovak Republic	2011	96.7	(3)	2011	59.7	(4)	2008	60.5	
Slovenia	2011	98.6	(3)	2011	43.3	(4)	..	..	..
South Africa	..	..	..	..	..	..	..	..	..
Spain		98.6			45.9		..	..	..
Sweden	2011	92.2	(3)	2011	75.4	(4)	..	..	..
Switzerland		99.5	(1)		90.7	(1)	2008	76.8	
Turkey	..	..	..	..	..	..	..	..	..
United Kingdom		83.1	(4)		52.5	(5)	..	..	..
United States		42.7	(2)		16.4	(2)	..	..	..
OECD sample median		**98.6**			**54.6**			**62.4**	

Notes:

Civil oriented

1. Federal or central government only.
2. Provisional and federal or central government only.
3. Provisional.
4. National estimate or projection.

Generic research

1. Federal or central government only.
2. Provisional and for federal or central government only.
3. Federal or central government only.
   General university funds are national estimate or projection.
4. Provisional.
5. National estimate or projection.

Funded through institutional "block" funding

1. National sources.

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Panel 4. **Overview of national innovation policy mix, 2010**

	Public support to business R&D and innovation					
	Public support to business R&D and innovation (as a percentage of the sum of HERD and GOVERD funded by government and higher education, and indirect and direct funding of BERD)			Direct funding of business R&D and innovation (as a percentage of the sum of indirect funding of business R&D and innovation through R&D tax incentives and direct funding of BERD through grants, contracts and loans)		
	Year (2010)	Value	Note	Year (2010)	Value	Note
Argentina	..	..	..	..	..	..
Australia	2008	13.1	(1)	2009	23.9	(1)
Austria	2009	29.9	(2)	2009	62.3	(2)
Belgium	2009	25.9	(3)	2009	51.9	(3)
Brazil	..	..	..	..	..	..
Canada	2009	23.6	(4)		12.2	(4)
Chile	2008	2.0		2008	99.2	
China	..	..	..	..	..	..
Colombia	..	..	..	..	..	..
Czech Republic	2009	23.2		2009	82.3	
Denmark		17.6	(4)		33.7	(4)
Egypt	..	..	..	..	..	..
Estonia		12.6			100.0	
Finland		7.0			100.0	
France		37.2	(5)		27.9	(5)
Germany	2009	10.1	(6)		100.0	(6)
Greece	..	..	..	..	..	..
Hungary	2008	27.6	(7)	2008	33.5	(1)
Iceland	..	..	..	..	..	..
India	..	..	..	..	..	..
Indonesia	..	..	..	..	..	..
Ireland	2008	30.3		2008	26.3	
Israel	..	..	..	..	..	..
Italy	..	..	..	..	..	..
Japan	2009	10.2		2009	35.4	
Korea	2009	31.1	(1)	2009	50.8	(1)
Luxembourg		7.7	..		100.0	..
Mexico	2007	5.4		2007	100.0	
Netherlands	2009	17.4		2009	21.2	
New Zealand	2009	6.5		2009	100.0	
Norway	2009	15.3			62.5	
Poland	2009	5.3		2009	98.8	
Portugal	2009	24.4		2009	20.1	
Russian Federation	..	..	..	..	..	..
Slovak Republic	..	..	..	..	..	..
Slovenia		35.0	(8)		79.0	(7)
South Africa	2008	29.2		2008	90.0	
Spain	2007	23.3		2007	79.3	
Sweden	2009	14.8		2009	100.0	
Switzerland	2008	5.1	(9)	2008	100.0	(8)
Turkey	2009	19.1		2009	53.3	
United Kingdom		24.6	(10)		53.5	(4)
United States	2009	33.5	(11)	2009	83.9	(9)
OECD sample median		**18.4**			**70.7**	

Notes:

Public support to business R&D and innovation

1. *Source:* NESTI data collection 2010 on R&D tax incentives (estimate of R&D tax concession).
2. Estimate of R&D tax concession includes only research premium.
3. OECD estimate based on country response to the *OECD STI Outlook 2012* policy questionnaire.
4. OECD estimate based on national estimate or projection.
5. 2010 estimates of tax concession are based on national sources.
6. BERD financed by government is overestimated or based on overestimated data.
   Public R&D expenditure includes government funding only.
7. *Source:* NESTI data collection 2010 on R&D tax incentives (estimate of R&D tax concession).
   Public R&D expenditure includes government funding only.
8. Estimates of R&D tax incentives are based on national sources.
9. Government funding includes federal or central government only.
10. Provisional.
11. Estimates of R&D tax concession are only tax credit, not expensing R&D.
    Government funding includes federal or central government only.
    BERD and HERD exclude most or all capital.

Direct funding of business R&D and innovation

1. *Source:* NESTI data collection 2010 on R&D tax incentives (estimate of tax concession).
2. Estimates of tax concession include only research premium.
3. OECD estimate based on country response to the *OECD STI Outlook 2012* policy questionnaire.
4. The part of BERD financed by government is provisional or a national estimate or projection.
5. 2010 estimates of tax concession are based on national sources.
6. *Source:* NESTI data collection 2010 on R&D tax incentives (estimate of tax concession).
   The part of BERD financed by government is a national estimate or projection overestimated or based on overestimated data.
7. Estimates of R&D tax incentives are based on national sources.
8. The part of BERD financed by government is for federal or central government only.
9. The part of BERD financed by government is for federal or central government only, and excludes most or all capital expenditure.

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Panel 4. **Overview of national innovation policy mix, 2005**

	Public Research					
	University-centred			Basic research oriented		
	(as a percentage of the sum of HERD and GOVERD)					
	Year (2005)	Value	Note	Year (2005)	Value	Note
Argentina		39.4			38.6	
Australia	2004	63.5		2004	44.1	
Austria		82.6	(1)	2004	44.6	(1)
Belgium		72.7		..	..	..
Brazil	..	..	..	..	..	..
Canada		77.8		..	..	..
Chile	2007	81.4		2007	35.1	(2)
China		31.2			15.0	
Colombia		89.7	(2)	..	..	..
Czech Republic		45.0			68.5	
Denmark		79.2			47.8	
Egypt	..	..	..	..	..	..
Estonia		78.6			53.1	
Finland		66.6		..	..	..
France		51.4			54.5	
Germany		54.0			23.7	
Greece		70.1		..	..	..
Hungary		47.3			48.2	
Iceland		48.3			37.5	
India		6.3	(2)	..	..	..
Indonesia	..	..	..	..	..	..
Ireland		78.6			46.4	
Israel		75.0	(3)		61.3	(3)
Italy		63.6			50.4	
Japan		61.8			31.5	(4)
Korea		45.6	(4)		28.4	(5)
Luxembourg		11.1		..	..	..
Mexico		55.4		..	..	..
Netherlands		73.6		..	..	..
New Zealand		55.6			44.5	
Norway		66.3			38.3	(2)
Poland		46.5			40.9	
Portugal		70.8			33.9	
Russian Federation		18.1			40.9	(2)
Slovak Republic		40.8	(5)		79.0	(6)
Slovenia		40.9			29.6	
South Africa		48.1			32.9	
Spain		63.0			40.0	(2)
Sweden		81.6		..	..	..
Switzerland	2006	96.4	(6)	2004	76.8	(7)
Turkey		82.5		..	..	
United Kingdom		70.9		2007	13.3	(8)
United States		52.8	(7)		51.8	(9)
OECD sample median		**64.9**			**44.1**	

Notes:

University-centred

1. National estimate or projection.
2. *Source:* UNESCO Institute of Statistics, April 2012.
3. HERD excludes R&D in the social sciences and humanities.
   GOVERD excludes defence (all or mostly).
4. Public R&D expenditure excludes R&D in the social sciences and humanities.
5. GOVERD excludes defence (all or mostly).
6. GOVERD is for federal or central government only.
7. HERD excludes most or all capital expenditures.
   GOVERD is for federal or central government only.

Basic research oriented

1. Public expenditure on basic research performed by government is underestimated or based on underestimated data.
2. Estimations based on current costs only.
3. GOVERD excludes defence (all or mostly).
   HERD excludes R&D in the social sciences and humanities and is provisional.
4. Public expenditure on basic research performed by higher education is underestimated or based on underestimated data.
5. Excludes R&D in the social sciences and humanities.
6. GOVERD excludes defence (all or mostly).
   Public expenditure on basic research is a national estimate or projection.
7. GOVERD is for federal or central government only.
8. Public expenditure on basic research is a national estimate or projection.
9. Estimations based on current costs only.
   GOVERD is for federal or central government only.

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Panel 4. **Overview of national innovation policy mix, 2005**

	Public Research								
	Civil oriented			Generic research			Funded through institutional "block" funding		
	(as a percentage of GBAORD)						(as a percentage of total funding to national performers)		
	Year (2005)	Value	Note	Year (2005)	Value	Note	Year (2005)	Value	Note
Argentina		99.6	(1)		25.9	(1)	. .	. .	. .
Australia		93.1	(1)		39.7	(1)		55.3	
Austria		100.0	(1)		74.2	(1)		75.9	
Belgium		99.7			42.1		. .	. .	. .
Brazil	. .	. .	. .	. .	. .	. .	. .	. .	. .
Canada		95.9	(1)		38.2	(2)		63.5	
Chile	. .	. .	. .	. .	. .	. .	. .	. .	. .
China	. .	. .	. .	. .	. .	. .	. .	. .	. .
Colombia	. .	. .	. .	. .	. .	. .	. .	. .	. .
Czech Republic		97.5			58.5			56.6	
Denmark		99.3			66.4		. .	. .	. .
Egypt	. .	. .	. .	. .	. .	. .	. .	. .	. .
Estonia		99.0	(2)		49.6	(3)	. .	. .	. .
Finland		96.7			42.7			53.8	
France		79.2			57.7		. .	. .	. .
Germany		94.2			61.1		. .	. .	. .
Greece		99.5			59.5		. .	. .	. .
Hungary		99.9			11.5		. .	. .	. .
Iceland		100.0			14.1		. .	. .	. .
India	. .	. .	. .	. .	. .	. .	. .	. .	. .
Indonesia	. .	. .	. .	. .	. .	. .	. .	. .	. .
Ireland		100.0			66.0		. .	. .	
Israel	. .	. .	. .		50.2			58.9	
Italy		96.4			47.9		. .	. .	. .
Japan		96.0	(3)		52.3	(4)	. .	. .	. .
Korea		85.4		. .	. .	. .		30.9	
Luxembourg		100.0			33.3		. .	. .	. .
Mexico		100.0		. .	. .	. .	. .	. .	. .
Netherlands		98.1			68.5			77.6	
New Zealand	2006	99.0		2007	76.4			25.4	
Norway		93.6			52.2			56.3	
Poland		98.7			83.3			66.8	
Portugal		99.3			50.1		. .	. .	. .
Russian Federation	. .	. .	. .	. .	. .	. .	. .	. .	. .
Slovak Republic		91.7			67.1			59.1	
Slovenia		95.1			62.7		. .	. .	. .
South Africa	. .	. .	..	. .	. .	. .	. .	. .	. .
Spain		96.1			41.6		. .	. .	. .
Sweden		82.6			71.1		. .	. .	. .
Switzerland	2006	99.4	(1)	2006	87.5	(1)		74.7	
Turkey	. .	. .	. .	. .	. .	. .	. .	. .	. .
United Kingdom		76.1			56.1		. .	. .	. .
United States		43.1	(1)	2007	14.5		. .	. .	. .
OECD sample median		**97.5**			**54.2**			**58.9**	

Notes:

Civil oriented

1. Federal or central government only.
2. National estimate or projection.
3. Data exclude R&D in the social sciences and the humanities, and are for federal or central government only.

Generic research

1. Federal or central government only.
2. Federal or central government only.
   General University Funds are national estimate or projection.
3. National estimate or projection.
4. Data exclude R&D in the social sciences and the humanities, and are for federal or central government only.

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Panel 4. **Overview of national innovation policy mix, 2005**

	Public support to business R&D and innovation					
	Public support to business R&D and innovation			Direct funding of business R&D and innovation		
	(as a percentage of the sum of HERD and GOVERD funded by government and higher education, and indirect and direct funding of BERD)			(as a percentage of the sum of indirect funding of business R&D and innovation through R&D tax incentives and direct funding of BERD through grants, contracts and loans)		
	Year (2005)	Value	Note	Year (2005)	Value	Note
Argentina	..	..		..	..	
Australia	2006	13.00	(1)		45.7	(1)
Austria	2006	26.3	(2)	2006	73.0	(2)
Belgium	..	..	..	..	..	..
Brazil	..	..	..	..	..	..
Canada		23.0	(3)		13.2	
Chile	..	..	..	..	..	..
China	..	..	..	..	..	..
Colombia	..	..	..	..	..	..
Czech Republic		25.6			81.7	
Denmark		19.7	(4)		26.2	
Egypt	..	..	..	..	..	..
Estonia		7.2			100.0	
Finland		10.4			100.0	
France		19.9	(5)		76.5	(3)
Germany		10.9	(6)		100.0	(4)
Greece	..	..		..	..	
Hungary		20.1	(7)		15.3	(1)
Iceland	..	..	..	..	..	..
India	..	..	..	..	..	..
Indonesia	..	..	..	..	..	..
Ireland		20.4			34.1	
Israel	..	..	..	..	..	..
Italy	..	..	..	..	..	..
Japan		16.9			20.6	
Korea	2008	31.8	(1)	2008	45.2	(1)
Luxembourg		26.9			100.0	
Mexico		9.3	(8)		100.0	
Netherlands		12.8			33.0	
New Zealand		14.2	(9)		100.0	(5)
Norway		17.2			50.5	
Poland	2006	6.6		2006	99.2	
Portugal	2006	15.5	(10)	2006	23.0	(6)
Russian Federation	..	..	..	..	..	..
Slovak Republic	..	..	..	..	..	..
Slovenia		10.9	(11)		100.0	(7)
South Africa	2006	26.5		2006	90.6	
Spain		21.3			68.2	
Sweden		13.2			100.0	
Switzerland	2006	5.1	(12)	2004	100.0	(8)
Turkey	..	..	..	..	..	..
United Kingdom		22.4			63.8	
United States		25.2	(13)		81.1	(9)
OECD sample median		**17.0**			**76.5**	

Notes:

Public support to business R&D and innovation

1. *Source:* NESTI data collection 2010 on R&D tax incentives (estimate R&D tax concession).
2. Estimates of R&D tax concession include only research premium.
3. OECD estimate based on national estimate or projection.
4. Public R&D expenditure includes government funding only.
5. Estimates of R&D tax concession are based on national sources.
6. The part of BERD financed by government is overestimated or based on overestimated data.
   Public R&D expenditure includes government funding only.
7. *Source:* NESTI data collection 2010 on R&D tax incentives (estimate tax concession).
   Public R&D expenditure includes government funding only.
8. Public R&D expenditure is a national estimate or projection.
9. OECD estimate.
10. National estimate or projection.
11. Estimates of R&D tax concession are based on national sources.
12. Funding by government only includes federal or central government..
13. Estimates of R&D tax concession are only tax credit, not expensing R&D.
    Funding by government only includes federal or central government.
    BERD and HERD exclude most or all capital expenditure.

Direct funding of business R&D and innovation

1. *Source:* NESTI data collection 2010 on R&D tax incentives (estimate R&D tax concession).
2. Estimate of tax concession includes only research premium.
3. Estimates of R&D tax concession are based on national sources.
4. The part of BERD financed by government is overestimated or based on overestimated data.
5. OECD estimate.
6. BERD is a national estimate or projection.
7. Estimates of R&D tax incentives are based on national sources.
8. The part of BERD financed by government only includes federal or central government.
9. Estimate of R&D tax concession includes only tax credit, not expensing R&D.
   The part of BERD funded by government excludes most or all capital expenditure and is for federal or central government only.

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