Delegates will find attached the draft of Chapter 1 of the 2014 OECD Science, Technology and Industry Outlook.

Delegates are invited to review the chapter and submit final written comments to the Secretariat by 10 April. The chapter will be revised according to and based on:

- Forthcoming country responses to the STI Outlook policy questionnaire 2014 (this draft has been prepared on the basis of country responses that were available at the time of drafting).
- Discussions to be held at CSTP meeting and written comments provided by countries in the next month.
- Data updates to include the latest available data.
- A final editing round.

The final draft of this chapter will be declassified via written procedure.

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.

For further information, please contact: Dominique GUELLEC; Tel +33 1 45 24 94 39; E-mail: dominique.guellec@oecd.org; Sandrine KERGROACH; Tel: +33 1 45 24 18 25; E-mail: sandrine.kergroach@oecd.org; Nils DE JAGER: Email: STI.Outlook@oecd.org
ACKNOWLEDGEMENTS

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

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

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

4. Thanks to Sylvia Appelt, Brigitte van Beuzekom, Hélène Dernis, Guillaume Kpodar and Fabien Verger for statistical input. Lihan Wei provided statistical assistance. Martine Zaïda provided editorial recommendations and Laura Victoria Garcia provided secretarial support and assistance processing country responses to the STI Outlook questionnaire 2014.
EXECUTIVE SUMMARY

Key Messages

- The economic recovery is gaining momentum, but science, technology and innovation (STI) activities are expected to experience only moderate increases over the coming years. The recovery remains fragile and too contrasted to create a risk-favourable environment for investment, which is still below its pre-crisis levels in many OECD and non-OECD countries. The impact of the crisis has not yet been fully absorbed, and a wait-and-see attitude of business and sluggish demand keep the STI outlook modest. STI policies have to adapt to this new “deal”: leveraging business engagement in innovation and exploiting the potential offered by frugal demand.

- The deterioration of public finances challenges public policy generally, and STI policy in particular. In many countries public R&D budgets are levelling off, or receding. Yet governments have maintained, or reinforced their commitment to STI and adjusted their policies. Greater use is made of public procurement for R&D and innovation. Governments also intend to lower costs and to leverage private investment by streamlining and consolidating public programmes for innovation. A sharper focus on policy evaluation is becoming more apparent too: countries are building evaluation capacity by strengthening evaluation institutions and expanding the knowledge base on STI policy.

- The global research system is expanding driven by rising research and innovation activities in Asia, while technological catch-up costs increase for lagged countries as well as the risk of being excluded from GVCs and global knowledge flows. Scientific and technological (S&T) production has been recovering gradually from the downturn in STI investments. The outlook of the global research system should improve as macroeconomic prospects and the business climate improve, the pace of fiscal consolidation slows down and the benefits of STI policy rationalisation become more evident. However the situation will remain contrasted: the rise of China should continue, albeit at a slower pace, while the situation should still be varied in the European Union.

- Globalisation brings a new complexity to STI policy making: it questions the appropriateness, efficiency and sustainability of national policy frameworks to incentive STI activities, and it increases the risk of leakage of STI related public investments. Innovation, more than ever, is a key to strategic positions in global value chains (GVCs). As talent and knowledge-based assets become increasingly available and mobile around the globe, the global pool of knowledge resources has enlarged and global competition to attract them has intensified. Countries are building supportive ecosystems to attract foreign direct investment or for new firms and SMEs to integrate global supply chains. Efforts are also made to foster the attractiveness of national
research systems. Particular attention has been paid recently to strengthen universities’ capacity and international features, including new job opportunities for researchers, branding activities, new mobility schemes, new educational products and improved learning environments.

- Environmental and social issues raise both challenges and opportunities. Progress has been made on the environmental front, but further progress requires technological breakthroughs, the rapid deployment of new or existing technological solutions and systemic changes. While the impact of fiscal consolidation is already being felt on green R&D budgets, significant investments are still required in R&D, demonstration and smart infrastructures. Innovation for an ageing society offers the prospect of new growth industries, but remains constrained by a lack of finance and of policy coherence between various actors in charge of health and social care services. In addition, innovation policies are usually designed with no consideration of their impacts on inclusiveness and innovation can potentially increase inequalities among social groups, “islands of excellence” v. poorly performing industrial segments, national innovation hubs v. rural areas, etc. Social and global issues have created the need for policy makers to rethink their policy strategy in a more systemic approach, to consider trade-offs and possible synergies between different policy areas (regulation, tax, education etc.) and to review the design of their innovation policies accordingly. In the context of system innovation, national governments may not be the unique level to mobilise resources to break social and technological lock-ins: Regions and cities may become more important in steering and transitioning innovation systems.

- Recent technology breakthroughs have focused on addressing global challenges (e.g. climate change mitigation, ageing societies, food security) and supporting structural adjustment and a new approach to growth (e.g. new manufacturing processes). Considering technological acceleration and the growing costs required to stay at the knowledge frontier, future technological developments will increasingly call on cooperative research, specialisation and technology monitoring. Interdisciplinary research, that raises opportunities of technology convergence and promises transformative changes to industries and societies, is altering the ways of doing research and commercialising results. Another major area of technology breakthrough is the Internet that now affects nearly all sectors of the economy. The vulnerability of open and interconnected digital environments to cybercriminality has prompted countries to promote a new approach to cybersecurity and to foster international co-operation to ensure an open and secure internet.

- Business innovation will be the driver of a sustainable economic recovery. Business R&D investments have been preserved compared with other investments and have partially recovered after the crisis. The recovery should provide further momentum to this uptake.

- Public support for business R&D has increased significantly over the past decade driven by increasingly generous R&D tax arrangements. Taken altogether, direct funding and tax reliefs finance 10% to 20% of business R&D expenditure in many countries and over a quarter in France or Canada (2011). R&D tax incentives have become an instrument to foster the attractiveness of national research ecosystem and countries sometimes engage in tax competition to attract foreign R&D centres. However, many countries keep channelling most of public funding to business R&D through competitive grants, and in recent years higher importance has been given to debt funding (e.g. loans and loans guarantees) and equity funding (e.g. venture capital funds of funds).
Some countries that were traditionally among the most generous in terms of tax concession for R&D have also tightened their tax policy and reinforce compliance and control mechanisms.

- Service innovation has become a source of competitiveness along the entire value chain and services are increasingly considered to be fundamental inputs and outputs of innovation processes taking place in other sectors. However, existing policy frameworks have been designed from a mainly technological or manufacturing perspective, and tend to neglect the specificities of services. Recently, the policy focus has evolved from a sectoral perspective towards embedding service innovation in the overall policy mix.

- Innovative entrepreneurship, i.e. new firm creation and innovations in existing SMEs, contributes to the creation of new products and services in all sectors. However, accessing finance and qualified personnel are significant burdens on the process of starting and growing businesses. In recent years SMEs faced more severe credit conditions, such as higher interest rates, shortened maturities and increased request for collateral. Equity financing was also severely affected and uncertain economic climate continued to drag down equity investment. Persistent weaknesses in the European banking sector and ongoing Basel III reforms put the lending activities of banks under pressure. In this context new sources of finance (e.g. crowdfunding and other forms of non-bank financing), albeit still marginal, offer promising alternatives of funding and could be encouraged.

- Governments are reconsidering the need to encourage the emergence or expansion of new industries that would become nodes in global innovation networks. Consequently, the policy debate around industrial policy has recently resurfaced, and major national policy initiatives are being implemented to strengthen the competitiveness of industries that offer high potential, and to encourage the collocation of R&D and related manufacturing activities.

- Public R&D plays a pivotal role in the innovation system and science is increasingly implemented in universities rather than in public research institutions (PRIs). R&D expenditure by universities and PRIs has shown resilience during the crisis, highlighting a sustained public commitment to R&D. Modern science is increasingly data-driven, calling for new forms of collaboration and broader knowledge and resources sharing. But open science, beyond access to IT infrastructures or skills needed to use these infrastructures, requires new approaches to the funding of public research, the process of undertaking research, the valorisation of research output, the access, protection and intellectual property (IP) of research results, and the interaction between science and society.

- Research excellence requires also new forms of funding. Public research funding has gradually shifted from institutional core funding (so-called ‘block grants’) to project funding, often on a competitive basis. Current public budgetary situations call for further selectivity and efficiency in funding, while the issue of an optimal proportion of stable funding is raised. Research excellence initiatives have emerged, as a combined institutional-project funding mechanism, with the aim to encourage outstanding research, support a prioritisation of public research and raise international visibility of research teams.
The objectives of public research policies have extended from knowledge production to knowledge transfer. Policy initiatives have been designed to introduce a market perspective in upstream science (e.g. industry-science co-operation on R&D) and, more recently, to develop downstream support for the commercialisation of publicly-funded research results. Governments and institutions are revising their approach towards IP protection and IP sharing, encourage open research data, more closely involve students in the commercialisation process, are restructuring and professionalising technology transfer offices. Overall, governments are aiming to strengthen the business culture in commercialisation activities which have been often dominated to date by more administrative approaches.
## EXECUTIVE SUMMARY

INTRODUCTION

### RECOVERY: A NEW DEAL FOR STI POLICIES

Economic recovery is gaining momentum, but STI activities are likely to experience only a slight increase over the coming years.

The recovery remains fragile and contrasted.

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

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

Productivity is the top economic challenge for many countries and innovation remains the driving force to improve performance.

### GLOBALISATION: RISING COMPLEXITY FOR INNOVATION POLICIES

The crisis has urged many countries to restore their competitiveness. Innovation more than ever is a key to strategic positioning in global value chains.

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

The advantage of advanced economies in higher education is shrinking.

New talent circulation is likely to affect skills labour markets.

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

National innovation hubs are increasingly interconnected to global innovation networks.

### SOCIAL AND ENVIRONMENTAL ISSUES RAISE CHALLENGES AND OPPORTUNITIES

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

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

For innovation to benefit all, education and ICT play a key role to foster the democratisation of innovation.

### LOOKING INSIDE THE GLOBAL INNOVATION SYSTEM

---

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXECUTIVE SUMMARY</td>
<td>3</td>
</tr>
<tr>
<td>INTRODUCTION</td>
<td>10</td>
</tr>
<tr>
<td>RECOVERY: A NEW DEAL FOR STI POLICIES</td>
<td>12</td>
</tr>
<tr>
<td>Enforcement</td>
<td>12</td>
</tr>
<tr>
<td>Economic recovery</td>
<td>12</td>
</tr>
<tr>
<td>The recovery remains fragile and contrasted</td>
<td>12</td>
</tr>
<tr>
<td>The impact of the crisis has not yet been fully absorbed. Investment and employment remain below pre-crisis levels.</td>
<td>12</td>
</tr>
<tr>
<td>The deterioration of public finances has challenged public policy generally, and STI policy in particular. Yet many governments intend to maintain or reinforce their commitment to STI.</td>
<td>15</td>
</tr>
<tr>
<td>Productivity is the top economic challenge for many countries and innovation remains the driving force to improve performance.</td>
<td>20</td>
</tr>
<tr>
<td>GLOBALISATION: RISING COMPLEXITY FOR INNOVATION POLICIES</td>
<td>22</td>
</tr>
<tr>
<td>The crisis has urged many countries to restore their competitiveness. Innovation more than ever is a key to strategic positioning in global value chains.</td>
<td>22</td>
</tr>
<tr>
<td>Global competition for talent and knowledge-based assets is on the rise.</td>
<td>26</td>
</tr>
<tr>
<td>The advantage of advanced economies in higher education is shrinking.</td>
<td>26</td>
</tr>
<tr>
<td>New talent circulation is likely to affect skills labour markets.</td>
<td>27</td>
</tr>
<tr>
<td>Innovation activities, including R&amp;D, are increasingly offshored or outsourced.</td>
<td>28</td>
</tr>
<tr>
<td>National innovation hubs are increasingly interconnected to global innovation networks.</td>
<td>30</td>
</tr>
<tr>
<td>SOCIAL AND ENVIRONMENTAL ISSUES RAISE CHALLENGES AND OPPORTUNITIES</td>
<td>34</td>
</tr>
<tr>
<td>Progress has been made on the environmental front, but further progress requires technological breakthroughs and systemic changes.</td>
<td>34</td>
</tr>
<tr>
<td>Innovation for an ageing society offers new market opportunities and new growth industries.</td>
<td>38</td>
</tr>
<tr>
<td>For innovation to benefit all, education and ICT play a key role to foster the democratisation of innovation.</td>
<td>40</td>
</tr>
<tr>
<td>LOOKING INSIDE THE GLOBAL INNOVATION SYSTEM</td>
<td>42</td>
</tr>
</tbody>
</table>

---
The global research system is expanding
Research and innovation are on the rise in Asia
Relative cost to access world-class research is increasing
S&T output has been recovering gradually.
Outlook for the global research system
Recent technology developments
Fields of technology acceleration
The challenges of technology convergence
Internet development and cybersecurity
Business innovation will be the driver of a sustainable economic recovery
Business R&D has been preserved compared to other investments and has partially recovered
Blurring frontiers between industry and services, technology and innovation
Innovative entrepreneurship
Collaboration and agglomeration in innovation
Public R&D is targeting excellence and openness
The science base is increasingly implemented in universities
Open science calls for new approaches to research and new governance arrangements
Research of excellence requires new forms of funding
Transfer of public research results would require further professionalisation and strengthening of business culture in commercialisation activities

CONCLUSION: THE FUTURE OF STI POLICIES

REFERENCES
Figures

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

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

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

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

Figure 1.5. OECD and non-OECD economies are increasingly interdependent of the global economy

Figure 1.6. The multinationals of emerging economies are increasingly offshoring their activities abroad

Figure 1.7. BERD financed from abroad

Figure 1.8. Multinationals play a major role in domestic R&D in many countries

Figure 1.9. National innovation hubs are increasingly engaged in international co-operation

Figure 1.10. Growth in public R&D budgets for energy and environment is easing

Figure 1.11. Gross Capital Formation in environmental protection by level of government, 2009

Figure 1.12. World R&D efforts have weathered the turmoil and remain concentrated around a few major global players

Figure 1.13. Gross R&D expenditure, 2012 compared to 2007

Figure 1.14. Patenting activities have been hit and are slow to start

Figure 1.15. China should outpace the United States as the major global R&D performer in the coming years

Figure 1.16. Technology acceleration

Figure 1.17. Business investment on knowledge assets weathered the crisis better and recovered earlier

Figure 1.18. Business research capacity has been relatively preserved

Figure 1.19. Business R&D expenditure has intensified in most countries

Figure 1.20. Total public support for business R&D has increased markedly since 2006

Figure 1.21. Most innovative firms tend to combine multiple modes of innovations, 2008-10

Figure 1.22. Services value-added content of gross manufacturing exports, 2009

Figure 1.23. The science base is expanded by universities

Figure 1.24. Public R&D expenditure by archetype of research system

Figure 1.25. International collaboration networks in science
INTRODUCTION

1. This chapter provides an overview of recent developments in science, technology and innovation (STI) developments and STI policies in a cross-country approach. It is based on various streams of work conducted at the OECD in many different fields, such as science, technology, industry, education, innovation, migration, trade, environment, economics affairs, finance, tax systems, public governance, statistics, etc. It also draws heavily on country responses to the OECD STI Outlook policy questionnaire 2014, which is a unique source of country-specific information on national innovation policies. Although the quality of macroeconomic, competition, regulation, tax and labour market framework conditions is essential for innovation to flourish, this chapter focuses on science, technology, industry, entrepreneurship and innovation policies.

2. The first section considers the evolution of the macroeconomic context in the aftermath of the 2008 crisis and the economic conditions under which national innovation systems and national innovation policies have evolved over the past decade, and are likely to evolve in coming years. The section focuses on the impact of the uneven recovery across regions and countries, and on the capacity of governments and firms to engage in innovative activities. It sketches a “new deal” for STI policy makers, and addresses issues such as productivity, unemployment, fiscal pressure, investment and demand.

3. The second section focuses on the rise of global value chains (GVCs), the growing global competition for talent and knowledge-based assets, internationalisation of R&D and the emergence of globally interconnected innovation hubs. It explores policy implications for STI and the rising complexity that STI policy makers have to deal with. It addresses issues such as competitiveness, offshoring, outsourcing, internationalisation of higher education, the attractiveness of research systems, cross-border STI governance and smart specialisation.

4. The third section analyses global challenges that impact on the world and the global innovation system. It highlights the environmental urgency, demographical pressure in ageing societies and potential risks of non-inclusive innovation for equity, social cohesion and innovation itself. It explores the business and policy opportunities carried on by climate change, the “silver service economy” and the democratisation of innovation. It addresses issues such as deployment of clean technologies, smart cities, system innovation, public-private partnerships (P/PPs), training, ICT and policy trade-offs between accumulation and “trickle-down” mechanisms.

5. The fourth section provides insights on the expansion and outlook of the global research system, the changing landscape of global R&D, and recent technology developments. It explores policy implications and addresses issues such technological catch-up, science and technology (S&T) acceleration and technology convergence, interdisciplinary research and cybersecurity.

6. The fifth and sixth sections consider recent development in the two main sub-parts of national innovation systems—business R&D and innovation on the one hand, and public research on the other hand. It analyses the changing modes of innovation, changing modes of research and innovation funding, the growing openness in science and innovation, the agglomeration of firms, universities and STI actors in globally-connected nodes, and innovative entrepreneurship. Recent policy developments for business R&D
and innovation are outlined, including shifting policy mixes for funding business R&D and innovation, the revival of industrial policy, IPR enforcement, etc. Likewise, recent policy developments for the public research, including open science, research excellence and technology transfer are also discussed.
Economic recovery is gaining momentum, but STI activities are likely to experience only a slight increase over the coming years.

The recovery remains fragile and contrasted.

7. Growth in world real GDP is estimated to be 3.6% and 3.9% in 2014 and 2015, respectively, and a lower 2.3% and 2.7% in the OECD in the same years (OECD, 2013a). Economic activity and world trade have recovered slowly since 2011 and are expected to gradually strengthen over the next two years, driven by the dynamism of non-OECD economies (5.3% and 5.4%), particularly China (8.2% and 7.5%).

8. Within the OECD, countries are recovering at an uneven pace (Figure 1.1). The recent acceleration in the United States signals a global return to growth. But the tightening of US monetary policy and federal debt still raise uncertainties about the stability of US GDP growth (1.68% in 2013). Growth prospects in Japan (1.79% in 2013) are constrained by the level of public debt. Some Southern and Central European countries have not recovered from the shock and should experience modest growth of less than 2% in the next two years. They also show structural deficiencies that affect the whole European Union. Few European countries are expected to grow faster than 2% in 2014 and 2015. Even the most dynamic countries in the OECD (Chile, Israel, Korea and Turkey) that grew by more than 2.5% in 2013 are still expanding slower than their pre-crisis growth rates.

9. The BRICS countries (Brazil, Russian Federation, India, China and South Africa) have lost their earlier momentum. In 2013, major emerging economies showed the first signs of an economic slowdown and revealed a high sensitivity to US financial markets fluctuations. As their dynamism had steered global growth during the crisis, their slowdown imposed a brake on recovery: global GDP growth has been revised downwards by half a percentage point for 2013 and 2014. In addition, BRICS development remains constrained by structural rigidities (e.g. infrastructure and education), a heavy dependence on foreign direct investment (FDI) and demographic challenges that impose limitations on growth over the medium term.

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

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

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

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

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

Panel 1. OECD, EU, Japan and the United States are experiencing a modest recovery

Panel 2. BRICS have lost their earlier momentum

*Source: OECD, Economic Outlook no 94 Database, November 2013. Data retrieved from OECD IPP.Stat <> on XXXX*
Figure 1.2. Corporate margins have deteriorated and firms wait to reinvest

Change in firms’ profit margin rate\(^1\) and investment rate\(^1\), percentage point, 2012 compared to 2007

---

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

Source: OECD, National Accounts Database, December 2013. Data retrieved from OECD IPP.Stat <> on XXXX.

12. In many countries unemployment rates have been slow to reverse. The wait-and-see attitude of business is reflected in labour markets by persistently high unemployment rates—in some countries at historical highs. At the peak of the crisis, nearly 50 million people were looking for a job in the OECD area and in 2013 more than 48 million people were still unemployed (OECD, 2013a). The OECD unemployment rate is still above its pre-crisis level at 8%.

13. In addition, although higher education guarantees higher employability, tertiary graduates have not been completely spared (OECD, 2013d). On average 4.8% of 25-64 year-old graduates with tertiary level education were looking for a job in 2011, compared with 3.3% in 2007. The Southern European countries (Greece: 12.8%, Spain: 11.6% and Portugal: 8.0%) have been the hardest hit. In Germany (2.4%), however, unemployment of tertiary graduates has steadily declined and in 2011 the country recorded one of the lowest unemployment rates in the OECD, along with Norway (1.5%) and Austria (2.3%).

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

15. The issue is of particular concern with regard to the young cohort of the labour market, because skills learnt in the early years of professional life are decisive for future careers. Youth unemployment could have long-term effects on economic and fiscal sustainability, for instance by encouraging informal economic activity, reducing tax revenues or by increasing public health outlays. Historically, 15-24 year-olds are more likely to be unemployed than older employees. They have been particularly hit by the crisis (OECD, 2011a), since the generation gap has widened in most countries. In 2012, more than 50% of young people aged 15-24 were unemployed in Greece, Spain and South Africa, compared with around 20-22% of 25-64 year-olds (OECD, 2011a). With the recovery, these differences have narrowed, but it will be more challenging for governments to rehabilitate young people who were not in education, not employed, or not active during the downturn.

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

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

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

Policy trends

18. Fiscal consolidation typically forces governments to increase the tax burden and reduce public spending. Strategic choices regarding specific areas of policy intervention and government budget appropriations and outlays can affect innovation systems. The risk is that a higher tax burden further curbs sluggish demand, reduces the net return on capital, and subsequently discourages private investment in R&D and innovation. In addition, although governments have shown the importance they placed on education, research and innovation in preserving, or even reinforcing, their STI budgets during the crisis, the new budgetary discipline could force them to reconsider their commitments to STI and could reduce leverage potential through public procurement for research and innovation.

---

1 Several studies have documented the correlation between unemployment and mental disorders, including depression, which may result in additional costs to society (OECD, 2008a).

2 Israel is as an exception. It is noteworthy that in 2011 Israel had the highest rate (37.7%) of “not in education, employment or training” (NEETs), twice the OECD average (18.5%) (OECD, 2013d).
19. In the present fiscal climate some countries may find it difficult to maintain STI budgets at current levels. Resources allocated to education have declined since 2009 as teachers’ salaries were frozen in half of OECD countries, and more cuts are expected in education over the next two years (OECD, 2013f).

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

21. Yet, OECD countries and non-OECD economies have confirmed their commitment to STI and their intentions, either to preserve (Italy, United States) or, for most of them, to increase national R&D budgets (see policy profile on national STI strategy and plan). France is implementing the second phase of its “Investment for the Future” programme with funding of USD 14 billion (EUR 12 billion), mainly as capital endowment. The UK plans to unlock additional funding and will prioritise long-term infrastructure spending. Germany puts a “top priority” on public spending on R&D and innovation and the draft 2014 Federal budget provides additional USD 290 million (EUR 224 million) to education and research. China will continue to enhance, albeit at a slower pace, government S&T appropriations and plans to set up budgetary mechanisms in order to encourage local governments to invest in S&T.
Figure 1.3. Public R&D budgets are levelling off, or have started to recede
Government budget appropriations and outlays for R&D, 2002-13

Panel 1. Stable or decreasing
Panel 2. On the rise or levelling

22. Public research and public R&D are usually counter-cyclical and have a buffering effect during periods of economic downturn (Figure 1.4). This is in part a reflection of the fact that the importance of STI policy has increased over time compared with other policy domains. But with the lingering crisis and the unsustainability of public debt, this may be not the case any more in a number of countries. As business R&D expenditure depends on business expectations, it is particularly affected by the economic cycle. Over the past two decades, growth rates in gross domestic expenditure on R&D (GERD) exceeded GDP growth rates, leading to a growing R&D intensity in the OECD. In 2008-09, the volume of GERD decreased as a result of a sharp decline in private investment. Governments have partially offset this fall by higher support for the national R&D effort. In view of the current budgetary outlook and recent developments in public R&D budgets, the recovery in R&D is likely to be primarily driven by business investment in coming years.

23. The budgetary pressure has also encouraged governments to adjust the design and governance of their policies (e.g. demand-side policies), to streamline and consolidate their policy programmes, and to systematize and strengthen their evaluation practices.

24. Governments are making greater use of public procurement in general. In recent years, STI policy makers have increasingly focused on demand-side instruments, in search of stronger and better articulated public demand for innovative solutions and products (OECD, 2012a). Following a series of reviews on federal procurement, Canada has recently developed its National Procurement Strategy (NPS), to leverage R&D procurement and streamline procurement processes. Germany has reinforced its general
framework for innovative public procurement with a new German Procurement Law and the creation of a Centre of Excellence for innovative procurement in 2013. Since 2011, the UK Innovation and Research Strategy for Growth has emphasised the key role that government has to act as a lead customer for innovative products and services. The budget of the Small Business Research Initiative (SBIR) has been consequently expanded for 2013-14 and again for 2014-15 (see policy profile on demand-side policies).

25. Governments are attempting to reduce fragmentation in public support to business R&D and innovation and to improve and simplify access to programmes. Streamlining and consolidating public programmes aim to lower administration and application costs for both public administration and firms and to leverage private funding for innovation. In that respect, Canada, Chile and Norway have recently simplified eligibility criteria and application procedures to their R&D tax incentives scheme. Costa Rica and Norway have introduced changes to the overall application process and qualification requirements to venture capital and entrepreneurship programmes. Finland is implementing a new Tekes Strategy that aims to foster a customer-approach in public support delivery, and to centralise and streamline financing to entrepreneurship. Germany has bundled R&D and innovation support activities into large framework programmes in recent years. In 2013 New Zealand established Callaghan Innovation to simplify the interactions between business and research institutions and to function as a one-stop-shop. The Czech Republic (Technology Agency), Denmark (Innovation Fund) and Slovenia (Spirit Slovenia) have also reduced fragmentation by merging various institutions in charge of technology and entrepreneurship policy into a single agency.

26. A sharper focus on evaluation and impact assessment of STI policy is also becoming more apparent (see policy profile on STI policy evaluation and impact assessment). While fiscal constraints have raised the need to demonstrate value for public money, potential resources available for evaluation have also been reduced. Nevertheless, some countries have recently engaged in broad evaluations, adopting a holistic approach to assess the performance of national STI system or sub-parts of the system, e.g. through national reviews (Canada, Chile), international reviews (Denmark, Finland), or OECD reviews of innovation policy (France, Norway, Slovenia, Sweden).

27. A number of countries have also implemented initiatives to strengthen evaluation institutions (i.e. agencies, legal frameworks, methodologies) and encouraged knowledge building on STI policy. Chile established an advisory committee on S&T in 2013 to review the national STI governance system. France set up a Strategic Research Council to manage the design and implementation of its National Research Strategy. Australia announced the creation of the National Commission of Audit in 2013 to improve the overall efficiency of public services and policy advice delivery. In addition, the new Australian Public Governance, Performance and Accountability Act 2013 was adopted with a stronger focus on evaluation, and the Department in charge of science and industry policy is building capacity through staff training and the implementation of new data collection methods. Efforts to build knowledge on STI policies have also been made, for instance in the framework of the US research programme in the Science of Science and Innovation Policy (SciSIP), while “big data” offers new possibilities to increase the knowledge base and to reduce evaluation costs. SciSIP-type initiatives are also being implemented in Japan and the EU.

28. Innovation policy has become increasingly challenge-driven, focused on mobilising innovation actors and entire systems to address social and economic challenges. One of the lessons from decades of innovation studies is that innovation systems, although dynamic, can become locked into trajectories that
make it difficult to mobilise or shift resources to address new goals or objectives. The policy challenge is to foster the transformation or the transition of large scale socio-technological systems along more sustainable paths, in other words, to promote “system innovation”. This challenge has several elements or implications. The first is to redefine who the innovation actors are. Innovation policy has long focused on addressing market and coordination failures that affect the producers of knowledge and innovation, namely firms and PRIs, with some attention to the surrounding environment. But system innovation also means engaging the demand-side, including consumers and citizens. Secondly, challenge-driven innovation requires entire systems to be rebuilt. In other words, it’s not just the outcome of innovation systems in the form of new products and process that can boost productivity, but also new structures, new institutions, new ways of working or cooperation among the actors in the innovation system. Thirdly, governance structures need to manage the transition from one system to another, for example, moving from a fossil fuel based transportation system to a system based on a diverse energy mix, including renewables. The complexity of system innovation also implies that national governments may not be the best placed to mobilise resources to break social and technological lock-ins. Certain actors, such as regions and cities, may become more important in steering and transition innovation systems. Cities in particular have emerged as laboratories for solutions to social and economic problems from education to waste management. A final implication that arises from a system innovation approach is that learning processes and outcomes are just as important—if not more—as outcomes in terms of new products and processes.

**Productivity is the top economic challenge for many countries and innovation remains the driving force to improve performance.**

29. A sustainable recovery from the economic crisis requires faster productivity growth. Countries can only motivate investment and job creation to sustain economic growth by improving productivity. Equally important, higher productivity is needed to address social challenges, such as the environment (greening the economy, ensuring the energy transition) and ageing (paying for pensions).

30. Innovation is a major factor driving productivity growth over the medium to long term, among others through implementing new technology-based manufacturing processes, commercialising products that provide more value to customers, and improved service delivery, etc. In addition, maintaining economic growth in open economies requires higher competitiveness and the ability of the national economy to exchange and compete with other economies. Therefore many governments have assigned a central role to innovation in their policy agenda in recent years (see policy profile on national strategies for STI).

31. During the crisis, recovery plans in many countries contained a strong research and innovation component. Moreover, in recent years, national innovation strategies have been included as a major pillar in post-crisis growth strategies. But these strategies have to be implemented in tight fiscal environments, requiring efficiency and value for money. The prospects in this regard are discussed in the relevant parts of this chapter, and will cover business innovation, global aspects and the contribution of public sector.

32. The main policy areas that governments are mobilising to increase productivity include:
• Targeting public research and innovation support on economic, social and environmental challenges beyond R&D and technological innovation, for society to benefit more directly from new knowledge and innovation.

• Structuring the public research sector around centres of excellence to increase the quality and relevance of scientific production, while keeping cost contained, and to ensure performance-based as well as long-term funding for research.

• Encouraging the commercialisation of public research to increase its economic and societal impact. Many countries are implementing a more integrated and professionalised approach after years of policy learning.

• Facilitating the restructuring of industry and implementing new policy approaches to support innovation, by building on new or refined policy instruments, e.g. by leveraging private funding (public-private partnerships (P/PPs), crowdfunding).

• Fostering entrepreneurship, which is a major carrier of radical innovation in new activities. This is done by strengthening capabilities (management support and training, incubators) and by facilitating funding (by providing capital to venture capital funds, or by implementing lower tax rates on the relevant capital or income).

• Streamlining innovation support programmes, focusing on instruments that provide the highest leverage. Some countries have terminated programmes that had a limited impact, concentrating more resources on fewer instruments.

• Developing the more systematic evaluation of policies to increase efficiency.
GLOBALISATION: RISING COMPLEXITY FOR INNOVATION POLICIES

The crisis has urged many countries to restore their competitiveness. Innovation more than ever is a key to strategic positioning in global value chains.

33. The prosperity of a country depends on its participation in the global economy, which in turn depends on its integration into global value chains (GVC) (OECD, 2013g). Integrating into GVCs help countries to strengthen their productive capacities, access a broader portfolio of technologies, skills or knowledge-intensive assets and support growth. Foreign direct investment (FDI) and trade in goods and services are the two on-ramps to GVCs.

<table>
<thead>
<tr>
<th>Box 1.1 The rise of global value chains (GVCs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>As economic globalisation progresses, national economies deepen their specialisation. Economies participate in GVCs both as users of foreign inputs and as suppliers of intermediate goods and services used in the exports of other economies (Koopman et al. 2011). Production processes have become more geographically fragmented and production is ‘sliced and diced’ into separate fragments that are dispersed globally (OECD, 2007; WTO and IDE-JETRO, 2011). Owing to their investment and international trade, in particular intra-firm trade within their networks, multinationals’ (MNEs) are leading actors in GVCs.</td>
</tr>
</tbody>
</table>
Figure 1.5. OECD and non-OECD economies are increasingly interdependent of the global economy

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

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


The increasing interdependency of the global economy is reflected in the general increase in the foreign content of exports (OECD, 2013h). Foreign value added clearly depends on the size of economies and patterns of specialisation (Figure 1.5). Smaller economies tend to have higher shares of foreign value added embodied in their exports, while larger economies have a wider variety of domestically-sourced intermediate goods available and are therefore less reliant on foreign imports of intermediates. Countries with substantial natural resources, such as Australia, typically have lower ratios of foreign value added in their exports, as mining activities require fewer intermediate goods in the production process.

Innovation is key to reach segments of higher value-added in GVCs. The most value creation in a GVC is often found in upstream activities, such as the development of a new concept, R&D, or the manufacturing of key parts and components, or in downstream activities, such as marketing, branding or customer service (OECD, 2013g). Final assembly, which is generally offshored, often to emerging economies, represents only a small part of value generation. This is typically the case in industries characterised by high degrees of modularity (e.g. electronics) as international standards guarantee that the output of one production stage closely matches the input requirements of the subsequent stage (OECD, 2014a). It is less the case in a large number of industries whereby important feedback effects between R&D, design and actual manufacturing/assembly take place (e.g. automotive and pharmaceuticals industry).
34. International capital flows have been hit by the crisis, both in volume and distribution. A slowdown in cross-border mergers and acquisitions, declines in "greenfield" investment, suspension of intra-firm loans and repatriation of retained benefits resulted in shrinking stocks of foreign direct investments (UNCTAD, 2013). Although GDP slowed at the same time, FDI stocks slipped from an historical high 32.2% of world GDP in 2007 to 25.4% in 2008 (ibid). Trade in goods and services have experienced a similar decline, reflecting a general 'contamination' of GVCs.

35. A recovery in global FDI flows was recorded in 2010 and continued modestly in 2011 (OECD, 2013i). However, preliminary estimates indicate that FDI activity dropped again for three consecutive quarters in 2012, confirming a declining trend over the year (OECD, 2013i).

36. A FDI slowdown could have a serious impact on productive and technological capacity of host economies. First, is raised the question of the sustainability of FDI-financed jobs, particularly in the context of high unemployment. FDI is often "made with the objective of establishing a lasting interest in an enterprise" (OECD, 2008b) and signals long-term engagement of multinationals, which may be difficult to reverse. MNEs are also among the most important vehicles through which technology is transferred across countries and a significant part of foreign MNEs’ value added, labour compensation and investment "sticks" to the host economy (OECD, 2014a). A slowdown in FDI could in turn have a negative impact on the productive capacity of investors, because their competitiveness depends on their ability to tap into foreign reservoirs of labour and resources.

37. The FDI landscape is also changing. In 2012, BRIICS were the main recipients of FDI in the world, accounting for over a quarter of total FDI flows (UNCTAD, 2013). Developing countries received more than half of global capital invested, and more than developed economies. European countries have been particularly affected as FDI inflows to the zone declined sharply. Stocks were maintained, however, illustrating the wait-and-see attitude of foreign investors. The same scenario applied to European outward investments—sluggish European markets resulted in a brake in FDI outflows, but European multinationals have refrained from abandoning their equity abroad.
The multinationals of emerging economies are increasingly offshoring their activities abroad

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

Note: For Indonesia, the 2001-04 average is not available.


38. The BRIICS countries (Brazil, Russian Federation, India, Indonesia, China and South Africa) also confirmed their place as major international investors (Figure 1.6). Although rising global FDI outflows are largely driven by OECD countries, investments by the BRIICS increased substantially over the past decade. Chinese and Russian multinationals, respectively, invested USD85 billion and USD 55 billion abroad in 2008-11. However the interests of large emerging economies tend to focus on neighbouring regions and developing countries (UNCTAD, 2013). In 2011, 43% of international investment from BRICS was ‘nearshoring’, illustrating their progression in regional value chains (ibid). Their growing equity in Africa, although small in volume, is particularly interesting. Most of their investments have been made in manufacturing and services in recent years. Offshoring of manufacturing and services activities to Africa questions an investment model based on access to natural resources only. It also reflects industrial modernization of BRICS, who have lost growth potential from technological catch-up, and some competitiveness because of rising wages. To escape the "middle-income trap", the BRICS are attempting to switch to higher value-added activities and move upstream and downstream the value chain (OECD, 2013g). Innovation is the key.
**Policy trends**

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

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

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

The advantage of advanced economies in higher education is shrinking.

41. A skilled labour force is a pillar for knowledge-based economies, and its size—more than the actual density of talent—is a key location factor for multinationals (OECD, 2011b). It is also a key determinant of integrating global value chains. A more educated population is also more likely to adopt new technological or innovative products. Training skilled workers and enlightened consumers is a public mission. Higher educational attainment eases a broader adoption of technological innovations and ensures that innovation benefits the largest number which in turn can result in greater equity and social cohesion. The democratisation of education therefore supports the democratisation of innovation (see policy profile on inclusive innovation).

42. The crisis has not slowed the expansion of higher education systems in major emerging economies, while the ageing OECD population is likely to impact on OECD higher education systems. In 2011, BRICS countries granted more than 7.3 million university degrees, compared with 8.5 million in the OECD (OECD, 2014b), the Russian Federation trained more engineers than the United States, and Indonesia trained more engineers than Germany. According to national sources, Chinese universities delivered over 27 000 doctorates in science and engineering in 2011, potentially more than their American counterparts.

---

counterparts (24 792) (OECD, 2014b). The doctoral graduation rate in China (2.2%)—all disciplines included—is now equivalent to that of Denmark (2.2%) and Austria (2.1%) (OECD, 2013d).

43. In addition, university programmes in large emerging economies meet international standards, and in some cases, have reached a level of quality equivalent to the best universities in the world. According to the Shanghai ranking, China had seven universities among the top 200 universities in 2012, and was on par, regardless of country size, with Australia (7) and Canada (7) (ARWU, 2013). Universities in Argentina, Brazil, Russia and Singapore were also included in the top 200 ranking (ibid). Educational opportunities in emerging economies are also improving: Shanghai and Hong Kong appear at the top of the PISA 2012 ranking and comprise a large share of top 15-year-olds performers in science (OECD, 2010a). Singapore and Chinese Taipei recorded equivalent scores to the OECD average, or even higher.

New talent circulation is likely to affect skills labour markets.

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

45. Over the past decade, Asian migration has been the engine of an unprecedented talent migration. As Asian immigrants are on average more skilled than other migrants and, for newcomers, even more skilled than OECD nationals (OECD/UNDESA, 2013). South-South migration has become as common as North-South migration. Damaged employment conditions in Southern Europe have pushed residents to leave for more resilient European markets. Spanish and Portuguese found job prospects outside Europe too, in former Spanish and Portuguese-speaking colonies. Lastly, a growing share of international talent is coming from Africa. Over the years covering the crisis, between 2005 and 2010, 450 000 immigrants with tertiary degree entered the OECD from Africa, exceeding 375 000 from China (ibid).

46. There is no evidence yet to conclude on the duration and impact of these migration flows on skills stocks. However, improved socio-economic conditions and the adoption of active policies to attract talent in emerging economies should change the situation vis-à-vis countries where ageing dynamics are depleting stocks of skilled labour force. In addition, the selective nature of migration, i.e. the propensity of more skilled or higher educated people to be more mobile, tends to reinforce international competition for talent, and reduces skills scarcities in the most attractive destinations.
47. The internationalisation of higher education adds to global competition for talent. International students contribute significantly to this cultural mix and the creation of international knowledge networks. They are an additional source of funding for education institutions during their studies and this may have a long-term impact on the host country’s economy if they settle after graduation.

48. The internationalisation of higher education was a key driver of higher education expansion (OECD, 2013f). There were twice more international students globally in 2011 than in 2000, with nearly 4.5 million students at the tertiary level. In recent years, new players have emerged in the international education market, such as Australia, New Zealand, Russia, Spain, and most recently, Korea (OECD, 2013f). Conversely, the percentage of international students has declined in traditionally more attractive countries (Germany and the United States). The international mobility of students reflects to a large extent inter-and intra-regional migration patterns, but it is also influenced by the attractiveness of higher education systems in terms of prestige, quality and cost. A preference for English-speaking countries is also noticeable.

49. Research systems of major R&D players depend increasingly on international students. The United States, the largest training system for research in the world, had 73,000 doctorates awarded in 2011, with 28% of international students in its advanced research programmes (OECD, 2013d). International students account for almost half the doctorate students in Switzerland, and around 40% in New Zealand and in the United Kingdom. More than 40% of doctorate students in France are not French.

50. In addition, more and more institutions are creating offshore campus or double degrees (OECD, 2012c), or offer online courses through the Internet, as part of their internationalisation strategy. This aims to increase their reputation, revenues (e.g. tuition fees), to access a wider pool of high-potential students and to promote cross-faculty fertilization. Massive open online courses (MOOCs), in particular, are changing higher education by radically expanding the reach of existing campuses and by launching a whole new fields of learning informatics that could provide unprecedented level of feedback for universities (Waldrop, 2013). Global competition for talent is further increased as demand for these new educational programmes and products is the strongest in disciplinary areas that are central to innovation—science, engineering and business management (OECD, 2012c).

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

51. GVCs are changing the international division of labour and the higher mobility of talent has accelerated the internationalisation of R&D. The size and growth of markets were typically the most important for attracting FDI (OECD, 2011b). But more recently, a key determinant of the location of innovation activities has been access to strategic assets, such as technology, knowledge, expertise or the presence of suppliers, competitors and lead users (internationalisation of business R & D).
52. Many large international companies have supplemented their internal R&D efforts by collaborating with external suppliers, competitors, customers, research institutes and universities. The internationalisation of R&D is reflected in the relative importance of foreign sources of funding for business R&D. In the EU about 10% of business R&D is funded from abroad (OECD, 2014c). But some European countries are more attractive than others. In Ireland (25%), the UK (24%) and Austria (22%), funding from abroad account for around a quarter of total business expenditure. Israel (50%) and Korea (0.1%) are two extreme cases.

53. Trends in business foreign-funded R&D reflect the changing landscape of global R&D. Since 2007, the volume of funding from abroad (at constant prices) has declined in Canada, the Netherlands, Russia and the United Kingdom (Figure 1.7)

54. In contrast, it has increased significantly in Israel and China, reinforcing the trend over the decade. Within Europe, Germany and Sweden also experienced an increase in foreign funding.
Figure 1. Multinationals play a major role in domestic R&D in many countries

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

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

Source: OECD, MSTI Database, January 2014. Data retrieved from OECD IPP.Stat <> on XXXX

55. Multinationals have been playing a key role in the internationalisation of R&D. Foreign affiliates account for up to 70% of business R&D in Ireland and over 50% in Israel, the Czech Republic, Belgium, Hungary, Austria, Poland and the United Kingdom (Figure 1.8).

National innovation hubs are increasingly interconnected to global innovation networks

56. The internationalisation of R&D is also affected by the growing internationalisation of science through co-operation networks.

57. Firms, universities and STI actors have clustered around geographical areas, industries or groups of related technologies, in order to improve networking and generate greater spillovers from open and collaborative innovation. Spatial clustering in knowledge-driven sectors is strong, because important local knowledge spillovers occur in these sectors. These local business linkages and networks are particularly critical to new and small firm innovation.

58. Among the 40 most innovative regions in the world (as measured by the highest number of PCT patent applications), different patterns of collaboration emerge, but foreign collaboration is intensifying almost everywhere (Figure 1.9). The Flemish region (Belgium), Ontario (Canada), the east of England (United Kingdom) and Western Netherlands display a high share of collaboration with foreign hubs, but are comparatively less connected to other hubs in their own country. Some states in the United States show weak (but increasing) international connections, and strong national connections. In Japan and Korea, both domestic and international propensities to collaboration are low, while the reverse is true for Shanghai and Beijing in China. It appears that country size does matter in shaping collaboration patterns.
Figure 1.9 National innovation hubs are increasingly engaged in international co-operation

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


Policy trends

59. Globalisation of STI raises several issues regarding the efficiency and sustainability of national innovation policies. Some of these issues include the appropriateness of national policy frameworks to incentivise STI activities that are shaped by a more global context, the risk of public money leakages, the suboptimal appropriation of the benefits of STI related public investments, and an erosion of the tax base due to the profit-shifting strategies of multinationals (MNEs). STI networks have deployed beyond national frontiers, whereas international policy co-operation frameworks in many areas are still in their infancy (tax, cybersecurity etc.) or non-existent (e.g. environment).

60. Attracting knowledge-based assets and human capital require building supportive ecosystems that will further enrich and flourish with the entry of new talent, technologies and knowledge. Governments have a major role to play in initiating and feeding this virtuous circle, by e.g. ensuring the quality and absorption capacity of domestic science base and fostering the attractiveness of the STI system. Research excellence initiatives, R&D and IP tax policies, immigration laws are increasingly becoming common instruments. Canada revised immigration laws in 2013 to streamline access for highly qualified applicants.
and plans to introduce changes in study and work permit regulations for international students in the course of 2014. Germany introduced the EU Blue Card in 2012, offering highly-qualified professionals more flexible immigration opportunities, and in 2013 launched a new service for S&T professionals in India, Indonesia and Vietnam, providing them advice and support to move to Germany. The 2012 Recognition of Qualifications Act establishes a nationally standardised system to assess foreign professional qualifications.

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

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

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

---

4 Temporary visas holders.  
5 Or permanent residents
International collaboration implies the pooling of financial resources, the sharing of large-scale research infrastructure, and the improvement of the global knowledge base (OECD, 2012d). While it is increasingly vital to collaborate globally in order to reap the benefits of STI, the major part of available resources for research promotion is still programmed, spent, monitored and evaluated at the national level (OECD, 2012d). Cross-border STI governance involves the delegation of part of the policy initiative from the national to the supranational level. In addition, international co-operation and network building cause higher transaction costs, greater risks of failure and the inclusion of a broader range of actors (OECD, 2012d). Effective governance mechanisms regarding priority setting, funding and spending arrangements, knowledge sharing and IP, or capacity building can help to address such problems.

Global markets are not the preserve of large firms only. As SMEs integrate into global supply chains and entrepreneurial ventures seek growth potential and access to knowledge, skills and networks, opportunities for internationalisation have become important for all types of enterprises, including young innovative firms. Governments are increasingly promoting global knowledge flow initiatives to support cross-border alliances among and between firms and research organisations, with the aim to create linkages between SMEs and foreign direct investment ventures and to attract highly-skilled labour from abroad. Costa Rica has several proactive programmes to link SMEs to multinationals (MNEs) and to upgrade their capabilities. In order to support the internationalization of SMEs, the UK Trade & Investment (UKTI) run a series of new support programmes, including the Technology Partnerships Unit. This Unit assists UK technology-intensive SMEs to identify and qualify for supply chain opportunities with global companies and funding opportunities with venture capitalists and business angels. A “mid-sized business” programme has also been implemented to support and advise mid-sized businesses looking to grow in international markets (see policy profile on the internationalisation of firms). While most governments promote a cluster-based approach to innovation, many OECD countries and regions have tended to combine clusters policies and specialisation strategies (OECD, 2012a). Governments have long encouraged the location of knowledge producers, transformers, assemblers and first users in special zones in order to accelerate technology transfers and social return on public investments in research. More recently, governments have considered a more bottom-up approach and focused support on accompanying “entrepreneurial discovery” at regional levels. This is the core of the new EU approach named “smart specialisation” that will apply to the structural funds to be spent in European regions in 2014-20 (around EUR 80 billion). Australia is considering policy initiatives to target priority areas and allocated about USD 350 million (AUS 514 million) over 2012-17 to Industry Innovation Precincts to create networks and clusters in areas of economic potential (e.g. food and manufacturing). Global precincts have also been defined in areas of research strengths. In 2013 the Brussels Capital Region (Belgium) included a smart specialisation strategy in its new regional innovation plan and Wallonia implemented a Trends Observatory. Estonia is considering the implementation of a smart specialisation strategy, with the emphasis on co-operation schemes in the future (see policy profile on clusters policy and smart specialisation).

A key policy question is emerging also around the potential impact of agglomeration dynamics on social cohesion. The emergence of globally-connected innovation spots that are more integrated into global value chains than with the rest of the country may contribute to enlarge social and cultural divide. Some STI policies could be prejudicial to “territorial” inclusiveness if they are not linked to policies that ensure that knowledge and associated benefits trickle down to other geographical regions.
SOCIAL AND ENVIRONMENTAL ISSUES RAISE CHALLENGES AND OPPORTUNITIES

67. An emerging economic recovery is likely to push environment and social challenges higher on the public policy agenda.

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

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

69. Our current growth model is altering the environment, and natural systems are already experiencing irreversible changes (OECD, 2012e). Air pollution is set to become the top environmental cause of premature mortality globally, ahead of lack of clean water and poor sanitation (ibid). OECD projections to 2050 forecast that a global economy four times larger should see, ceteris paribus, energy needs increase by 80%, greenhouse gas (GHG) emissions increase by 50%—mainly due to energy-related emissions of carbon dioxide (CO2)—and water demand grow by 55%. The increase in the atmospheric concentration of GHG could result in an average global warming of 3°C to 6°C. More than 40% of the world population would live in areas subject to ‘water stress’. Climate change could become a major driver of mass migration (OECD, 2013m).

70. The challenge for our society is both the transition to a low carbon economy and the preservation of natural resources. Progress has been made, but not enough. Many countries have managed to decouple CO2 emissions, or freshwater abstractions, from GDP growth (OECD, 2013m) but decoupling is still too weak. In many other countries the situation continues to deteriorate as emissions continue to rise.

71. At the last meeting of the International Energy Agency (IEA) in November 2013, member countries at Ministerial-level agreed that progress is not fast enough on clean technologies, that considerable energy efficiency potential remains untapped, and that energy-related R&D and demonstration need to accelerate (IEA, 2013). OECD countries are still more than 80% reliant on fossil fuels (OECD, 2013m).

72. The crisis has had a mixed impact on environmental conditions. Economic and trade contraction contributed to temporarily lower CO2 and GHG emissions. Many governments have also introduced a green component in their recovery plan that allowed deploying new green investments and modernizing infrastructures (OECD, 2009). Public R&D budgets granted for energy-related purposes increased significantly between 2007 and 2009, in both volume and relative share of total budgets (Figure 1.10). But lower raw materials prices dampened financial incentives for alternative energy sources and for the more efficient use of natural resources. Government efforts to support green technology markets found little support from private demand, which was less responsive to more expensive products. Fiscal austerity which is prevailing in many countries could also delay the implementation of a greener agenda. The impact is already being felt on R&D budgets. The volume of funds allocated to energy and environmental issues has fallen since 2009 in the OECD (Figure 1.10).
Figure 1.10  Growth in public R&D budgets for energy and environment is easing

Millions USD 2005 PPPs and as a percentage of total GBAORD

Panel 1. Energy R&D budgets  Panel 2. Environment R&D budgets

Source: OECD RDS Database, March 2013. Data retrieved from OECD IPP.Stat <> on XXXX

Policy trends

73. The transition to a low carbon future requires the deployment of new or existing technological solutions and a radical transformation of the global energy system.

74. A 2°C scenario—i.e. a scenario that would limit global warming below what is perceived to be the tipping point of natural systems—requires a portfolio of new technologies, including renewables production, end-use fuel and electricity efficiency, technologies for carbon storage and decarbonisation (CCS) and even nuclear energy. China and the United States place an increasing policy emphasis on innovation to contribute to sustainable and green growth. China’s 12th Five-Year Plan has devoted particular attention to energy and climate change and has established a set of targets and policies for 2011-15 to reduce CO2 emissions, fossil-energy dependency and to increase energy efficiency. The US government announced a Climate Action Plan in 2013, with the ambition to lead the world in the R&D and demonstration and deployment of clean energy technology. USD 7.9 billion is proposed for clean technologies and an additional USD 2.7 billion for global climate change research.

75. Existing technologies already offer significant potential to achieve a sharp CO2 emissions reduction, e.g. in the building and construction sector. Residential energy consumption, that has been relatively static since 1990—despite substantial energy efficiency improvement and residential space heating—offers the greatest potential for energy and emission savings (IEA, 2013). Hybrid-electric (HEV) and electric vehicles (EV) also show encouraging progress, on the conditions that electricity is generated
from low-carbon sources, but their deployment must be accelerated to be on track to meet a 2°C scenario. This entails a projected increase in sales by around 80% (EVs) and 50% (HEVs) per year up to 2020. The 2014 US Budget proposal includes provisions to improve clean-vehicle technologies and to move closer to one million advanced vehicles on the road. The Norwegian Strategy for Environmental Technology will fund experimental development with particular attention to green transport and offshore wind production facilities. In January 2013, the Canadian Government announced the renewal of the Automotive Innovation Fund (AIF), which provides repayable contributions to automotive firms that are undertaking large-scale R&D projects focused on greener and more fuel-efficient vehicles.

76. Decoupling economic activity and energy intensity cannot come from only a few technologies, whether they are new or not. It requires structural and behavioural changes (IEA, 2012), as well as significant investments in infrastructures (e.g. smart grids) to improve the system as a whole (IEA, 2013). Clean energy solutions like electric vehicles and solar photovoltaic (PV) systems depend on smart infrastructure that enables system-wide gains. The United Kingdom endorsed the Green Investment Bank with USD 5.5 billion (GBP 3.8 billion) in 2012 in order to invest in green infrastructure projects.

77. In addition, the complexity of the links between issues related to energy and water and food, requires a holistic approach and a better integration of innovative solutions and policies around these three questions. In Germany, the Energiewende Research Forum provides a platform for dialogue among relevant stakeholders involved in the transformation of Germany’s energy system. In Denmark, the Fund for Green Business Development promotes green industrial symbioses between firms, where waste of a given resource, e.g. water or materials, of one company becomes a resource in another.
Box 1.2. Smart cities: tackling with social and global challenges at local level

For the first time in history, more than half the world’s population live in urban areas. Cities are critical drivers of national growth and play disproportionately large roles in the economies, knowledge generation and environmental performance of countries. Compared to higher levels of government, cities offer more easily identifiable policy synergies and complementarities. Urban policy makers are more likely to identify and combine complementary climate policies within and across sectors given the interconnectedness of urban systems such as transport, land-use planning, and economic development (OECD, 2010b). Cities are for instance responsible for a significant share of green infrastructure investments (Figure 1.11).

Cities are therefore the places where smart innovative approaches driven by ICTs, the analysis of (big) data and machine-to-machine communication naturally arise. Smart city solutions often target different areas of urban development such as transport, electricity grids, buildings, as well as the delivery of public services, in fields such as healthcare or education. Beyond governance challenges raised by multiple levels of government and stakeholders, smart cities are likely to improve citizens’ well-being and increase the efficiency of the urban system as a whole.

Figure 1.11 Gross Capital Formation in environmental protection by level of government, 2009

![Gross Capital Formation in environmental protection by level of government, 2009](image)

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

In 2014, Brussels Capital (Belgium) will launch a tender for public procurement to develop a smart city project around transport and mobility. In 2013 France devoted new funding to “tomorrow’s city” in the framework of its Investments for the Future. Sustainable smart cities are becoming a prominent feature within the Swedish Challenge Driven Innovation Program (CDI) and a part of its emerging Strategic Innovation Areas (SIA). Costa Rica includes in 2011 smart cities and smart grids in its roadmap for renewable energies. The same year, the Finnish government, Tekes and private companies have set up a test environment for about 400 electric vehicles in the Helsinki Metropolitan area, in order to develop the infrastructure and transportation system, services for users and business models.


78. Environmental pressure also requires radical changes in lifestyles and behaviours. Governments have a key role to play in this area. Household consumption patterns and behaviour have a profound effect on natural resources stocks and the quality of the environment (greening households’ behaviour 2011). A
2008 OECD survey of over 10,000 households has analysed household responses to various policy measures in five policy areas (energy, waste, organic food, water and personal transport) across ten countries\(^6\). The survey highlights the importance of providing the right incentive to spur behavioural change, and shows that price-based incentives encourage energy and water savings, increases recycling volumes, and lower car ownership and use. The mere fact of metering and introducing a price on the use of environment-related resources has an effect on people’s decisions, even if the price is very low. In addition, the survey findings indicate that “softer” instruments, based on the provision of information to consumers and on public education, can have a substantial complementary role to induce changes on the demand side.

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

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

80. Ageing will generate a range of serious challenges linked to growing pressures on economic performance, social and health care, and public finances. 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 and productivity performance, as labour forces age in some countries and shrink in others (OECD, 2012a). Ageing societies will face critical policy challenges to maintain and enhance the supply of health and social services for the elderly. The rising numbers of the elderly, combined with other societal changes, such as rising female labour market participation, declining family sizes, and the continuing rise in the stepfamily, will increase demand for care (OECD, 2012f; 2011c) at a time when public health workforce shortages are forecast and have already affected the pool of care providers (OECD, 2011c).

81. Dementia and Alzheimer’s disease, in particular, represent already today a significant public health challenge. An estimated 36 million people lived with dementia in 2010 worldwide, of which 42% lived in high-income countries (OECD, 2013o). This could rise to as many as 115 million worldwide in 2050. Addressing the challenges posed by dementia has become a major endeavour at international level. A landmark G8 Summit on dementia, held in London in December 2013 concluded with a call for countries to accelerate research, promote open science and greater data sharing at international level, and improve quality of care of for people with dementia (www.oecd.org/health/dementia.htm). Critically, this is not a challenge for OECD countries alone. An estimated 58% of the 36 million people living with dementia in 2010 worldwide are from middle and lower-income countries.

82. In light of such long-term prospects, it is essential that the elderly remain as healthy, independent and active as long as possible, so that they can play a part in family life, society and in the economy.

---

\(^6\) Australia, Canada, the Czech Republic, France, Italy, Korea, Mexico, the Netherlands, Norway and Sweden.
Science and technology, and particularly ICT applications, will play an important role to achieve this objective (OECD, 2012a).

**Policy trends**

83. The urgency today is to promote innovation opportunities of services in sectors such as health care and nursing, education, transportation, urban development, and on the re-organization of firms and work processes. Public services are currently facing new demands and priorities in the context of ageing societies. In particular, innovation of home and community-based services provides a key starting point for smart ageing approaches. Housing design that supports independence and access to adaptations and technology that support ageing, flexible support at home and integrating housing services with health and care to create integrated teams on a neighbourhood basis can all play a role.

84. 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 (EC, 2010).

85. The aged-care services sector, while diverse, faces common policy challenges. Although there has been increased interest in recent years to finance R&D for ageing by institutional investors such as pension funds or insurance companies, funding is still a major constraint. On the one hand, the public good nature of innovation when it addresses health and wellbeing of older populations, and uncertainty and insufficient awareness of market opportunities (including reimbursement and user adoption and unclear business models for industry) lead to under-investment by the market. On the other hand, governments are increasingly limited to respond as a result of fiscal consolidation. Some national policy programmes around public-private partnerships (Denmark) and “silver” public procurement (Denmark, Finland, Sweden and the UK) have recently been initiated to stimulate investments and demand for smart ageing projects.

86. Other barriers to innovation may arise from systemic failures. In this case the issue is less about investment on goods and services than the preparedness of the innovation system itself. Barriers to transformative change of health and social care services include lack of policy coherence, poor demand articulation and regulatory uncertainty. In most OECD countries the suite of political, regulatory and funding structures is, for example, different between health care and social care. Despite being interdependent, governance and funding structures are often not coordinated and integrated, and care provision and delivery is often fragmented. Sweden is currently moving towards a challenge-driven innovation strategy, focusing *inter alia* on health, wellbeing and medical care. A large national initiative, Strategic Innovation Areas (SIA), has been implemented, with strong financial support to catalyse innovation agendas, public-private partnerships and institutional change.

87. The need for more efficient, effective and sustainable services for health and wellbeing requires a rethink of traditional models that redefines the boundaries of state and market and state and society, based on greater social responsibility and collaboration between public and private sectors.
For innovation to benefit all, education and ICT play a key role to foster the democratisation of innovation.

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

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

90. Information and communication technologies (ICTs) offer opportunities to support inclusive innovation by ‘democratising innovation’ and by extending the circle of individuals and businesses that engage in innovation activities. ICTs have brought about the most transformative innovation in the recent past and have facilitated better access to knowledge and improved means of communication to the wider society, including rural communities in developing and emerging countries. The potential of ICTs becomes clear by judging by the importance of ICT-based products and services among the success stories of inclusive innovation initiatives\(^7\). Some of these products have e.g. provided market information to farmers and training to unskilled groups, and supported business conditions for disadvantaged groups. Many of the most successful applications involved local entrepreneurs as part of the development processes. These cases illustrate the potential of adequate ICT-based applications to support innovation activities of entrepreneurs and small businesses.\(^8\)

---

\(^7\) These are initiatives that lead to the development of new products and services that serve lower-income groups. A wide number of cases are provided in OECD (2013a), Innovation and Inclusive Growth, OECD Publishing, Paris.

Policy trends

91. Innovation policies are usually designed with no consideration as to their impacts on inclusive growth. For example, fiscal incentives benefit only taxable firms at the exclusion of loss-making firms (which are often start-ups) and the informal sector. Innovation grants and public procurement usually go to larger firms with closer links to government. Focusing government expenditure on particular domains or sectors (often high-tech) might come at the expense of more basic, lower-tech innovations that could better address social challenges like poverty. Expenditure can be concentrated more on particular actors, and be less conditional. This could enable a larger number of firms or individuals to become innovators and could promote the democratisation of innovation.

92. The policy debates about the “digital divide” illustrate that the Internet and ICTs are not always an obvious integrating factor. Lower-income groups are often at a disadvantage with respect to access, and therefore at a disadvantage to reap the benefits of ICTs. This is because skills, innovation and technical change are complementary. Skills help exploit the opportunities ICTs offer and are generally critical to widen the circle of innovators. Skills and training policies will be critical to avoid exclusion. In 2013, the Australian government made USD 130 million (AUD 192 million) available to universities to increase the access and participation of people from low socio-economic backgrounds, particularly Indigenous Australians. South Africa has implemented equity targets in human development projects in order to ensure gender and black representation within S&T and engineering sector. Costa Rica provides rural and vulnerable communities with an access to Intelligent Community Centres which offer Internet access and have become centres of learning, particularly in the field of digital technologies.

93. A variety of innovative products and services, some of which make use of ICTs, have substantially improved welfare of lower-income groups. Many of them, however, have had limited aggregate impact due to small scale. But success stories, such as Kenya’s mobile banking service M-PESA, which now reaches an estimated 15 million users, indicating the potential to upscale.

94. The critical policy issue is to explicitly consider potential trade-offs of policies that support innovation and information technology (IT) with respect to their impact on aggregate efficiency and growth on the one hand, and the distribution of benefits on the other hand. Innovation could potentially increase inequality, as benefits accrue to innovators. But the diffusion process can lead to equalisation over time. In this respect, an important dimension to consider is the prioritisation of certain economic activities (e.g. ICTs, biotechnology or agriculture).

95. Economic activities differ in their employment, skills and wages patterns. The promotion of certain activities may therefore have a more direct impact on income distribution than others. Activities also differ in the way they are connected to other activities through sales, purchases or knowledge circulation. The promotion of certain activities may have broader economic impact, depending on the links they have with each other. This will not only affect growth but also industrial inclusiveness and, via wages, social inclusiveness. This issue is of particular interest at a time when countries are reconsidering the benefits of industrial policies.
LOOKING INSIDE THE GLOBAL INNOVATION SYSTEM

96. Many of today’s innovations are inconceivable without the S&T developments enabled by research.

The global research system is expanding

Research and innovation are on the rise in Asia

97. In spite of the economic downturn, global investment in R&D has steadily increased since 2007 (Figure 1.12 and 1.13). OECD R&D spending reached over USD 1.1 trillion in 20129 (OECD, 2014c). R&D expenditures by Brazil, the Russian Federation, India, Indonesia, China and South Africa (BRIICS) amounted to an additional USD 340 billion. Global R&D expenditure could be at about USD 1.5 trillion in 2012, of which almost 82% would be spent by ten countries (OECD estimate). The OECD would account for 75% of global R&D expenditure, compared to about 90% ten years ago (Figure 1.12).

98. The 2008 crisis has reinforced ongoing shifts in global research landscape. The top 10 largest R&D performing economies have changed since 2007, with the entry of Chinese Taipei and the exit of Canada. Since 2009, China has become the second largest R&D country behind the United States, ahead of Japan (Figure 1.12). Country shares of global R&D investment has decreased over time in the United States (31% estimate in 2012), Japan (11%) and the European Union (23%).

---

9 As official OECD data on R&D investment are based on retrospective surveys of performing units, the discussion of cross-country R&D spending patterns is currently limited to the end of 2012.
Figure 1.12  World¹ R&D efforts have weathered the turmoil and remain concentrated around a few major global players

Panel 1. Total world¹ R&D expenditure in millions USD 2005 PPPs and share of major R&D performers in the total world¹ estimate

Panel 2. Gap between R&D intensities, OECD and selected countries¹, as a percentage of GDP

1. Global gross R&D expenditure (GERD) is estimated by the sum of GERD performed by OECD countries, the BRIICS, and Argentina, Colombia, Costa Rica, Egypt, Latvia, Malaysia, Romania, Singapore and Chinese Taipei. A world estimate would amount therefore to USD 1 370 billion PPP in 2011 and USD 1 490 billion PPP in 2012 approximately.


99. Korea has become the most R&D intensive country in the world in 2012, overtaking Israel¹⁰ where R&D spending incurred by firms and government slowed down over the crisis (Figure 1.19 and Figure 1.24). When considered as a proportion of GDP¹¹, OECD R&D expenditure has risen slightly from 2.26% in 2007 to 2.40% in 2012. This sustained commitment to R&D is broadly based across countries. Most economies recorded an increase in R&D intensity, with a sizeable upward shift in some. The sharpest increases took place in Korea (+1.95%) and Estonia (+1.47%) where GERD/GDP ratios increased by more than 1 percentage point of GDP¹². In the United States, R&D intensity rose from 2.63% to 2.79% over the period mentioned above. From a lower base, the EU28 experienced a slow increase in its GERD/GDP ratio, rising by 0.21 of a percentage point over the period to 1.97% in 2012.

¹⁰ It is noteworthy that Israel’s R&D expenditure is underestimated because it does not include defence-related R&D budgets.

¹¹ In interpreting and comparing these figures, it must be remembered that the GERD-to-GDP ratio reflects changes in countries’ nominal spending on R&D as well in their GDP growth rate.

¹² For Estonia, a significant investment in new technology in the oil industry explains part of the increase. For Slovenia, a change in methodology of data collection in 2011 introduced break in the series.
100. Conversely, some countries have experienced a decline in R&D intensity since 2002 while, in most cases, the relative drop of R&D expenditure took place before the crisis. Iceland (−0.55%), Sweden (−0.40%), Canada (−0.31%) and Israel (−0.24%) have recorded the sharpest falls.

101. Outside the OECD area, Chinese Taipei (+0.92%) and China (+0.91%) showed the sharpest increases in R&D intensity. In 2012, Chinese Taipei spent 3.07% of its GDP on R&D, and was ranked between Japan (3.34%) and Denmark (2.98%), while China’s R&D intensity is now on par with the EU28.

**Relative cost to access world-class research is increasing**

102. The global R&D system remains the playground of a handful of economies. The top ten economies have maintained their share of global R&D expenditure since 2007, but the gap between the ten most R&D intensive economies and the rest of the world has widened (Figure 1.15). The convergence of leading economies tends to take place outside the OECD area, as the latter appears to experience a degree of stagnation in its research spending.

103. R&D concentration around big players and economies with more mature research infrastructure (i.e. showing higher GERD intensity) changes the conditions under which smaller and lower income countries can access world class research. As the gap widens, technological catch-up costs increases for lagging countries, and increases the risk of being excluded from GVCs and global knowledge flows.
S&T output has been recovering gradually.

104. The crisis has slowed scientific and technological output worldwide. While scientific production—as measured by scientific publications—has been less adversely affected and has been accelerating since 2010, technological production—as measured by patenting activities—has decreased significantly, and is still slow to recover (Figure 1.14). This reflects to some extent the different impacts of the downturn on parts of the R&D system, in particular public research and business R&D.

![Figure 1.14. Patenting activities have been hit and are slow to start](image)

Panel 1. Evolution of total world triadic patent families and share of major players

Panel 2. Evolution of total world top scientific publications and share of major players


Note: Publications in the top 10% journals are drawn from the SciVal Elsevier database and ranking is based on the Scientific Journal Ranking (SJR) an impact-factor normalised index that takes into account the prestige of the journals as a measure of quality. Scientific production is based on whole counts of documents by authors’ institutional affiliation in the country.


105. Triadic patent families\textsuperscript{13} data show that the steady growth of patenting activities during the first half of the 2000s has slowed down before the 2007-09 downturn. The crisis has reinforced this trend, as

\textsuperscript{13} Triadic patent families are defined as patent for an invention filed at the European Patent Office (EPO) and the Japan Patent Office (JPPO) and granted at the US Patent and Trademark Office (USPTO) to protect a same invention. Triadic patents are typically of higher value and eliminate biases from home advantage and the influence of geographical location.
depressed economic conditions discouraged firms to engage in innovative activities. The number of patents filed at the three patent offices has increased since 2009, but remains low by past standards.

106. Changes in the global R&D landscape described above are already being reflected in global S&T production. The share of the U.S. and Japan in total world patents and scientific publications is on the decline, slowly giving way to S&T production by the BRIICS countries, especially China (Figure 1.14.). BRIICS countries produced about 16% of top-quality scientific publications globally in 2013, compared to 39% in the United States. The BRICS share is almost three times more than that of ten years ago. This shift in scientific leadership is also apparent in patents, albeit less striking.

**Outlook for the global research system**

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

108. The current uneven economic recovery is expected to widen the gap between countries that experience flat or slow growth (hardly maintaining R&D expenditure) with those countries with strong economic momentum (with good conditions for expanding national R&D). The rise of China, driven by its economic dynamism and its long-term commitment for the STI, should continue. China’s Medium and Long-term National Plan for S&T Development (2006-20) targets R&D spending of 2.5% of GDP by 2020. Assuming a linear growth in Chinese and US R&D expenditure, China should outpace US R&D spending by about 2022 (Figure 1.15.). However, the recent economic slowdown in China might delay this scenario. The situation in the European Union will be more varied and several countries will struggle to achieve a 3% target by 2020.
Figure 1.15. China should outpace the United States as the major global R&D performer in the coming years
GERD, million USD 2005 PPPs, 2000-12 and projections to 2024

Note: Trends are estimated on the basis of US, Japanese and Chinese GERD data back to 2000.

Recent technology developments

Fields of technology acceleration

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

14 New technology-based firms can however make substantial contributions to radical innovation and technological breakthroughs.
Figure 1.16. Technology acceleration

Panel 1. Major fields of R&D investments by the largest worlds’ corporate investors, 2012

Million current EUR

<table>
<thead>
<tr>
<th>Category</th>
<th>EUR 2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICT</td>
<td>50,000</td>
</tr>
<tr>
<td>Health and food</td>
<td>100,000</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>150,000</td>
</tr>
<tr>
<td>Transport</td>
<td>200,000</td>
</tr>
<tr>
<td>Other (incl. defence)</td>
<td>300,000</td>
</tr>
<tr>
<td>Leisure</td>
<td>400,000</td>
</tr>
<tr>
<td>Energy and environment</td>
<td>500,000</td>
</tr>
<tr>
<td>Construction</td>
<td>600,000</td>
</tr>
<tr>
<td>Financial services</td>
<td>700,000</td>
</tr>
</tbody>
</table>

Panel 2. Major fields of technology acceleration, top 40 technologies, 2000-11

Level of increase in patent burst, i.e. patent filing (high, medium and low)

<table>
<thead>
<tr>
<th>Patent code</th>
<th>2000</th>
<th>2011</th>
<th>Number of patents, 2000-11</th>
</tr>
</thead>
<tbody>
<tr>
<td>A5P</td>
<td>799</td>
<td>14,720</td>
<td></td>
</tr>
<tr>
<td>C05G</td>
<td>118</td>
<td>519</td>
<td></td>
</tr>
<tr>
<td>A01P</td>
<td>486</td>
<td>6,750</td>
<td></td>
</tr>
<tr>
<td>C07B</td>
<td>521</td>
<td>2,545</td>
<td></td>
</tr>
<tr>
<td>C10J</td>
<td>11,977</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C11D</td>
<td>2,545</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C12N</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C48B</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A62F</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B00L</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B60N</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B65W</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F01D</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F01K</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F02N</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F03B</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F03D</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F05G</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H05J</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B81B</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B81C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B92B</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H31S</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H32J</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H32N</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H21K</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F21B</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F21Y</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F21W</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H41K</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G00Q</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G11B</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G24K</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G07F</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G04N</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H04W</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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


Note: The largest world corporate investors in R&D are the top world 2000 companies ranked by R&D investments. The sample consists of 527 companies based in the EU and 1473 companies based elsewhere. The total R&D investment of these companies is estimated to more than 90% of the total expenditure on R&D by businesses worldwide.

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

111. The accelerated development of new successful technologies (“burst”) is apparent in patent filings. Experimentation in the form of R&D or inventive activity over several years is sometimes followed by a sudden and marked increase in innovative activity that is typical of the development of successful new technologies (OECD, 2013h). Early developments generally occur in patent classes that are later abandoned in favour of new technological solutions in different patent classes (Figure 1.16). Depending on the field, the shift from one technology to another may take place in a continuous fashion (e.g. in data processing and storage), or as simultaneous bursts followed by relatively flat patenting activity, and then by later bursts as different technologies emerge (e.g. in chemistry and biotechnology, phone and wireless communication).

112. Areas of acceleration are new technologies related to:

- Climate change mitigation (e.g. lighting, electric power, electric and hybrid vehicles, energy generation, batteries, motors and engines),
- Ageing, health and food security (e.g. chemistry and biotech.),
- Information and communication management (including infrastructures for ‘big data’ and virtual payments), and
- New manufacturing processes (e.g. chemistry, nanotechnology, composite materials, new materials, 3D printing and laser technology).

**Policy trends**

113. Countries are engaging new large-scale R&D investments in promising technology fields (see policy profile on policies for emerging, enabling, converging technologies). In the framework of its new Industrial Strategy, the United Kingdom has granted USD 710 million (GBP 492 million) to its “Eight Great Technologies” in 2013 that cover the four areas of technology acceleration mentioned above.¹⁵

114. **Ageing, health and food security.** The United States has increased federal investment and interagency co-operation in neuroscience to improve health and learning. The USD 100 million Brain Initiative aims to advance knowledge on brain disorders, such Alzheimer’s disease. China has identified Big data and energy-efficient computing, satellites and the commercial applications of space, robotics and autonomous systems, life sciences, genomics and synthetic biology, regenerative medicine, agri-science, advanced materials and nanotechnology, and energy and its storage.

¹⁵
the development of agricultural technologies as an emerging STI policy issues and will promote entrepreneurship in this field.

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

The challenges of technology convergence

116. The convergence of key emerging and enabling technologies—Nanotechnology, Biotechnology, Information Technology and Cognitive Sciences—and the combination of different disciplines into new R&D fields have the potential to generate transformative changes to industries and societies and provide new potential to address global and social challenges (e.g. managing mega-cities, clean water production, food security, etc.).

117. Inter-disciplinary research supports convergence in scientific research. New fields of research emerge between S&T disciplines that follow a mixture of approaches in doing research and that use a variety of analytical instruments and evaluation methods. Technology platforms connect up data, models and actors to integrate knowledge, identify gaps and support global research coordination. But they are difficult to map and are likely to have few commercial or publishable output. The concentration of science actors in convergence hubs, for instance around technology platforms, can enable sharing facilities, equipment and skilled technicians between different technology and research fields.

Policy trends

118. Increasing investments are required to follow S&T developments and technological acceleration tends to reduce the time during which R&D investors can expect to maintain their advantage and reap the benefits of their discovery. As funding is scarce, this should prompt large and smaller players to strengthen their participation in cooperative projects, support "smart specialisation" and encourage technology monitoring and foresight analysis in order to identify technological niches and long-term technology development. Germany engaged in 2012 in a new foresight cycle by adopting an interdisciplinary approach and a demand perspective (“demand pull”) that better integrates technology-oriented results and results from social sciences and humanities.

119. Increasing enthusiasm in specific areas of convergence provides a stimulus to adopt new technology policy agenda, develop roadmaps and implement dedicated research centres. But technology convergence covers a wider range of issues, including actual convergence of scientific communities to produce knowledge, commercialisation and valorisation of research, convergence of manufacturing and product development infrastructures, and embedding these technologies into society.
**Internet development and cybersecurity**

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

121. As our dependency on the Internet increases we are becoming more vulnerable, making security, privacy and consumer protection more essential than ever (OECD, 2014d). Over the course of only a few years, information flows grew independent of jurisdictional borders, without significant additional cost. The open and interconnected nature of the digital environment made it more vulnerable to cybercriminals, ranging from organised criminal and terrorist groups to “hacktivists”, whose actions undermine the economic and social interests of an organisation (e.g. loss of competitive advantage, damage to reputation and image, or financial loss generated by breaches of confidentiality, breaches of integrity and unavailability of knowledge-based capital).

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

**Policy trends**

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

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

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

126. Cybersecurity policy-making faces challenges such as the co-ordination of government agencies with different roles and the development of appropriate incentives to foster cybersecurity risk management across a variety of public and private actors. These include aspects of self-regulation, regulation and legislation, as well as policies to address the cybersecurity skills shortage and to stimulate international cooperation and the development of cybersecurity industry. In this respect, the cybersecurity marketplace may evolve with the entry of military and aerospace industry players, bringing about a different innovation culture than the traditional ICT sector.

Business innovation will be the driver of a sustainable economic recovery

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

127. Firms are at the heart of global R&D system. Business enterprises account for the bulk of R&D performed in OECD countries (68% of OECD total R&D in 2012) (OECD, 2014c). In 2012, OECD firms spent nearly USD 750 billion on R&D, the United States accounting for 42%, Japan comprising 16% and the EU28 making up 28% of the OECD total. In the same year, Chinese firms invested over USD 185 billion in R&D, more than a fifth of the OECD total.
Figure 1.17. Business investment on knowledge assets weathered the crisis better and recovered earlier

OECD, Index 2005=100

- Business R&D expenditure
- Intangible assets
- Machinery and equipment (excluding transport)
- Other gross fixed capital formation

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

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

Source: OECD, MSTI Database, January 2014, OECD National Accounts Database, December 2013. Data retrieved from OECD IPP.Stat <> on XXXX.

128. The global economic crisis had a strong negative impact on innovation worldwide and total OECD business expenditure on R&D (BERD) declined by a record 4.2% in 2009 (Figure 1.17). However, business knowledge-intensive investments, such as R&D investments and investments in intangible assets (e.g. software), were more resilient than other types of investments (Figure 1.17, Note.). Investment in machinery and equipment dropped sharply during the crisis, while OECD R&D spending recovered to pre-2007 levels in 2012.

129. In addition, data for the 2,000 companies\(^{16}\) investing the most in R&D in the world\(^{17}\) show a resilience in R&D investments over the three years since 2009. This reflects the strategic importance

---

\(^{16}\) The EU Industrial R&D Scoreboard collects key information to enable the R&D and economic performance of companies to be assessed. Main indicators are R&D investment, net sales, capital expenditures, operating profits and number of employees. The data for the Scoreboard are taken from companies’ publicly available audited accounts.
companies attach to R&D despite economic uncertainty (EC, 2013). The top financial R&D investors in the world continued to increase their investment efforts in R&D significantly by 6.2% in 2012. This happened in a global context marked by a general slowdown of net sales growth (4.2% in 2012 compared with 9.9% in 2011) and a decline in operating profits (−10.1%) (EC, 2013).

130. Recent growth in OECD BERD has been driven by US firms, whose R&D investments are back to pre-crisis levels (Figure I.18.). In the EU the situation has also improved gradually, although the recovery seems less robust judged by a new decrease in private research spending in 2012. Japanese firms face difficulties to restore their R&D capacities and Japan’s BERD remains at 2007 levels (USD 114 billion). Outside the OECD, Chinese companies have accelerated the deployment of their research facilities since 2008 and as a consequence China overtook Japan as the second largest country of industrial research in the world in 2009.

Figure 1.18. Business research capacity has been relatively preserved

Panel 1. Evolution of BERD by largest performing economies, million USD 2005 PPPs, 2002-12

Source: OECD, MSTI database, January 2014. Data retrieved from OECD IPP.Stat <> on XXXX.

According to the EU Industrial R&D Scoreboard 2013, these companies account for more than 90% of global business R&D.
Panel 2. *Business R&D proximity to the markets, index, 2010 or latest year available*

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


Source: OECD estimates based on OECD RDS Database, March 2013. Data retrieved from OECD IPP.Stat <> on XXXX

131. Business expenditure on R&D tends to be more closely linked to the creation of new products and techniques than R&D performed in the government and higher education sectors (OECD, 2010c). Experimental development is the segment of business R&D that is most likely to turn into rapid innovation, as it is “directed to producing new materials, products or devices, to installing new processes, systems and services, or to improving substantially those already produced or installed” (OECD, 2002b). In most countries for which comparable data are available, little business R&D is spent on basic research, but applied research and experimental development comprise the lion’s share of BERD. When considering an aggregate index of BERD shares by type of research (basic, applied and experimental), it appears that firms in Switzerland, China or Chinese Taipei are more likely to be engaged in R&D activities, showing closer connection with end-use products and markets (Figure 1.19).

132. During difficult economic times, firms become more risk-adverse and may respond to weaker market prospects by concentrating innovative efforts on activities offering short-term benefits. BERD data by type of research are inconclusive on this and do not point to a substantial shift in business R&D orientation during the downturn. For the countries where more substantial changes could be observed, firms seem to have refocused their efforts on earlier stages in the research process, i.e. applied research.
Despite a notable fall in business spending on R&D, Israel remains the most BERD intensive country in the world, with BERD measuring 3.54% of GDP in 2012 (Figure 1.19). Korea (3.09%) has made significant progress since 2007 and overtook Japan, Finland and Sweden in terms of BERD intensity, reaching the second position after Israel. From a lower base, OECD performance has been essentially flat during this period. The OECD’s BERD was at 1.62% in 2012. The low BERD intensity for the EU28 (1.22%) weighs on OECD aggregate performance. The figure for Japan is a high 2.61% and that of the United States (1.95%) is still above average.

Outside the OECD, China and Chinese Taipei have increased their BERD intensity since 2009. China (1.51%) is now on par with Belgium (1.52%) and France (1.45%), while Chinese Taipei (2.28%) is on par with leading OECD industrial R&D performers.

However countries’ industrial structure has an important influence on the amount of their R&D, as some industries are more R&D-intensive than others (OECD, 2010c). 2011 estimates of adjusted BERD for industrial structure show that Germany and Korea would be below OECD average and Belgium, France and the Netherlands above average if they had the same industrial structure (OECD, 2013h).

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

**Policy trends**

137. Most business-performed R&D is financed by industry, with 87% of total OECD BERD funded by industry in 2011 (OECD, 2014c). But public funding for business R&D has increased significantly over the past decade, driven by the deployment of increasingly generous R&D tax arrangements while legal restrictions (e.g. WTO, EU) capped the volume of direct state aids.

138. Regarding direct (e.g. grants, subsidies, loans, procurement etc.) and indirect (e.g. tax incentives etc.) funding, the focus is on either one form or the other. In many cases, firms succeed to combine both direct and indirect support, especially the largest firms. Direct and indirect funding combined account for 10–20% of business R&D expenditure in most countries (Figure 1.20). France, Canada and Hungary have the most attractive combined arrangement with over a quarter of business expenditure potentially subsidised or refunded. Denmark, Japan or Italy are less generous (less than 10%). The total volume of R&D support provided to firms has increased in most countries since 2006, with the most notable increase observed in Belgium, France and Canada (Figure 1.20).

139. Although not all countries provide tax relief on R&D expenditure, 27 OECD countries have offered tax incentives to support business R&D since 2011\(^\text{18}\)—more than twice the number in 1995 (OECD, 2013p). By 2011 over a third of total public support to business R&D were in the form of tax incentives—this is more than half when the US with its large direct procurement of defence R&D is excluded. Indirect tax support is considered the major funding instrument of business R&D in Australia, Belgium (Federal Government), France, South Africa and the United States. The Netherlands has made tax relief the main instrument for industrial policy, which focuses on the “Top 9 sectors”.

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

141. R&D tax incentives have become an instrument to foster the attractiveness of national research ecosystem and to engage in a tax competition to attract foreign R&D centres. The UK introduced an expenditure credit scheme (RDEC) in 2013 to make R&D relief more attractive to large firms and to leverage domestic R&D activity.

\(^{18}\) More recent cost estimates of and policy information on R&D tax incentives are available from the April and November 2013 NESTI data collections on R&D tax incentives but full results were not accessible at the time of drafting this chapter. Policy information used in the text above is therefore based on country responses to the STI Outlook policy questionnaire 2014.
142. Direct funding through grants, debt financing and public procurement, however, remains the main channel of public support to business R&D in many countries (see policy profile on funding of business R&D and innovation). Competitive grants are prominent instruments in a majority of countries and not only those that have no fiscal incentives for R&D (e.g. Finland, Germany and Sweden). China, where equity funding is the main instrument, is an exception.

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

144. Countries also increasingly emphasize debt and equity financing in the policy mix for business innovation (see policy profile on financing business R&D and innovation). The United Kingdom is currently setting up a new national development bank, the British Business Bank, that will offer lending and guarantee solutions for UK SMEs. France has created the Public Investment Bank (BPI) in 2012 to support business innovation and technology transfer and provide seed capital and loan guarantees. Denmark has introduced new subordinated loans to SMEs and Danish entrepreneurs in 2013.

145. Canada announced the Venture Capital Action Plan in 2013. This is a comprehensive strategy for deploying USD 320 million (CAD 400 million) in new capital over the next 7 to 10 years to attract close to USD 800 million (CAD 1 billion) private investments in funds of funds. Germany implemented the Investment Grant for Business Angels in 2013 to activate additional funds for innovative start-ups by incentivizing private venture capital investors. The United Kingdom launched the Venture Capital Catalyst Fund to invest in commercially viable venture capital funds that might otherwise suffer because of a reduction in institutional investment.
Figure 1.20  Total public support for business R&D has increased markedly since 2006

Sum of government-funded BERD and tax incentives on business R&D, as a percentage of total BERD, 2006 and 2011 or nearest years available

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

Estonia, Germany, Luxembourg, Sweden, Switzerland do not provide R&D tax incentive. Mexico and New Zealand repealed their R&D tax incentive on 2009 and 2009-10 respectively. Finland is setting up the conditions for introducing a R&D tax incentive scheme for companies

In Austria, Poland and South Africa, R&D tax incentive support is already included in official estimates of direct government-funding of business R&D (OECD, 2013h). Iceland, Israel and Greece provide R&D tax concession but the cost estimate of R&D tax relief is not available and therefore not included in the total.

For Chile, China and the Russian Federation, R&D tax estimates are available only for 2010, 2009 and 2011 respectively. The same year for 2006 and 2011 is thus represented on the above figure.

More recent cost estimates of R&D tax concession are available from the April 2013 NESTI data collection but were not accessible at the time of drafting this chapter. For more technical information about R&D tax data coverage, please see the OECD Directorate for Science, Technology and Industry webpage on Measuring R&D tax incentives at <www.oecd.org/sti/rd-tax-stats.htm>.


146. As R&D tax incentives have increasingly been substituting direct subsidies, their relative cost-efficiency must be questioned. Despite the large amounts of public money provided, few evaluations have recently assessed the additionality of R&D tax incentives (Köler, Laredo and Rammer, 2012), and no internationally comparable data exist on the management costs incurred by tax authorities and claimants. More broadly, increasing tax concessions (of all kinds) raise the issue of tax base erosion and sustainability of national budgets at a time when many governments are required to consolidate public finance. It is noteworthy that, in recent years, some countries that were traditionally among the most generous in tax concession for R&D have tightened their tax policy (Australia and to a lesser extent France) and have reinforced compliance and control mechanisms (Canada). The Australian Government has changed legislation to exclude very large companies from claiming tax offsets under the R&D Tax Incentive and a R&D Tax Incentive Advisory Committee was established to monitor the implementation of the R&D Tax Incentive. The Canada Revenue Agency is receiving more resources to strengthen reviews of its R&D tax programme. In France, the R&D tax credit (Crédit d’impôt Recherche) has been revised by marginally reducing the eligible expenditure-base and repealing enhanced deductibility for new claimant firms.

**Blurring frontiers between industry and services, technology and innovation**

147. Innovation is more than science and technology. While R&D remains vitally important, many highly innovative firms do not engage in R&D at all (OECD, 2010d). Technological innovation does not systemically require R&D to be performed either. Innovation survey data show that most innovative firms tend to adopt mixed innovation strategies, combining multiple modes of innovations (Figure 1.21.). In addition, non-technological innovation, i.e. marketing\(^{19}\) and organisational changes in business practices, workplace organisation or external relations, combined with technological innovations, account for a substantial share of firms’ innovative activities. Non-technological innovation is of particular importance in services (OECD, 2013h).

---

\(^{19}\) The marketing mix focusses on so-called 4Ps: Product (design or packaging), product Placement, product Promotion and product Pricing.
The growing importance of the service sector in OECD economies and its role in job creation and innovation activities have been widely documented as services have been increasingly acknowledged as more knowledge-based, innovative and drivers of growth than previously expected (OECD, 2005). At the same time, this structural shift has in some OECD economies led to resource reallocation towards a sector with a lower average productivity performance.
149. More recently, the focus towards services has changed—services are increasingly considered to be fundamental inputs and outputs of innovation processes taking place in non-service sectors. Statistics in Trade in Value-Added (TiVA) show that in most OECD and non-OECD countries, over a third of manufacturing exports include value added from service industries, domestic or not (Figure 1.22). This provides an indication of the importance of services for export competitiveness in manufacturing. Knowledge-intensive services, including R&D services, are now part of wider business strategies and participate in the fragmentation of production along GVCs. In addition the boundaries between sectors have blurred as manufacturing firms have increasingly exploited new market opportunities by bundling experience, products and finance and expanding to related services. Service innovation has become a driver of competitiveness along the entire value chain.

**Policy trends**

150. The non-technological dimension of innovation and the potential offered by service innovation calls into question existing policy frameworks, which have been designed from a mainly technological or manufacturing perspective that tend to neglect the specificities of services. However, there is still little evidence on service-specific market and systems failures and the rationale for service-specific policies. There is also a limited understanding of the role of services and the policies needed to foster the ir development. As a consequence few countries have paid particular attention to services in national innovation policies design.

151. A number of policy areas have been identified in the past with the aim to enhance innovation in the service sector (OECD, 2005). They include policies for skills development given the high reliance of services on highly skilled workers, entrepreneurship programmes because newly established firms tend to play a greater role in services than manufacturing, IPR protection especially as related to software and business-method patents and ICT development as a key enabler of service innovation. Standards are also
seen as a means to promote innovation in services because they improve interoperability and compatibility among various components used in services development. They lower transaction costs, increase market transparency and consumer confidence and enable deregulation.

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

**Innovative entrepreneurship**

153. Taking a broader perspective of innovation, new firm creation and innovation in existing SMEs play an important role in innovation performance, as they contribute to the creation of a multitude of new products and services in all sectors (OECD, 2013p). Non-technological innovation that requires less knowledge capital and investments, changing technologies, more “niche market” demand, and the rise of GVCs, have reduced the structural disadvantages of small-sized firms (SMEs).

154. A distinction has to be made between new innovative firms and SMEs. While new innovative firms are knowledge intensive, high-risk and high-ambitions firms that can have a disproportionate effect on innovation and job creation, the bulk of SMEs may have a more modest economic impact individually, but collectively they make a substantial difference. Evidence for different countries suggests that around 4-6% of high-growth firms might produce up to half to three-quarters of all new jobs (OECD, 2013p).

155. There are significant constraints on SME innovation performance and the process of starting and growing businesses. SMEs experience specific problems in accessing finance and qualified personnel (OECD, 2013p). In addition, young firms are more sensitive to entrepreneurship framework conditions than older firms (OECD, 2013r) Business growth calls for instance for high-level management skills to cope with disruptive processes in organisation (OECD, 2013s).

156. The financial obstacle is particularly critical at seed and early stages of development, when banks are reluctant to lend to small and young firms as they can offer little or no collateral. In addition venture capitalists focus more and more on later investment stages where risks are lower (OECD, 2011e). Angel investors have therefore become increasingly an important source of equity capital at the seed stage and play a key role in providing strategic and operational expertise and social capital (i.e. personal networks). The angel investment sector is growing, and is becoming more formalised and organised through the creation of angel groups and networks (OECD, 2011e).

157. During 2007-2010 SMEs faced more severe credit conditions than large enterprises in the form of higher interest rates, shortened maturities and higher collateral (OECD, 2013q). After a slight improvement in 2010, credit conditions tightened in most countries in 2011. SMEs survey data on access to finance also

---

20 In all countries most business are micro-enterprises, i.e. firms with less than ten persons employed (entrepreneurship at a glance). Micro-enterprises account for 70% to 95% of all firms and SME, as defined as firms employing less than 250 employees, for 99% of the total.
show deterioration in SME’s perception about banks’ propensity to lend (ECB, 2013). Increases in payment delays and bankruptcies over the same period reflect SME’s difficulties to maintain cash flows (OECD, 2013p). Equity financing was also severely affected and the uncertain economic climate continued to drag down equity investment. In 2011 the level of equity investments was still well below pre-2007 levels in many countries (OECD, 2013p). In addition, although angel investors tend to be less sensitive to market cycles than venture capitalists, the financial crisis widened the existing gap at the seed and early stage of investments (OECD, 2011e).

158. A significant degree of uncertainty continues to characterise the financial environment at the time of drafting STI Outlook 2014. Concerns about public debt sustainability, structural weaknesses of the banking sector in the euro area, the sovereign debt issue in some countries and Basel III reforms²¹ could lead to further deleveraging by banks. This can further deteriorate lending activities and increase the risk of a credit crunch for small businesses (OECD, 2013q).

159. In this context of resources constraints, new sources of finance, such as peer-to-peer (P2P) lending, crowd funding and IP, backed equity funds are promising, but remain marginal²². P2P lending, whereby individuals lend to each other via websites, has been growing in the United States, China, Germany and the United Kingdom (Wehinger, 2012). Many of these lending websites which offer higher returns to investors as the loans are sold in slices are now becoming more active in lending to SMEs (ibid). Anectodal evidence have shown an explosive growth in the number of crowd funding platforms and the amount of funds committed by this means for a relatively short time over the past five years (Ham, 2013). This alternative funding mechanism has far-reaching potential, for instance to accelerate technology transfer from universities. Initiatives around the regulation and institutionalisation of crowd funding can be observed worldwide (ibid). Some challenges, however, remain. Crowdfunding raises issues of security on the cyberspace and in money transactions, it calls into question the true motivation of platforms managers and it suffers a lack of mentoring and coaching for non-professional investors who may be unfamiliar with sophisticated risk-and-return analysis and decision-making tools.

Policy trends

160. An untapped abundant and growing source of funding for innovation is private wealth. Tax policies could provide the incentives for wealthy individuals or private wealth funds to invest in innovative start-ups. Sovereign Wealth Funds in the Middle East Asia are also investing in innovative ventures.

²¹ Basel capital accords are capital adequacy standards that are formulated by the Basel Committee on Bank Supervision (BCBS). National regulators usually implement the standards to regulate the bank capital and to ensure health in the banking system. The objectives are to strengthen the soundness and stability of the international banking system and to diminish sources of competitive inequality among international banks. By now there are three accords published, improving upon the previous one: Basel I, Basel II, Basel III. Source: OECD glossary of statistical terms accessible online <http://stats.oecd.org/glossary/detail.asp?ID=6194> retrieved on 26.01.2014.

²² Total funds leveraged by crowdfunding were estimated at roughly USD 1.5 billion globally in 2011 (Ham, 2013).
Much policy attention has focused in recent years to improve access to finance for entrepreneurs, while the skills barriers in SMEs have received less attention (OECD, 2013q). Most popular interventions have been credit loan guarantee programmes to promote new lending by banks to SMEs and venture capital programmes. Governments are also considering measures to promote the wider use of hybrid instruments, combining features of debt and equity, such as mezzanine finance\(^{23}\), to supply “growth capital” to SMEs and entrepreneurs (OECD, forthcoming).

Governments are playing a more active role in helping the transition towards increased non-bank intermediation (e.g. insurance companies, hedge funds). Insurance companies and pension funds, albeit major players, would not be able to fill the lending gap by bank deleveraging and therefore other non-bank entities are needed (Wehinger, 2012). The US JOBS Act recently legalised crowd funding for start-ups that can now raise up to USD 1 million per year from small investments online and through social media (ibid).

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

**Collaboration and agglomeration in innovation**

Increased openness is not specific to science. In a complex and highly competitive global market, companies have to adopt new approaches to innovation and enter new modes of collaboration. While firms traditionally seek to retain their core capabilities, open innovation may be a faster and less risky alternative to internal development to diversify. The balance is shifting between internal and external sources of innovation and innovative activities are increasingly organised across firm boundaries (OECD, 2008d). Moreover, corporate venturing has become a major channel to commercialise innovations that are not used internally (divestments, spinning out, spinning off).

Collaboration has become an important element in the strategies of innovative SMEs to overcome some of their size-related barriers, including limited funding, the lack of skills and inadequate time horizons to invest in a long-term strategy. New firms and SMEs are involved in collaboration with suppliers and customers, but also with universities and research organisations (OECD, 2010e).

**Policy trends**

The policy debate around the legitimacy of industrial policy has recently resurfaced. Policy interest in a new generation of industrial policies arises from various trends mentioned throughout this chapter. To name just a few: 1) the loss of productivity associated with the decline in manufacturing and structural shift towards services in OECD countries; 2) the growing fragmentation of production across GVCs and a recent erosion of OECD countries’ positions in higher value GVC segments; 3) the potential

---

\(^{23}\) A typical mezzanine facility combines several financing instruments of varying degrees of risk and return, such as subordinated debt, profit participation certificates and equity warrants (OECD, forthcoming). It is cheaper than equity finance, resulting in lower financing costs, and diminishes the dilution of control for founding entrepreneurs.
erosion of downstream and upstream activities in the value chain—including activities related to innovation and design following the loss of core manufacturing activities; and 4) more focus by large emerging economies on STI, often supported by substantial public endowment. The crisis has accelerated these trends, as it highlighted the need for countries to find new sources of growth (Warwick, 2013).

167. Governments are reconsidering the need to encourage the emergence or expansion of new industries that would become nodes in global innovation networks. As competition for talent and resources have increased while finance remains limited, governments have refocused policy action on priority areas with high potential for spillovers. In addition to the Industry Innovation Precincts mentioned above, the Australian government committed to support transition to a new era of manufacturing and to assist the transformation from heavy industrial manufacturing to higher value-added production. Canada place the highest policy priority on strengthening the competitiveness of its manufacturing sector, in particular the aerospace and shipbuilding industries. USD 1.1 billion (CAD 1.4 billion) tax relief will be provided to manufacturing and processing sectors over 2014-15. Around USD 800 million (CAD 1 billion) will be allocated to the Strategic Aerospace and Defence Initiative in the form of stable funding over five years. Denmark is preparing eight growth plans in areas of international competitiveness, including creative industries, health and care, energy-water-environment, food, ICT and tourism, to further enhance competitiveness in these areas. France adopted a new industrial policy based on 34 industrial plans, including energy, environment, in digital technologies. Germany’s High-Tech Strategy 2020 defines five fields of action (Climate/energy, health/nutrition, mobility, security and communication) and focuses on missions such as Industry 4.0. The United Kingdom has adopted a whole-of-government approach to build strategic partnerships with industry to support key technologies and to implement its new Industrial Strategy. The most significant initiatives are in aerospace, automotive and agri-industry. The United States is establishing the foundations for its “industries of the future”.

168. Infringement to intellectual property (IP) is seen as an important risk24 to global innovation networks. Although it often involves strong IP protection, open innovation may also increase the risk of IP leakage and involuntary spillovers. This can in turn reduce the ability of firms to fully benefit from their innovative activities. Several governments recently implemented reforms to improve national IP systems. Chile, Germany and Australia adopted changes in their IP and patent legislation. Canada launched the “Modernizing the IP Community” initiative in 2013 to review how the Canadian Intellectual Property Office (CIPO) and other relevant IP agents collaborate to support the needs of Canadian businesses. The first Norwegian White Paper on Intellectual Property Rights was also introduced 2013. The UK reformed the Patents County Court of England and Wales to ensure access to justice as a fair cost for all rights holders and other businesses, and renamed it the Intellectual Property Enterprise Court to clarify its jurisdiction. Furthermore, the Intellectual Property Office (IPO) of the United Kingdom launched an operationally independent Police Intellectual Property Crime Unit (PIPCU) in 2013.

169. Several countries (e.g. Belgium, China, Netherlands and the United Kingdom) have implemented tax relief on intellectual property (IP) revenues to encourage the commercialisation and exploitation of new technologies domestically and to better appropriate the full benefits of IPRs exploitation, including job creation and knowledge spillovers. As large multinationals develop global tax optimisation strategies and

24 Other potential drawbacks are transaction costs and dependency.
the production of knowledge is increasingly decoupled from its use, some governments have implemented tax strategies combined with R&D tax incentives with so-called ‘patent boxes’ to encourage collocation of R&D and manufacturing activities. Since 2013 the UK government has spent USD 1.3 billion PPP annually for its patent box, in addition to USD 1.2 billion PPP foregone through its R&D relief for corporation tax. The patent box issue has also been introduced in policy discussions in Sweden (see policy profile on tax incentives for R&D and innovation).

Public R&D is targeting excellence and openness

The science base is increasingly implemented in universities

170. Government and higher education sectors account for less than a third of R&D performed in OECD countries (30% of OECD total in 2012) (OECD, 2014c). In 2012, universities and PRIs spent USD 330 billion on R&D, with the United States accounting for 36%, Japan25 10% and the EU28 comprising 38% of the OECD total. Universities are the main actors of OECD public research, spending USD 201 billion R&D, compared to public labs spending USD 129 billion. China’s universities and PRIs spent USD 241 billion in 2011, mainly by public labs (USD 201 million).

Figure 1.23. The science base is expanded by universities

Panel 1. Higher education R&D expenditure (HERD) by largest performers, million USD 2005 PPPs, 2002-12

Panel 2. Government R&D expenditure (GOVERD) by largest performers, million USD 2005 PPPs, 2002-12

Note: The EU28 is an OECD estimate.

Source: OECD, MSTI Database, January 2014.

25 Data for Japan are for 2011 instead of 2012.
In the decade since 2002, the growth of the science base in the United States and the EU has been driven by universities that maintained a robust increase in their expenditure. Over time there has also been a shift towards university-based research across the OECD (OECD, 2013). In China, the growth of scientific activity has been driven by the PRIs, in particular by large spending by the Chinese Academy of Sciences. Structural differences in public research systems are notable across countries (Figure 1.24.). Korea or China have a public research system built on public labs, while in Denmark, Israel and Switzerland public research is based on universities (OECD, 2010c). The Russian Federation is currently restructuring its system in order to move closer to a university-based system.

**Figure 1.24. Public R&D expenditure by archetype of research system**

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

Notes: Countries differ regarding the extent to which their innovation systems are public-research centred or firm-centred, measured by the share of business in total R&D expenditure [...] The extent to which countries’ public research system is public lab-centred or university-centred plays a role [...] Actions taken [...] to enhance the contribution of public research are influenced by the country’s position in this respect (STIO10).

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

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

Source: OECD, MISTI database, January 2014.

With the exception of only a handful of countries (Canada, Hungary, Iceland, Israel and United Kingdom), both HERD and GOVERD as a percentage of GDP have consistently increased despite the
crisis, showing resilience and a public commitment to R&D (Figure 1.24). Largest increases have been observed in the Czech Republic, Estonia and Luxembourg.

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

173. Modern science is increasingly data-driven, calling for new forms of collaboration and broader knowledge and resources sharing. Universities and PRIs have strengthened knowledge and co-operation linkages with their counterparts worldwide to achieve economies of scale and increase the visibility of domestic research. Publication data show that international collaboration between research institutions has intensified over the past decade and that China, as well as several other economies, has become increasingly integrated in the global science system (Figure 1.25).

174. The shift towards a greater openness in science relies on the basic postulation that publicly-funded research is a public good. Although the issue of who should fund its diffusion and publication has not been resolved, such a shift has been supported by governments and scientific communities in search for improved efficiency (including less duplication) and faster knowledge spillovers to industry and the economy (OECD, 2013u). Open science also creates specific opportunities for emerging countries, as it could facilitate faster integration into world-wide scientific networks (OECD, 2013v) and facilitate international co-operation to address global challenges.

**Figure 1.25. International collaboration networks in science**

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

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

Governments have a key role to play to encourage open science and new ways of doing research. Although ICT development has largely supported openness in science, far more is at stake than access to IT infrastructures or skills availability to use these infrastructures. Open science requires new approaches to public research funding, the process of undertaking research, the valorisation of research output, the access, protection and IPRs of research results, and the interaction between science and society (OECD, 2013u) (see policy profile on open science).

Research of excellence requires new forms of funding

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

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

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

From a sample of 19 countries plus the European Commission (Seventh Framework Programme) that participated in the second OECD data collection on modes of public funding of R&D based on GBAORD, covering the period 2009 to 2011, and launched in November 2012.
Transfer of public research results would require further professionalisation and strengthening of business culture in commercialisation activities

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

180. In this area, lacklustre performance of academic patenting, licensing and spin-offs have prompted OECD countries to experiment and develop new policies and instruments to exploit, transfer and commercialise public research. First, governments and institutions have revised their approach towards intellectual property (IP) protection and IP sharing, e.g. in providing licenses free of charge, proposing a preferential access to “sleeping” patents, or requiring publication in digital format and providing open research data repositories. Overall, IP, although its importance is still recognised, is not seen any more as the main vehicle for commercialisation. Second, they have further involved students and researchers in the commercialisation process, e.g. by allowing faculty members to suspend their tenure for commercialisation activities; by taking into account their commercial experience; in better linking teaching, research and commercialisation, or in mentoring student start-ups. Third, they have restructured and regrouped technology transfer offices (TTOs), e.g. into regional centres, and foster the adoption of more effective business models. The aim is to increase the skills of the staff and strengthen their incentives. Last but not least, financing have focused on universities and PRIs that, in some cases, have established their own gap funding schemes to address the financing issue. Overall, governments are aiming to strengthen the business culture in commercialisation activities which have been often dominated to date by more administrative approaches: the issue is not only to file patents, but to commercialise them, not only to create spin-offs but to grow them etc.
CONCLUSION: THE FUTURE OF STI POLICIES

181. Research and innovation policy will remain a key field of public action in support of sustainable and inclusive growth in the coming years. Education, research and innovation (the “knowledge triangle”) should remain high on the policy agenda. However, fiscal consolidation weighs on the capacity of governments’ to maintain their financial commitment. Public R&D budgets have started levelling or receding in many OECD countries.

182. Innovation and technology are now expected to help restore competitiveness, boost productivity, upgrade industrial structure and address global challenges. The rise of GVCs, the search for new sources of growth and the challenges raised by environmental and social issues have introduced new objectives and instruments for policy intervention. Recent interest in systems innovation illustrates a shift in the policy paradigm of certain countries towards more resilient, equitable and sustainable innovation policies, connected with large-scale socio-economic transformations. Such expectations can have profound implications for the policy mix and governance arrangements.

183. More countries are now explicitly targeting most of their research, towards competitiveness and environmental and social challenges, while basic (untargeted) research is strictly fitted in an “excellence” framework (meaning high selectivity). In this context also broader and denser links between public and private actors are developing, beyond the traditional IP and incubators, with the view to exploit more fully the potential synergies between the two sectors.

184. As a consequence of this broadened scope of STI policy, STI matters are now managed by ministries and departments that are in charge of economic, competitiveness and employment affairs, or dedicated to global challenges (e.g. environment and social issues). The greening of STI policies is particularly noticeable, as technology and innovation are increasingly seen as ways to mitigate climate change (OECD, 2010c).

185. STI policy has also increased in complexity. A larger toolbox of STI policy instruments and the involvement of new actors in innovation policy design and delivery are making the policy landscape even more complex. This raises issues around multi-level governance. The “silo” approach that has underpinned STI policy developments so far, caused by thematic and vertical segmentation, is being questioned. Significant efforts are made to integrate more STI policies performed at different levels (regional, national, supra-national) and in different fields (research, industrial innovation etc.). Evaluation plays a key role as an instrument for public authorities to monitor policy developments in an integrated fashion. Innovation policies now require a ‘whole-of-government’ approach.

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


DSTI/STP(2014)2


OECD (2010e), *SMEs, Entrepreneurship and Innovation*, OECD Studies on SMEs and Entrepreneurship, OECD, Paris.


OECD (2012g), *OECD Internet Economy Outlook 2012*, OECD, Paris, 
[http://dx.doi.org/10.1787/9789264086463-en](http://dx.doi.org/10.1787/9789264086463-en)


OECD (2014c), *Main Science and Technology Indicators Database*, January.


