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Luxembourg

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LUXEMBOURG

Luxembourg is a small open economy with one of the world's highest income per capita. In recent years, the government has invested heavily in building an advanced science base, virtually from scratch, and is now looking to consolidate these investments, with a strong focus on the efficiency and effectiveness of the science base and the roles it can play in supporting national innovation performance and structural change of the Luxembourg economy.

Hot issue 1: Strengthening public R&D capacity and infrastructure. The government's R&D budget has continued to increase, with total government budget appropriations or outlays for R&D (GBAORD) climbing from USD 72 million (EUR 60 million) in 2004 to USD 318 million (EUR 264 million) in 2013 (Panel 2). The number of researchers in the public sector has also grown substantially (Panel 3). These large increases reflect the government's intention to expand the research system in order to develop and diversify the economy. The rate of budget increase has slowed markedly in the last couple of years, however, a trend that can be expected to continue as the research system enters a phase of consolidation. Two draft laws, currently under consideration by the legislature, aim to further strengthen and harmonise the research system. One law focuses on reforms of Luxembourg's only research council, the *Fonds National de la Recherche* (FNR) to allow it to fund research in a wider variety of types of organisations. The second proposes modifications to the public research institutes, the *Centres de Recherche Public* (CRPs), specifically the merger of CRP-Gabriel Lippmann and CRP-Henri Tudor and the incorporation of the Integrated BioBank into CRP-Santé. An ambitious infrastructure project, the *Cité des Sciences, de la Recherche et de l'Innovation* at Belval, will group most of Luxembourg's public research (the University of Luxembourg and CRPs) in one campus by 2015, with facilities for public-private partnerships and an incubator for start-ups. Ultimately, the campus will have 7 000 students and 3 000 teaching staff and researchers.

Hot issue 2: Targeting priority areas/sectors. With only a few thousand scientists across the public and private sectors (Panel 3), Luxembourg has to focus on areas in which it can have international impact. The FNR therefore continues to concentrate much of its funding on a limited number of pri-

ority domains identified in an earlier foresight exercise. The priorities of the university, an increasingly important player in the system (Panel 4), are also important in shaping national priorities. They include systems biomedicine and security and reliability of ICT systems, which already have relatively large interdisciplinary centres. Other university priorities are international finance and European and business law, which relate to Luxembourg's role as host of financial institutions, corporate headquarters and European institutions. The government also has special action plans on logistics, health care and sustainable development.

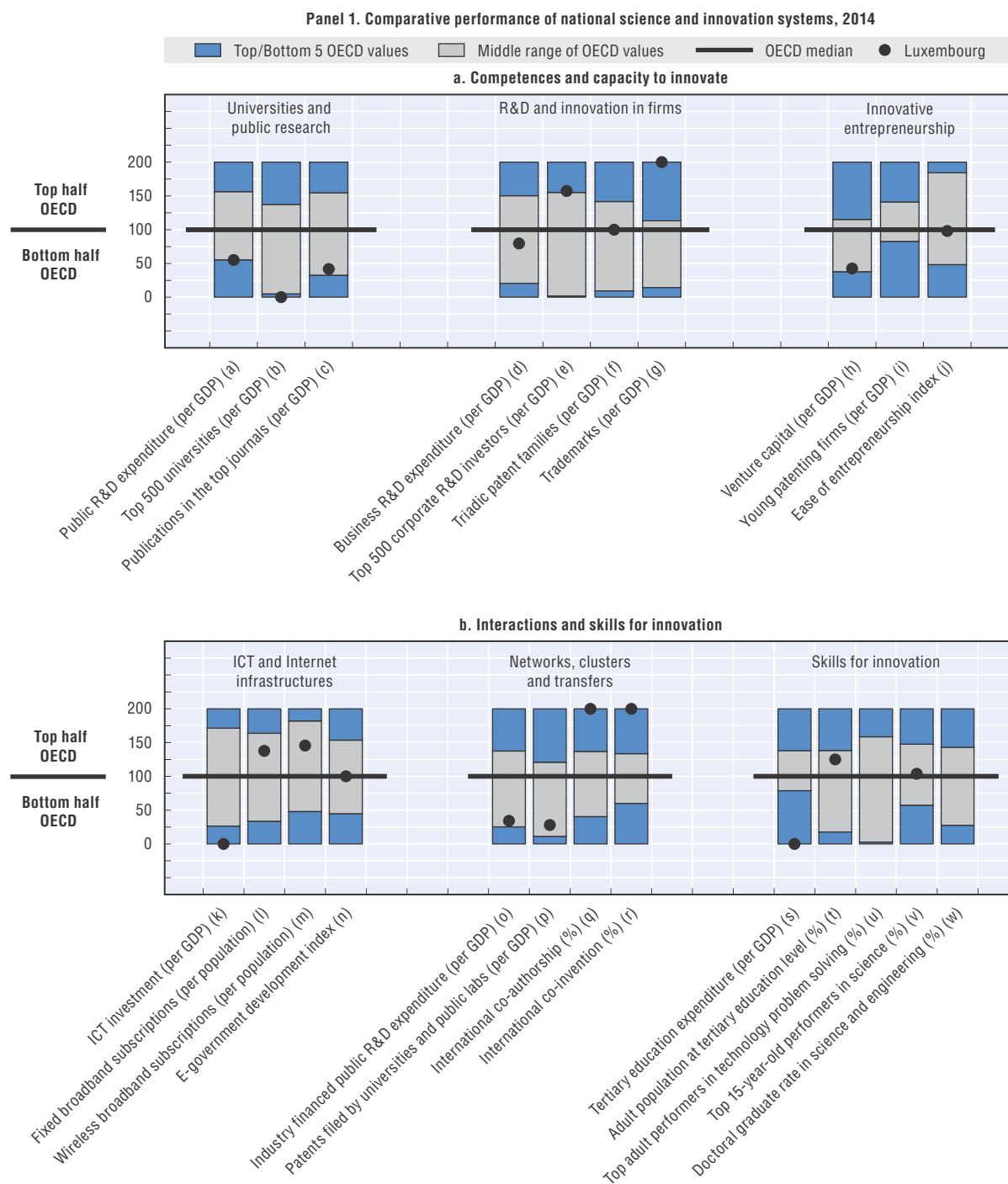
Hot issue 3: Improving overall human resources, skills and capacity building. The proportion of the adult population with tertiary-level education is above the OECD median (Panel 1^t). However, there is widespread perception that young people are not very interested in scientific careers. Measures such as *Go for Science* and *ProScience* seek to raise awareness of science among young people and to attract them to scientific careers. The FNR's *Aides à la Formation-Recherche* (AFR) programme aims to make scientific careers more attractive by offering better work contracts, working conditions and training opportunities to PhD and postdoctoral students. The government is considering professionalising the doctorate by setting up a series of doctoral schools to improve the professional skills of doctorate candidates in the coming years. The FNR also provides institutions with funding to attract high-level senior researchers and exceptional young researchers from abroad.

Hot issue 4: Improving returns and impact of science. Public research funding is tied to performance contracts between the government and research performers (the CRPs and the university) and the funding agency FNR as well as the innovation promotion agency Luxinnovation. For research performers, numbers of publications, doctorates, patents and spin-offs are among the main indicators used, along with targets for securing external funding. Regular evaluations of departments have also been introduced. New measures to support exploitation of research include the joint evaluation of thematic research project proposals by FNR and Luxinnovation and FNR's Proof of Concept pilot programme,

Key figures, 2013

Economic and environmental performance	LUX	OECD	Gross domestic expenditure on R&D	LUX	OECD
Labour productivity			GERD		
GDP per hour worked, USD PPP, 2013	85.1	47.7	Million USD PPP, 2012	692	1 107 398
(annual growth rate, 2008-13)	(-0.8)	(+0.8)	As a % of total OECD, 2012	0.1	100
Green productivity			GERD intensity and growth		
GDP per unit of CO ₂ emitted, USD, 2011	3.4	3.0	As a % of GDP, 2012	1.46	2.40
(annual growth rate, 2007-11)	(+3.2)	(+1.8)	(annual growth rate, 2007-12)	(-1.9)	(+2.0)
Green demand			GERD publicly financed		
NNI per unit of CO ₂ emitted, USD, 2011	2.3	3.0	As a % of GDP, 2011	0.44	0.77
(annual growth rate, 2007-11)	(-0.5)	(+1.6)	(annual growth rate, 2007-12)	(+8.5)	(+2.8)

Figure 9.29. Science and innovation in Luxembourg



which supports excellent research projects that seek to attract potential investors.

Highlights of the Luxembourg STI system

Innovation in firms: Relative to its size, Luxembourg hosts the headquarters of the largest number of top corporate R&D investors among OECD countries (Panel 1^e). It files more trademarks (Panel 1^g) than triadic patents (Panel 1^f). Business is the largest performer of R&D (Panel 4), although BERD has fallen since the financial crisis and has yet to recover (Panel 5). The reasons for the decline are currently under investigation. A law on state aid for R&D, implemented in 2009, extended the scope of policy intervention. Measures include special subsidies for SMEs and innovative start-ups and schemes to promote knowledge flows between academia and industry.

Innovative entrepreneurship: Luxinnovation is the main agency supporting innovative entrepreneurship, chiefly through advisory services, network building and information campaigns. Luxembourg has recently consolidated its various incubator structures in a single entity, Technoport S.A., whose mission is to facilitate the setup of start-ups and spin-offs. It offers a new physical incubator at the *Cité des Sciences, de la Recherche et de l'Innovation*, and aims to become an important relay between the university, the CRPs and the wider economy. It can also provide temporary premises for foreign companies planning to begin operations in Luxembourg. The installation of a fabrication laboratory has increased the diversity of the facilities. In addition, work has started on creating two new incubators in areas deemed national priorities, health technology and eco-technology.

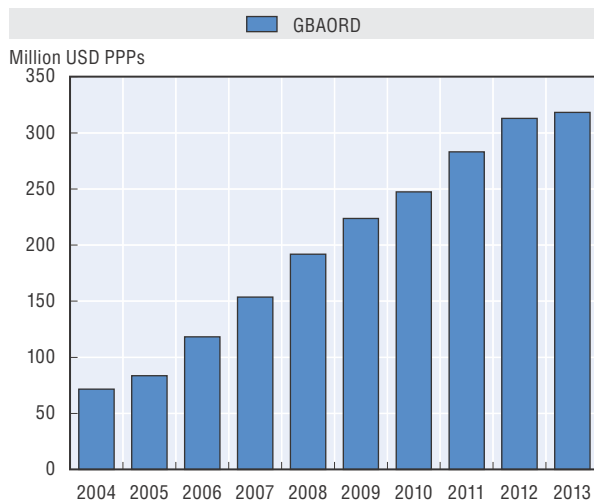
Globalisation: Luxembourg has made international research co-operation a priority, and this is reflected in high shares of international co-authorship (Panel 1^q) and international co-invention (Panel 1^r). The government places consider-

able emphasis on strong participation in the EU's Horizon 2020, particularly as levels of national funding are set to stabilise over the next few years. It has also signed many bilateral agreements. Over 2011-13, bilateral programmes of the FNR and foreign funding agencies supported 33 projects with funding of USD 13.3 million (EUR 11 million).

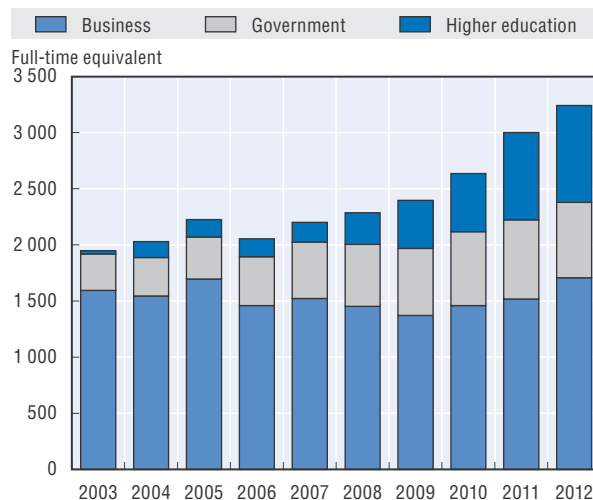
Clusters and smart specialisation: The Luxembourg Cluster Initiative has six theme-based clusters: materials, ICTs, aeronautics and space, health care and biotechnology, eco-innovation, and automotive components. In 2013, the clusters, in collaboration with the Ministry of the Economy, set up a new working framework based on five priority areas: business development, supporting flagship projects, improving brand image for the sector, intensifying promotion and prospecting, and developing the internationalisation of the initiative. Specific quantitative objectives have been set for each cluster.

ICT and Internet infrastructures: The national ICT infrastructure is well developed (Panel 1^{l, m}), an important location factor for many leading international ICT companies. ICT expertise underpins the sustainable development of the financial, media, environment, logistics, automotive and space industries, all of which are important in Luxembourg. The financial sector, for example, depends strongly on the fact that Luxembourg has become one of Europe's top locations for ICT infrastructures (e.g. in terms of data centres and low latency network connectivity) and offers specialised expertise to keep firms' data safe. Luxembourg is also investing heavily in ICT research in order to build scientific excellence. For example, the Interdisciplinary Centre for Security, Reliability and Trust at the University of Luxembourg aims to put the country on the world map in terms of high-quality research in secure, reliable and trustworthy ICT systems and services.

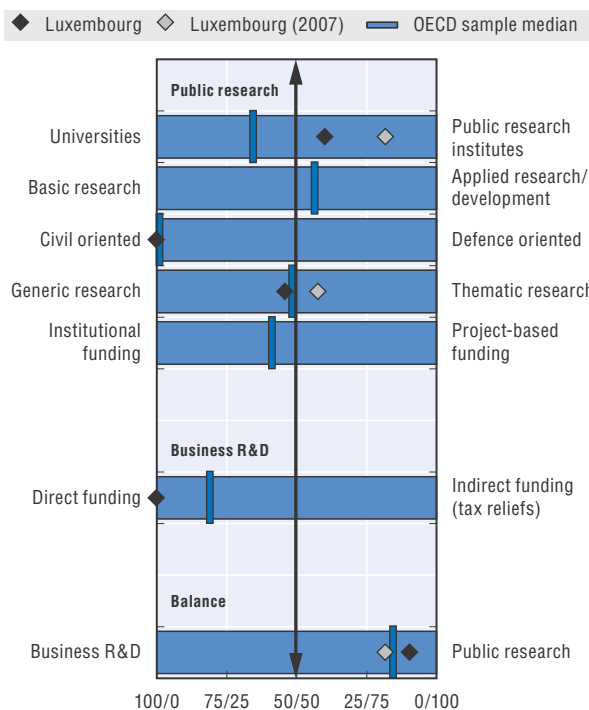
Panel 2. Total government budget appropriations or outlays for R&D (GBAORD), 2004-13



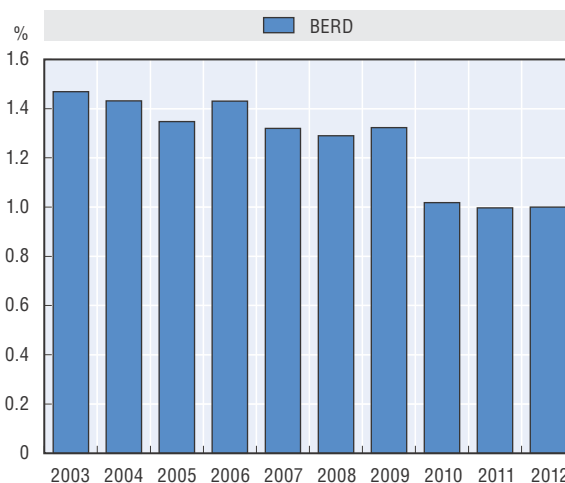
Panel 3. Number of researchers by sector of employment, 2003-12
Full-time equivalents



Panel 4. Allocation of public funds to R&D, by sector, type and mode of funding, 2012



Panel 5. BERD intensity, 2003-12
As a percentage of GDP



Note: Policy information comes from country responses to the OECD STI Outlook policy questionnaires 2012, and OECD Innovation Review of Luxembourg (2015, forthcoming).

Source: See reader's guide and methodological annex.

StatLink <http://dx.doi.org/10.1787/888933152299>

STI country profiles reader's guide

The country profiles (CPs) in the 2014 *OECD STI Outlook* (STIO) are designed to provide a concise overview of science, technology and innovation (STI) policy and performance in OECD members and selected non-OECD economies. Each country profile is based on information gathered from the country's response to the OECD STIO policy questionnaires 2012 and 2014, as well as various additional OECD and non-OECD sources.

Headings in the country profiles are linked to the STIO policy profiles, which examine the main global STI policy trends across countries. Issues featuring in both the policy and country profiles are: i) innovation policy governance; ii) new sources of growth; iii) new challenges; iv) universities and public research; v) innovation in firms; vi) innovative entrepreneurship; vii) technology transfer and commercialisation; viii) clusters and smart specialisation; ix) globalisation; and x) skills for innovation.

The table of key figures presents indicators on the country's economic performance (labour productivity), environmental performance (green productivity and demand), the size of its R&D system as measured by gross domestic expenditure on R&D (GERD), the degree of public commitment to S&T as measured by the share of GERD that is publicly financed, and the changes in these indicators over the past five years. In the text, all amounts are given both in USD in purchasing power parities (PPP) of the relevant year (if available) and in national currencies.

Panel 1 contains a double figure that sheds light on the strengths and weaknesses of the country's STI performance. It uses indicators on the country's national innovation system and performance with respect to: universities and public research, business R&D and innovation, innovative entrepreneurship, information and communication technology (ICT) and Internet infrastructure, networks, clusters and transfers, and skills for innovation. The dot for each indicator positions the country relative to the OECD median and to the top and bottom five OECD countries. Non-OECD countries are also compared to the OECD benchmarks, and may fall out of the range indicated in the figure (e.g. below the lowest OECD country). All indicators are normalised (by GDP and population cohorts) to take account of the size of the economy and the relevant population cohorts, and are presented as indices (OECD median = 100) for benchmarking purposes.

Panel 2 shows the structural composition of business expenditure on R&D (BERD) in terms of performance of the main industry sectors, firm size and firms' national affiliation. It reflects the country's industry structure and its business innovation efforts. Panel 3 presents the country's revealed technological advantage (RTA), as measured by international patent applications filed under the Patent Cooperation Treaty (PCT) in three key technology fields (bio- and nano-technology, ICTs, and environment-related technologies). It also shows the number of patents filed by universities and public research institutions in these fields.

Panel 4 gives an overview of the country's policy mix for public R&D, i.e. the orientation and funding modes of public research. It also illustrates changes in the policy mix for R&D over the past five years. Finally, Panel 5, a new feature in STIO 2014, reflects the balance and relative importance of various government measures to support business R&D and innovation. It is based on the country's self-assessment in its reply to the OECD STIO 2014 policy questionnaire.

Further details on the methodology, data sources and descriptions of indicators used in the country profile are provided in Annex 9.A. Data, metadata as well as the original sources and databases of the indicators used in the STIO 2014 are accessible at the statistical portal IPP.Stat (cut-off date: 8 July 2014).

Abbreviations used in the country profiles

BERD:	Business expenditure on research and development
EU:	European Union
FDI:	Foreign direct investment
GDP:	Gross domestic product
GERD:	Gross expenditure on research and development
HEIs:	Higher education institutions
IPRs:	Intellectual property rights
MNEs:	Multinational enterprises
PRIs:	Public research institutes
R&D:	Research and development
S&E:	Science and engineering
SSS:	Smart specialisation strategy (also known as 3S)
STI:	Science, technology and innovation
S&T:	Science and technology
3S:	See SSS
STEM:	Science, technology, engineering and mathematics
USD:	United States dollars (converted using the purchasing power parities of the relevant year)
VC:	Venture capital

Synthetic table

Table 9.1. Comparative performance of national science and innovation systems, 2014

Country relative position: in the top 5 OECD or above (★), in the middle range on par or above OECD median (▲), in the middle range below OECD median (△) and in the bottom 5 OECD or below (○)

		Competences and capacity to innovate									
		Universities and public research			R&D and innovation in firms				Innovative entrepreneurship		
		Public R&D expenditure (per GDP)	Top 500 universities (per GDP)	Publications in the top-quartile journals (per GDP)	Business R&D expenditure (per GDP)	Top 500 corporate R&D investors (per GDP)	Triadic patent families (per GDP)	Trademarks (per GDP)	Venture capital (per GDP)	Young patenting firms (per GDP)	Ease of entrepreneurship index
		PUB_XGDP	UNI500_GDP	PUB25_GDP	BE_XGDP	CORPRD500_GDP	PTRIAD_GDP	TRDMRK_GDP	VC_XGDP	PTYG_GDP	EASE_I
		(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
Argentina	ARG	△	△	○	○	○	○	○			
Australia	AUS	▲	▲	▲	▲	△	△	▲	△		▲
Austria	AUT	▲	★	▲	▲	▲	▲	△	△	★	▲
Belgium	BEL	△	▲	▲	▲	△	▲	△	▲	△	△
Brazil	BRA		△	○		△	○	○			△
Canada	CAN	▲	▲	▲	△	△	▲	★	★	○	▲
Chile	CHL	○	△	○	○	○	○	△			△
China	CHN	△	△	○	▲	△	△	○			○
Colombia	COL	○	○	○	○						
Costa Rica	CRI	○	○	○	○	○					
Czech Republic	CZE	▲	△	△	△	△	△	△	○		△
Denmark	DNK	★	▲	★	▲	★	▲	▲	▲		▲
Estonia	EST	▲		▲	▲	○	△	△	▲		▲
Finland	FIN	★	★	▲	★	★	★	▲	★	★	▲
France	FRA	▲	△	△	▲	▲	▲	▲	▲	△	▲
Germany	DEU	★	▲	△	▲	▲	★	▲	▲	★	▲
Greece	GRC	○	△	△	○	△	○	○	○		△
Hungary	HUN	○	△	△	△	△	△	○	△		△
Iceland	ISL	★	○	★	▲	▲	△	★			△
India	IND	△	○	○	○	○	△	○			○
Indonesia	IDN		○	○	○		○	○			△
Ireland	IRL	△	▲	▲	△	▲	▲	▲	★	○	△
Israel	ISR	△	★	▲	★	▲	▲	▲	★		○
Italy	ITA	△	△	△	△	△	△	△	○	▲	★
Japan	JPN	▲	△	○	★	▲	★	△	△	○	▲
Korea	KOR	▲	△	△	★	▲	▲	▲	▲		△
Latvia	LVA	△	○	○	○		△				
Lithuania	LTU	△	○	○	○		△				
Luxembourg	LUX	○	○	△	△	★	▲	★	△		△
Malaysia	MYS	△	△	○	△	△					
Mexico	MEX	○	○	○	○	○	○	△			○
Netherlands	NLD	▲	▲	★	▲	▲	▲	▲	▲	▲	★
New Zealand	NZL	△	★	▲	△	△	△	★	△		★
Norway	NOR	▲	▲	△	△	▲	△	△	△	▲	△
Poland	POL	△	△	△	○	○	△	○	○		○
Portugal	PRT	△	▲	▲	△	△	△	△	△		▲
Russian Federation	RUS	△	○	○	△	△	○	○	△		△
Slovak Republic	SVK	△	○	○	○	○	○	○			★
Slovenia	SVN	△	▲	▲	▲	△	△	△	△		△
South Africa	ZAF	○	△	○	△	△	△	△	△		○
Spain	ESP	△	△	△	△	△	△	△	○	○	○
Sweden	SWE	★	★	★	★	★	★	▲	▲	★	△
Switzerland	CHE	▲	▲	★	▲	★	★	★	▲	★	▲
Turkey	TUR	△	○	○	△	△	○	○			○
United Kingdom	GBR	△	▲	▲	△	▲	▲	▲	▲	△	▲
United States	USA	▲	△	△	▲	▲	▲	▲	★	○	★
EU28	EU28	▲	▲	★	▲	△	▲	△	▲	▲	

Table 9.1. **Comparative performance of national science and innovation systems, 2014 (cont.)**

Country relative position: in the top 5 OECD or above (★), in the middle range on par or above OECD median (▲), in the middle range below OECD median (△) and in the bottom 5 OECD or below (○)

		Interactions and skills for innovation												
		ICT and Internet infrastructures				Networks, clusters and transfers				Skills for innovation				
		ICT investment (per GDP)	Fixed broadband subscribers (per population)	Wireless broadband subscribers (per population)	E-government readiness index	Industry financed public R&D expenditure (per GDP)	Patents filed by universities and public labs (per GDP)	International co-authorship (%)	International co-invention (%)	Tertiary education expenditure (per GDP)	Adult population at tertiary education level (%)	Top adult performers in technology problem solving (%)	Top 15 year-old performers in science (%)	Doctoral graduate rate in science and engineering (%)
		ICTINV_XGDP	FBBAND_HAB	WBBAND_HAB	EGOV_I	PUB_BEF_XGDP	PATPRI_XGDP	INTCOA_XSA	COPAT_XPCT	TER_XGDP	ADTERPOP_XT	TOPAD_PST_XAD	TOP15_SCI_XT	PHDR_SCIENG_XCOH
		(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)	(s)	(t)	(u)	(v)	(w)
Argentina	ARG	○	○	○	○	○		△	★	▲	○		○	○
Australia	AUS	▲	△	★	▲	▲	▲	△	△	▲	▲	▲	★	▲
Austria	AUT	▲	△	▲	△	▲	△	★	▲	△	△	△	△	▲
Belgium	BEL	▲	▲	△	△	▲	▲	★	★	△	▲		▲	▲
Brazil	BRA		○	△	○		△	○	△	○	○		○	○
Canada	CAN	△	▲	△	▲	▲	▲	△	▲	★	★	▲	▲	▲
Chile	CHL		○	○	△	○	△	▲	△	★	○		○	○
China	CHN		○	○	○	▲	△	○	○		○			○
Colombia	COL		○	○	△			▲	△	★	△		○	
Costa Rica	CRI		○	○	○			★	★		△		○	
Czech Republic	CZE	△	△	△	○	△	△	△	▲	△	△	△	△	△
Denmark	DNK	★	★	★	★	△	★	▲	▲	▲	△	★	△	▲
Estonia	EST		△	▲	△	△		▲	★	▲	▲	○	★	△
Finland	FIN	△	▲	★	▲	★	▲	▲	△	★	▲	★	★	★
France	FRA	△	★	△	▲	△	★	▲	△	▲	△		▲	▲
Germany	DEU	△	▲	△	▲	★	▲	△	△	△	△	▲	▲	★
Greece	GRC	○	△	△	△	△	○	△	▲	▲	△		○	△
Hungary	HUN		△	○	△	▲	○	▲	▲	○	△		△	○
Iceland	ISL		▲	▲	△	★		★	▲	○	▲		△	△
India	IND		○	○	○		△	○	▲	○				
Indonesia	IDN		○	○	○			▲	★	○	○		○	○
Ireland	IRL	○	△	▲	△	○	★	▲	▲	▲	▲	○	▲	▲
Israel	ISR		△	△	▲	▲	★	△	△	▲	★		△	▲
Italy	ITA	△	△	△	△	○	△	△	○	○	○		△	△
Japan	JPN	★	▲	▲	▲	△	▲	○	○	▲	★	▲	★	△
Korea	KOR	▲	★	★	★	▲	★	○	○	★	★	○	▲	△
Latvia	LVA		△	△	△	▲		△	★	▲	△		○	△
Lithuania	LTU		△	○	△	★		△	△		▲		△	
Luxembourg	LUX	○	▲	▲	▲	△	△	★	★	○	▲		▲	
Malaysia	MYS		○	○	△			△	△	★	○		○	
Mexico	MEX	○	○	○	○	○	○	△	▲	△	○		○	○
Netherlands	NLD	▲	★	▲	★	★	▲	▲	△	▲	△	★	▲	△
New Zealand	NZL	★	▲	▲	▲	★	△	▲	△	▲	▲		★	▲
Norway	NOR		▲	▲	▲	▲	△	▲	△	▲	▲	★	△	▲
Poland	POL		○	▲	○	△	△	○	★	△	△	○	▲	○
Portugal	PRT	▲	△	○	△	○	○	△	▲	△	○		○	△
Russian Federation	RUS		○	△	△	★	○	○	△	△	★		○	○
Slovak Republic	SVK	○	○	△	○	△		△	▲	○	△	○	△	▲
Slovenia	SVN	△	△	△	△	▲	△	△	△	△	△		▲	▲
South Africa	ZAF		○	○	○	△	△	△	△	○	○			○
Spain	ESP	△	△	△	△	▲	▲	△	△	△	△		△	△
Sweden	SWE	★	▲	★	▲	▲	○	▲	△	▲	▲	★	△	★
Switzerland	CHE	★	★	△	▲		▲	★	★	△	▲		▲	★
Turkey	TUR		○	○	○	▲	○	○	○	△	○		○	○
United Kingdom	GBR	▲	▲	▲	★	△	▲	△	▲	△	▲		▲	★
United States	USA	▲	▲	▲	★	△	▲	○	○	★	★	△	△	△
EU28	EU28	△	▲	▲		△	▲	▲	▲		△		△	▲

Note: Non-OECD countries are also compared to OECD countries and may therefore be out of range (e.g. lower than the lowest OECD country). They appear in this table with top five and bottom five OECD values

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

Source: See references and methodological annex of the OECD STI Outlook 2014 country profiles.

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