OECD Science, Technology and Industry Scoreboard 2017

THE DIGITAL TRANSFORMATION

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OECD
BETTER POLICIES FOR BETTER LIVES

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Foreword

The OECD Science, Technology and Industry Scoreboard 2017 *draws on the latest internationally comparable data to uncover the strengths of the OECD and other leading economies, and shows how the digital transformation is affecting science, innovation, the economy, and the way people work and live. It aims to help governments design more effective science, innovation and industry policies in the fast-changing digital era.*

It features indicators traditionally used to monitor developments in science, technology, innovation and industry, and complements them with new and experimental indicators that provide new insights into areas of policy interest.

The aim of the STI Scoreboard *is not to "rank" countries or develop composite indicators. Instead, its objective is to provide policy makers and analysts with the means to compare economies with others of a similar size or with a similar structure and to monitor progress towards desired national or supranational policy goals. It draws on OECD efforts to build data infrastructure to link actors, outcomes and impacts, and highlights the potential and limits of certain metrics, as well as indicating directions for further work.*

Indicators are pointers; they do not address causal relationships. Moreover, the validity of a set of indicators depends on its use. The selected indicators have been developed with the following criteria in mind:

- *Indicators should be based on high-quality statistics and robust analytical principles and be measurable internationally, over time and with prospects of improvement.*
- *Indicators should be relevant, particularly for decision makers.*
- *Experimental indicators that complement more established ones should bring new perspectives and advance the measurement agenda. They should help to stimulate policy debates and uncover new dynamics.*

The first chapter, ***Knowledge economies and the digital transformation****, provides a broad overview. Trends in science, innovation and growth are presented in the context of today's fast-changing digital technology landscape. Section 1, "Science, innovation and the digital revolution", presents the latest developments and the top players in artificial intelligence (AI) and other breakthrough ICT technologies, and examines the overall science landscape and the concentration of business R&D. Section 2, "Growth, jobs and the digital transformation", provides insights into countries' participation in global value chains, in particular ICT global production networks, explores the changing nature of jobs, and presents the knowledge-based assets at the heart of innovation and productivity. Section 3, "Innovation today: Taking action", offers evidence in support of actions to address digital divides and foster innovation and entrepreneurship.*

Five thematic chapters focus on key areas of policy interest:

- ***Knowledge, talent and skills*** *examines the knowledge assets that many firms and governments view as current and future sources of long-term sustainable growth. It provides metrics of knowledge-based capital, such as formal and on-the-job training and organisational assets, both* *in the market and non-market sector. Skills required for the new working environment shaped by ICTs, as well as returns to ICT skills, are analysed through a new set of indicators.*

- ***Research excellence and collaboration*** *helps to inform the policy debate with a set of metrics on the variety and nature of mechanisms for knowledge diffusion in the age of digitalisation. It points to the research performance of countries that follow different paths of scientific specialisation, the international mobility of highly skilled individuals, innovation across borders and collaboration among firms in innovation processes.*
- ***Innovation in firms*** *explores the dynamism of the business sector and framework conditions crucial for innovation. It examines sectoral R&D patterns and intellectual property bundles with a focus on firms' joint use of ICT patents, trademarks and industrial designs to protect their innovations. Estimates of R&D tax incentives are combined with direct funding of R&D to provide a more complete picture of government efforts to promote business R&D, while innovation survey data allow an analysis of the participation of innovative firms in public procurement markets.*
- ***Leadership and competitiveness*** *investigates how countries seek to build their competitive strengths and the extent to which economies are successful in integrating and specialising along global value chains. It assesses indicators on R&D specialisation, technological advantages and relative strengths, and e-business uptake in firms and sectors together with start-up dynamics in ICT sectors vis-à-vis the rest of the economy. Indicators building on the OECD-WTO Trade in Value Added (TiVA) database shed light on economies' participation in global trade and value chains, and the implications for jobs and consumers everywhere.*
- ***Society and the digital transformation*** *uses metrics that focus on digital inclusiveness to help inform the policy debate. A set of key indicators is used to examine individuals' access to and use of technologies from an early age, the level of sophistication of users, and their role as e-consumers and e-citizens. Finally, a series of indicators on trust shed some light on firms and individuals' security and privacy concerns in an increasingly digitised world.*

The main audience of the STI Scoreboard is policy analysts with a good understanding of the use of indicators and those engaged in producing indicators for analytical or policy-making purposes. A few paragraphs introduce each indicator and offer some interpretation. Accompanying boxes entitled "Definitions", "Measurability" and "Did you know?" provide detail on the methodologies used, summarise measurement gaps, challenges and recent initiatives, and draw attention to interesting facts or figures based on the findings of the five thematic chapters.

All charts and underlying data can be downloaded via the StatLinks (hyperlink to a webpage). Additional data that expand the coverage of countries and time periods are available at the same links. Several thematic briefs and country notes, as well as online tools to visualise indicators and help users develop analyses based on their own interests, are available from the STI Scoreboard website (www.oecd.org/sti/scoreboard.htm).

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Reader's guide

Acronyms

AI	Artificial intelligence
API	Application programme interface
ASJC	All Science and Journal Classification
BERD	Business enterprise expenditure on research and development
CIS	Community Innovation Survey
CPC	Cooperative Patent Classification
DOI	Digital object identifier
EF	Extended footprint
EPO	European Patent Office
EUIPO	European Union Intellectual Property Office
EUR	Euros
FDI	Foreign direct investment
FTE	Full-time equivalent
GAK	General advancement of knowledge
GBARD	Government budget allocations for R&D
GDP	Gross domestic product
GERD	Gross domestic expenditure on R&D
GVC	Global value chain
HERD	Higher education expenditure on R&D
ICIO	Inter-Country Input-Output
ICT	Information and communication technology
IoT	Internet of Things
IP	Intellectual property
IP5	Five IP Offices (EPO, JPO, KIPO, SIPO, USPTO)
IPC	International Patent Classification
ISCED	International Standard Classification of Education
ISCO	International Standard Classification of Occupations
ISIC	International Standard Industrial Classification
JPO	Japan Patent Office
KBC	Knowledge-based capital
KIPO	Korean Intellectual Property Office
LFS	Labour Force Survey
M2M	Machine-to-machine
MFP	Multi-factor productivity

NACE	Statistical classification of economic activities in the European Community *(Nomenclature statistique des activités économiques dans la Communauté européenne)*
NDD	Neurodegenerative disease
NSE	Natural sciences, engineering
OA	Open access
oaDOI	Open-access DOI
PPP	Purchasing power parity
R&D	Research and development
roaDOI	Repository-based open-access DOI
SEO	Socio-economic objective
S&T	Science and technology
SIPO	State Intellectual Property Office of the People's Republic of China
SME	Small and medium-sized enterprise
SNA	System of National Accounts
TiVA	Trade in value added
USD	United States dollar
USPTO	United States Patent and Trademark Office
VC	Venture capital
WIPO	World Intellectual Property Organization

Abbreviations

For most of the charts, this publication uses ISO codes for countries or economies.

ARG	Argentina	ISL	Iceland
AUS	Australia	ISR	Israel
AUT	Austria	ITA	Italy
BEL	Belgium	JPN	Japan
BGR	Bulgaria	KHM	Cambodia
BMU	Bermuda	KOR	Korea
BRA	Brazil	LTU	Lithuania
BRB	Barbados	LUX	Luxembourg
CAN	Canada	LVA	Latvia
CHE	Switzerland	MEX	Mexico
CHL	Chile	MLT	Malta
CHN	People's Republic of China	MYS	Malaysia
CRI	Costa Rica	NLD	Netherlands
CYM	Cayman Islands	NOR	Norway
CYP	Cyprus	NZL	New Zealand
CZE	Czech Republic	PHL	Philippines
DEU	Germany	POL	Poland
DNK	Denmark	PRT	Portugal
ESP	Spain	ROU	Romania
EST	Estonia	RUS	Russian Federation
FIN	Finland	SAU	Saudi Arabia
FRA	France	SGP	Singapore
GBR	United Kingdom	SVK	Slovak Republic
GRC	Greece	SVN	Slovenia
HKG	Hong Kong, China	SWE	Sweden
HRV	Croatia	TUR	Turkey
HUN	Hungary	TWN	Chinese Taipei
IDN	Indonesia	USA	United States
IND	India	VGB	Virgin Islands (British)
IRL	Ireland	ZAF	South Africa

Country groupings

ASEAN	Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, the Philippines, Singapore, Thailand and Viet Nam.
BRICS	Brazil, the Russian Federation, India, China and South Africa.
BRIICS	Brazil, the Russian Federation, India, Indonesia, China and South Africa.
Euro Area	Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Malta, the Netherlands, Portugal, the Slovak Republic, Slovenia and Spain.
EU28	European Union
G7	Canada, France, Germany, Italy, Japan, the United Kingdom and the United States.
G20	Argentina, Australia, Brazil, Canada, China, France, Germany, India, Indonesia, Italy, Japan, Mexico, the Russian Federation, Saudi Arabia, South Africa, Korea, Turkey, the United Kingdom, the United States and the European Union.
NAFTA	Canada, Mexico and the United States.
OECD	Total OECD
ROW	Rest of the world
WLD	World

Executive summary

Mobility, cloud computing, the Internet of Things (IoT), artificial intelligence (AI) and big data analytics are among the most important technologies in the digital economy today. Collectively they are enabling a future of "smart everything", and empowering businesses, consumers and society as a whole. The *OECD Science, Technology and Industry Scoreboard 2017* shows how the digital transformation is affecting science, innovation, the economy, and the way people work and live. It aims to help governments design more effective science, innovation and industry policies in the fast-changing digital era. Below are key insights from the report, with a specific focus on digital trends among all the other themes covered.

The digital revolution continues apace

Over 2012-15, China, Chinese Taipei, Korea, Japan and the United States were responsible for developing between 70% and 100% of the top 20 cutting-edge ICT technologies, with Japan and Korea innovating across the whole spectrum of ICT technologies. AI technologies, as measured by inventions patented in the five top IP offices (IP5), increased by 6% per year on average between 2010 and 2015, twice the average annual growth rate observed for all patents. In 2015, 18 000 AI inventions were filed worldwide. Japan, Korea and the United States accounted for over 62% of those inventions. Up to 30% of patents filed on medical diagnostic include AI-related components.

Scientific power-houses drive digital innovation

Over the past 15 years, China has tripled its high-impact scientific efforts – as measured by its share of top 10% most-cited publications (14%) – making it the second largest scientific powerhouse, behind the United States (25%). The United States leads in machine learning research, followed by China. India has also entered the game and now accounts for a third of papers published in this field, though ranking fourth behind the United Kingdom when adjusted for quality. Machine-to-machine communication (M2M) is key to enabling the IoT. In June 2017, China accounted for 44% of worldwide M2M sim card subscriptions – three times the share of the United States.

Frontier technologies are highly concentrated

R&D is a highly concentrated activity: within economies a small number of firms are responsible for a large proportion of total business R&D. The 50 largest domestic R&D performers account for 40% of business R&D efforts in Canada and the United States, and for 55% in Germany and Japan. The headquarters of the top 2 000 R&D corporations worldwide are concentrated in just a few economies – notably the United States, Japan and China – and about 70% of their total R&D spending is concentrated in the top 200 firms.

These top 2 000 R&D firms lead in the development of digital technologies and own about 75% of global ICT-related patents, 55% of ICT-related designs and 75% of the IP5 patent families related to AI.

The digital transformation is not affecting every sector equally

Much of the value added related to ICT production is generated elsewhere in the economy. The non-ICT industry value added embodied in global demand for ICT goods and services (e.g. the glass that makes up a smart phone's screen) contributed by the rest of the economy accounts for 19–34% of overall value added, rising to 41% in China. The digital transformation is now affecting all sectors of the economy, though to varying degrees. A new taxonomy of digital-intensive sectors shows that Telecommunications and IT services rank consistently at the top in terms of digital intensity, while Agriculture, Mining and Real estate are consistently at the bottom. Other sectors show more heterogeneity across the various indicators, pointing to different rates of transformation. While almost no business today is run without ICTs, their impact depends on the type and sophistication of ICT tools integrated into business processes. For example, while most companies in the OECD area have a broadband connection, only 25% reported using cloud computing services in 2016 – 22% of small firms and 47% of large ones.

Broad skill sets are required

Creation, adoption and effective use of new technology require appropriate skills. Economies where workers use ICT more intensively at work (e.g. the Netherlands, Norway and New Zealand) also have a higher share of "non-routine jobs" involving relatively complex tasks. Workers in jobs that are 10% more ICT-intensive than the average job may earn hourly wages that are up to 4% higher. However, ICT skills alone are insufficient to thrive in the digital economy. Workers enjoy extra rewards when ICT and tasks requiring management and communication skills are performed together. Workers in digital-intensive industries exhibit both higher levels of cognitive skills (e.g. literacy, numeracy and problem solving), as well as non-cognitive and social skills (e.g. communication and creativity).

More people are being connected, but gaps remain

The Internet and connected devices have become a crucial part of everyday life for most individuals, and are now reaching nearly 100% of individuals in several OECD countries. Over 50% of 16-74 year olds in Brazil, China and South Africa use the Internet today, and the gap with OECD countries is narrowing. As the cost of online access technology falls further and today's "digital natives" become adults, this gap will continue to decline. In the OECD area, 17% of students first accessed the Internet at or before the age of 6, reaching 30% in Denmark. However, significant differences remain in the uptake and use of digital technologies in a majority of OECD countries, including between younger and older generations, by educational background, urban and rural locations, and firms of different size.

Women lag in the digital transformation

In the OECD area, approximately 30% of graduates in the natural sciences, engineering and ICTs are women. Only 22% of scientific authors are women, a figure that is even lower for subgroups of authors, such as those engaged in paid review or editorial activity, or those fully dedicated to research. The proportion of patents featuring women inventors ranges between about 4% in Austria to over 15% in Portugal. At work, women often earn significantly less than men, even after individual and job-related characteristics are taken into consideration. Skills, in particular ICT skills, partially explain the gender wage gap across countries. Estimates suggest that, other things being equal, returns to ICT tasks are higher for women than for men. Training women and endowing them with additional ICT skills may therefore contribute to increasing their wages and help bridge the gender wage gap.

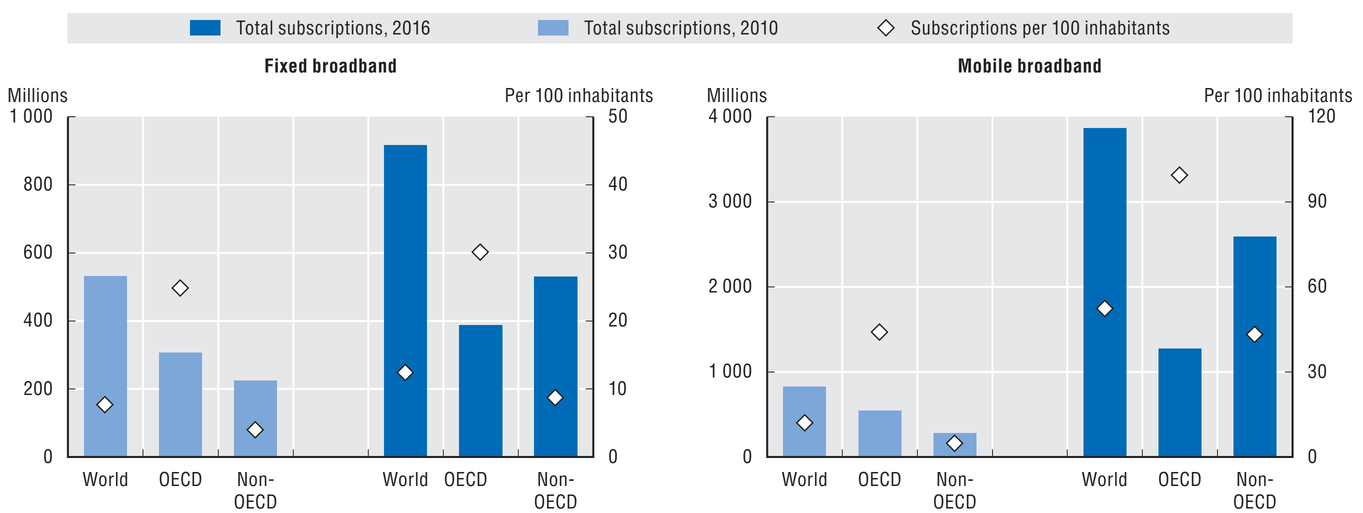
1. KNOWLEDGE ECONOMIES AND THE DIGITAL TRANSFORMATION

Broadband infrastructure

Fixed and mobile broadband subscriptions continue to grow apace. The number of worldwide fixed broadband subscriptions increased by 72% in the last ten years, from 531.8 million in 2010 to 916.7 million in 2016. In OECD countries, fixed broadband subscriptions increased from 307.3 million in 2010 to 386.8 million in 2016, an increase of 26%. Mobile broadband growth by far outstripped fixed broadband with worldwide subscriptions increasing from 824.5 million in 2010 to 3 864 million in 2016. At the end of 2016, just over half the world's population had a mobile broadband subscription. By way of contrast, the average for OECD countries was 99.3%. The pace of change can be rapid, however. Mobile broadband subscriptions in non-OECD countries registered a nine-fold increase over the last decade, with India adding almost 100 million broadband subscriptions in 2016 alone.

1. Worldwide fixed and mobile broadband penetration, 2010 and 2016

Total subscriptions and per 100 inhabitants

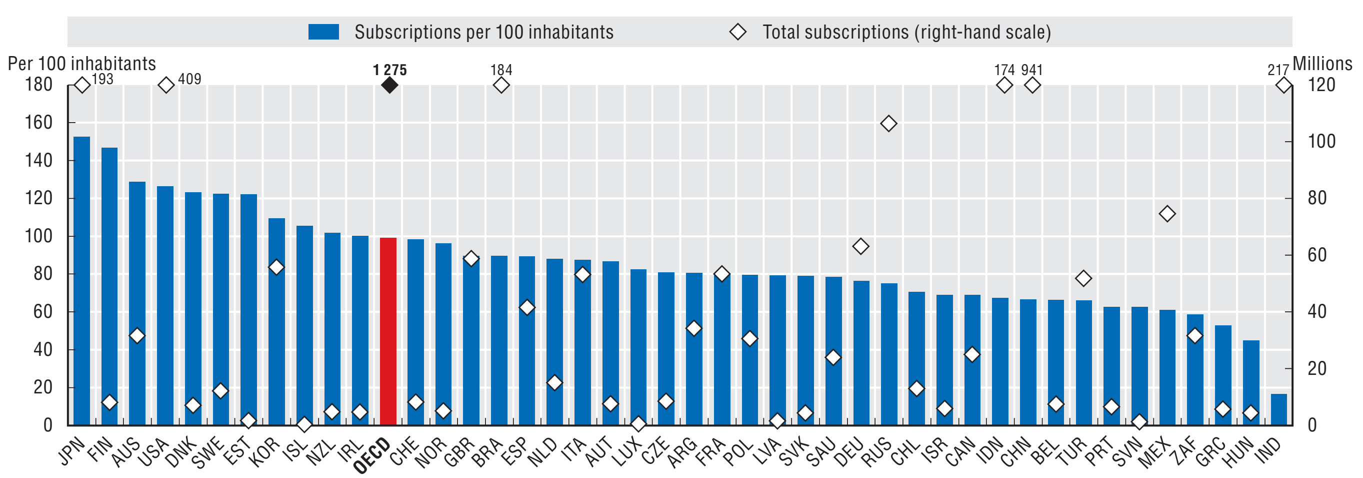


Source: OECD, Broadband Portal, *http://oe.cd/broadband* and ITU, World Telecommunication/ICT Indicators Database, July 2017.

StatLink http://dx.doi.org/10.1787/888933616864

2. Mobile broadband penetration, OECD, G20 and BRIICS, 2016

Total subscriptions and per 100 inhabitants



Source: OECD, Broadband Portal, *http://oe.cd/broadband* and ITU, World Telecommunication/ICT Indicators Database, July 2017. See chapter notes.

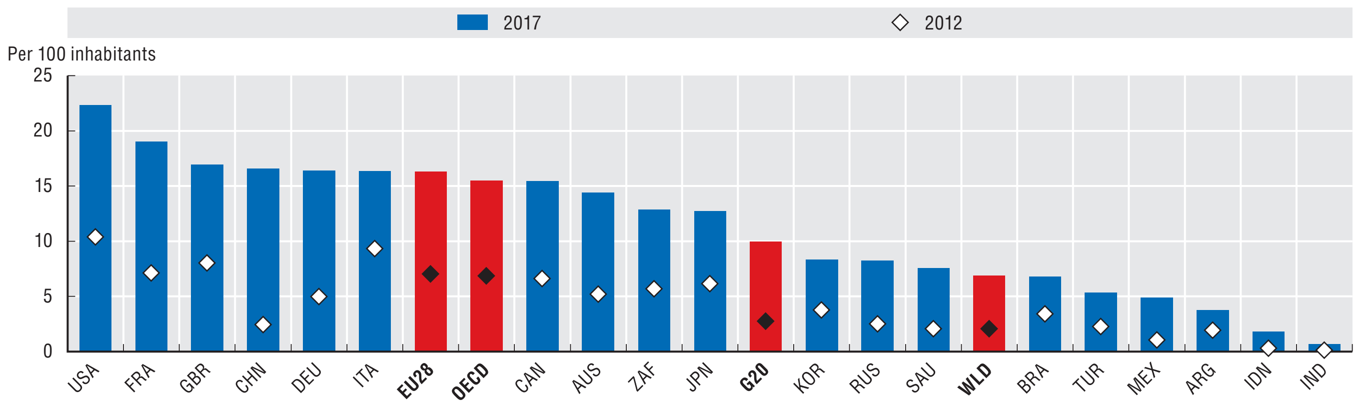
StatLink http://dx.doi.org/10.1787/888933616883

Machine-to-machine communication

The Internet of Things (IoT) refers to an ecosystem in which applications and services are driven by data collected from devices that act as sensors and interface with the physical world. This ecosystem could soon constitute a common part of the everyday lives of people in OECD countries and beyond. Important IoT application domains span almost all major economic sectors including: health, education, agriculture, transportation, manufacturing, electric grids and many more. Part of the underlying infrastructure of the IoT is machine-to-machine (M2M) communication. The Groupe Spéciale Mobile Association (GSMA) tracks the number of M2M subscriptions around the world. These data show the number of SIM cards embedded in machines, such as automobiles or sensors, which allow communication between such devices. Among G20 economies, the United States had the highest penetration (number of M2M SIM cards per inhabitant) in June 2017, followed by France and the United Kingdom. Between 2012 and Q2 2017, the number of subscriptions increased by 131% in OECD countries and 272% in the G20, although from a smaller base. The People's Republic of China (hereafter "China") had the largest share of worldwide M2M subscriptions (44%) at 228 million subscriptions in June 2017, representing three times the share of the United States.

3. M2M SIM card penetration, OECD, World and G20 countries, June 2017

Per 100 inhabitants

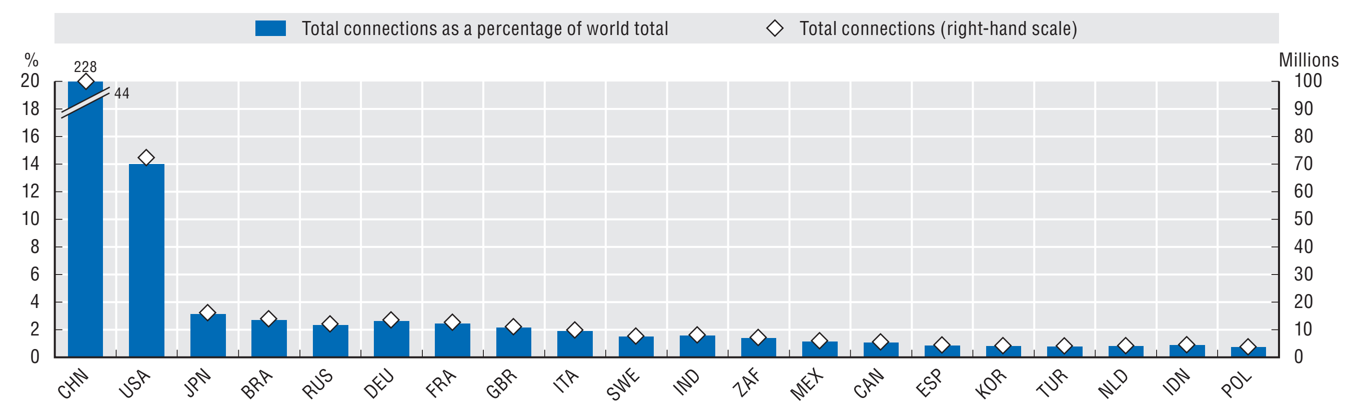


Source: OECD calculations based on GSMA Intelligence, September 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933616902

4. Top M2M SIM card connections, June 2017

Total connections and as a percentage of world total



Source: OECD calculations based on GSMA Intelligence, September 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933616921

Measuring the infrastructure for IoT using GSMA data on M2M

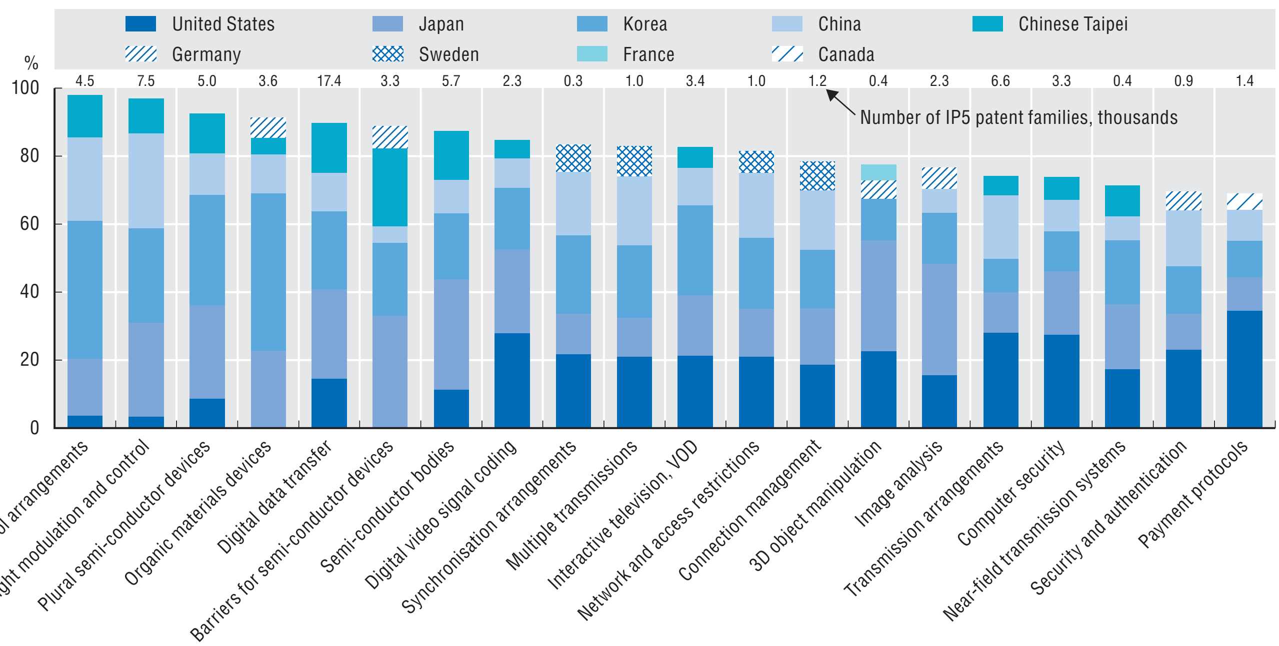
The GSMA's definition of M2M is: "A unique SIM card registered on the mobile network at the end of the period, enabling mobile data transmission between two or more machines. It excludes computing devices in consumer electronics such as e-readers, smartphones, dongles and tablets". The GSMA collects publicly available information about mobile operators that have commercially deployed M2M services. It then uses a data model based on a set of historic M2M connections reported at any point in time by mobile operators and regulators, along with market assumptions based on their large-scale survey of M2M operators and vendors. This pool of data is then reconciled by GSMA with their definition, normalised and analysed to identify specific M2M adoption profiles. These adoption profiles are then applied by the GSMA to all operators that have commercially launched M2M services, but do not publicly report M2M connections to produce national figures. For more information, see *www.gsmaintelligence.com*.

ICT technologies at the cutting edge

Technologies take time to develop and mature and may follow different development and adoption paths. Technologies that have several applications may at some point experience accelerated development – they may start to "burst". Information and communication technologies (ICTs) are an example of bursting technologies. ICT products such as mobile phones and computers are renowned for their complexity and modularity, their rapid obsolescence, and their reliance on a wide array of continuously evolving technologies. A novel data-mining approach is used to monitor the extent to which different ICT fields emerge and develop, and to identify bursting technologies. Over 2012-15, five economies accounted for 69% to 98% of the top 20 bursting ICT technologies. Japan and Korea contributed to the development of all ICT fields whose development accelerated during this period, together accounting for 21% to about 70% of all patenting activities in these bursting ICT fields. The United States led the development of ICT technologies related to payment protocols (34%), transmission arrangement (28%) and digital video signal coding (28%). China was among the top five economies developing technologies in most bursting ICT fields, and was particularly active in light modulation and control inventions (28%). A few European economies, namely Sweden, Germany and France, also featured among the top five leaders of some bursting ICT fields.

5. Top players in emerging ICT technologies, 2012-15

Share of top five economies' patents in top 20 technologies bursting from 2010 onwards



Source: OECD, STI Micro-data Lab: Intellectual Property Database, *http://oe.cd/ipstats*, June 2017. StatLink contains more data. See chapter notes.

StatLink *http://dx.doi.org/10.1787/888933616940*

Identifying acceleration in technological development

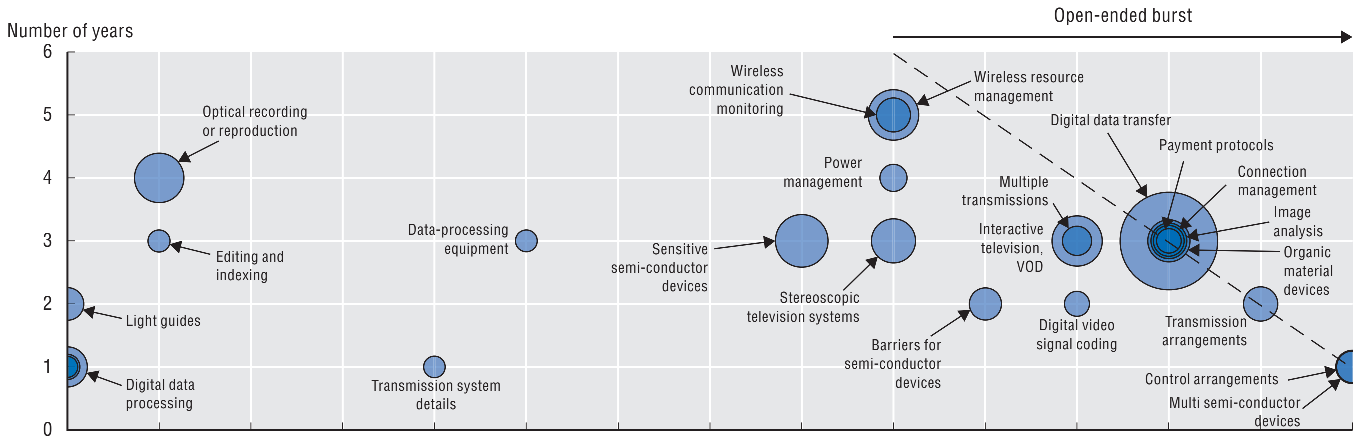
Patents protect novel inventions and technologies, and patent data can help investigate a number of policy-relevant issues related to innovation and technological development. A new data mining approach called "DETECTS" (see Dernis et al., 2016), exploits information contained in patents to identify technologies whose development increases sharply (i.e. "bursts"), compared to previous levels and to the development of other technologies, and maps the time it takes for such dynamics to unfold. A technology field is said to burst or accelerate when a substantial increase in the number of patents filed in the field is observed. DETECTS monitors such acceleration in relative terms (i.e. compared to past development patterns in the field and relative to the pace of development in other fields). Monitoring fields in which accelerations occur is vital for policy making, as developments tend to persist in these areas over the short and medium term. Furthermore, information contained in patents about the technologies themselves and the geographical location of patent owners and inventors enables the identification of economies leading such technology developments, and can shed light on the generation of new fields arising from the cross-fertilisation of different technologies (e.g. ICT and environmental technologies).

ICT technologies at the cutting edge

A burst analysis focusing on ICT-related fields over the period 2000-14 reveals the sequence of technological developments occurring during these 15 years, the extent to which some ICT fields saw their development accelerated and the length of the period during which such bursts were sustained (the "duration of the burst"). At the start of the 2000s, activities burgeoned in the field of digital data processing, editing and optical recording, whereas the late 2000s saw accelerations in semi-conductor devices and wireless communications. Since 2012, inventions patented in the five top IP offices (IP5) and related to digital data transfer experienced a persistent acceleration of unprecedented intensity, reaching about 24 000 IP5 patent families in 2012-14 alone. During the last part of the period considered, open-ended bursts are underway in various domains linked to organic materials devices, image analysis, connection management and payment protocols. Compared to those observed at the beginning of the period, recent bursts seem to last longer and consist of a higher number of inventions.

6. Intensity and development speed in ICT-related technologies, 2000-14

Intensity of bursts (bubble size) and duration over time



Source: OECD, STI Micro-data Lab: Intellectual Property Database, *http://oe.cd/ipstats*, July 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933616959

How to read this figure

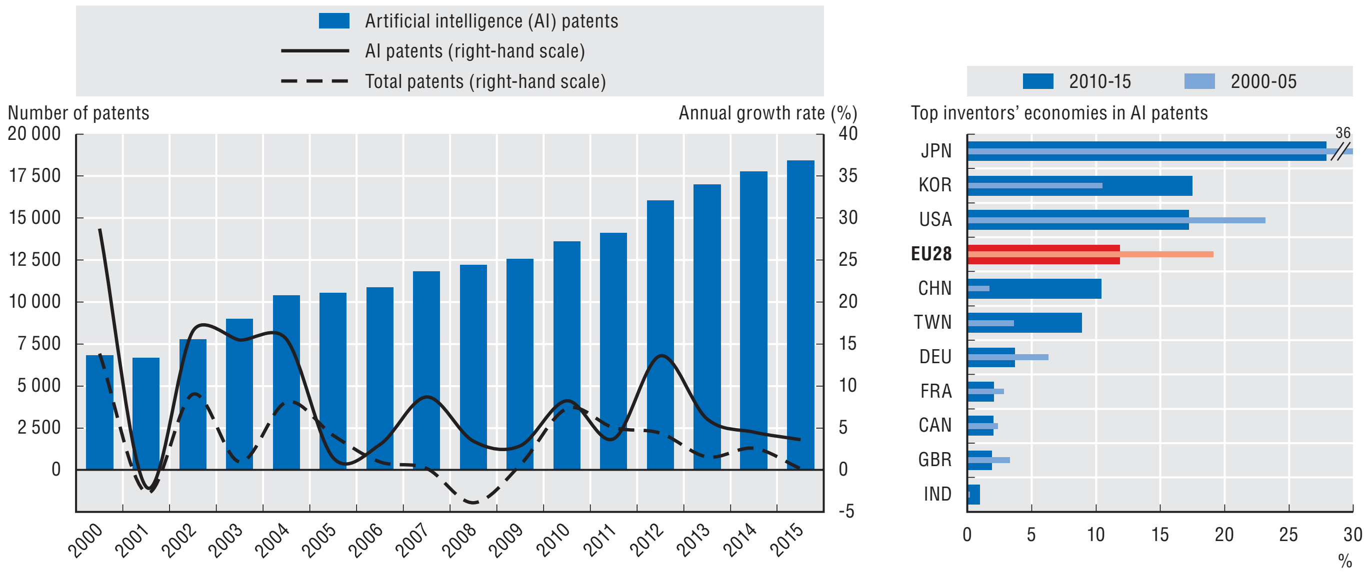
The size of the bubble indicates the intensity of the burst (i.e. the pace at which they accelerate), and the different shades indicate different technologies that start to burst at the same time. The X axis indicates the year in which technologies start to burst, and the Y axis displays the number of years after technologies stop bursting and continued their development at a very much slower pace. For example, acceleration in the development of patented technologies related to optical recording and reproduction (top-left) was first observed in 2001 (X axis), and lasted for four years (Y axis), until the end of 2004. Bubbles located along the diagonal line on the right-hand side of the figure represent open-ended bursting technologies (i.e. technologies still developing at an accelerated pace at the end of the sample period). Among ICT technologies that began to burst in 2012 are those related to digital data transfer, organic materials devices and image analysis. While developments in these fields were characterised by a varying number of patents – with digital data transfer accounting for the highest amount – inventive activities in all fields continued to occur at an accelerated pace up to the end of 2014.

Artificial intelligence

Artificial Intelligence (AI) is a term used to describe machines performing human-like cognitive functions (e.g. learning, understanding, reasoning or interacting). It has the potential to revolutionise production as well as contribute to tackling global challenges related to health, transport and the environment. The development of AI-related technologies, as measured by inventions patented in the five top IP offices (IP5), increased by 6% per year on average between 2010 and 2015, twice the average annual growth rate observed for patents in every domain. In 2015, 18 000 IP5 patent families related to AI were filed worldwide. Japan, Korea and the United States account for over 62% of AI-related patent applications during 2010-15, down from 70% in 2000-05. Over the same period, Korea, China and Chinese Taipei increased their number of AI patents compared to rates observed in 2000-05. EU 28 countries contributed to 12% of the total stock of IP5 AI-related inventions in 2010-15, down from 19% in the previous decade. AI technological breakthroughs such as "machine learning" coupled with emerging technologies such as big data and cloud computing are strengthening the potential impact of AI.

7. Patents in artificial intelligence technologies, 2000-15

Number of IP5 patent families, annual growth rates and top inventors' economies



Source: OECD, STI Micro-data Lab: Intellectual Property Database, *http://oe.cd/ipstats* June 2017. StatLink contains more data. See chapter notes.

StatLink *http://dx.doi.org/10.1787/888933616978*

How to measure AI technologies?

Measuring the development of AI technologies is challenging as the boundaries between AI and other technologies blur and change over time. The indicators presented here make use of technology classes (i.e. the International Patent Classification, IPC, codes) listed in the patent documents to identify AI-related inventions. All inventions belonging to the "Human interface" and "Cognition and meaning understanding" categories listed in the 2017 OECD ICT taxonomy (see Inaba and Squicciarini, 2017) are here considered as being AI-related.

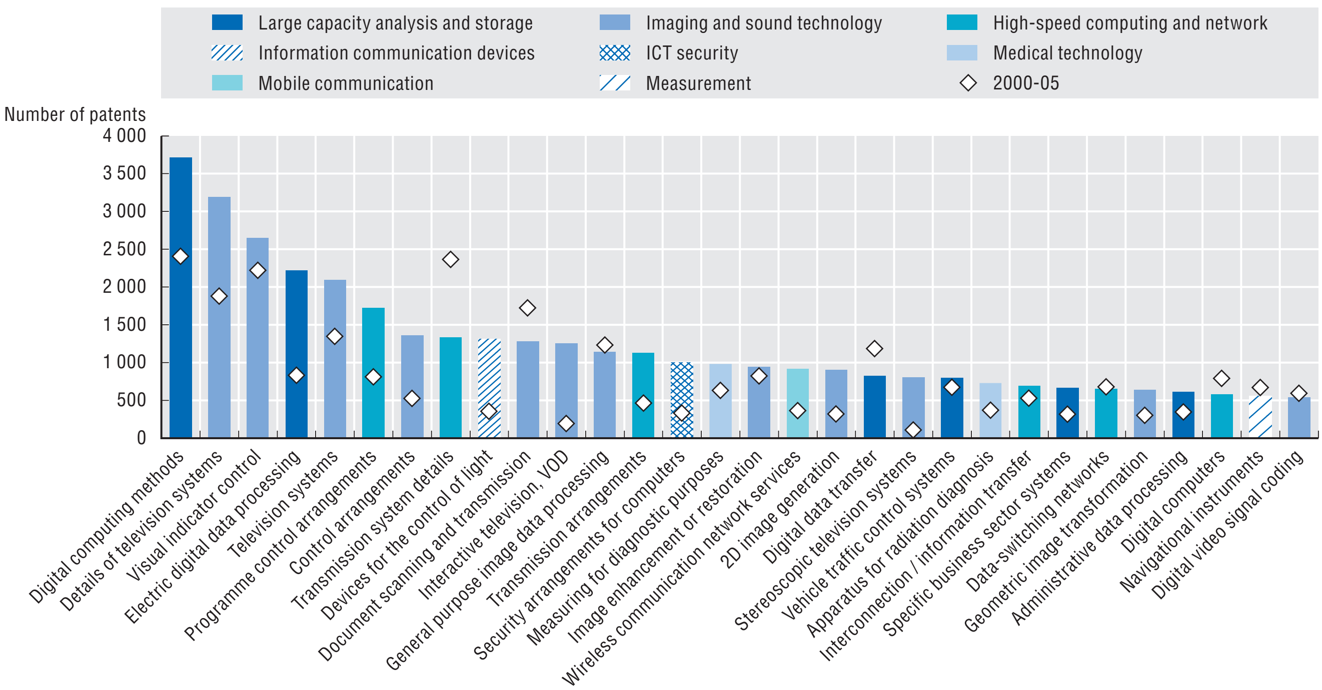
As inventions protected by patents can be assigned to a number of technology classes at the same time, it is possible to investigate the extent to which AI is combined with other technologies by examining the "co-occurrence" of IPC codes in patent families (i.e. the listing of several IPC codes in the same patent document). The figures presented here show technologies that are more often combined with AI, and are displayed in accordance with the WIPO IPC-Technology concordance (2013) and the ICT taxonomy.

Artificial intelligence

An examination of all technology fields in which AI-related patents are filed shows that AI technologies are frequently associated with a variety of digital technologies used for big data analytics. These include digital data processing and transfer as well as applications used for transport and health. For example, a closer look at medical technologies reveals that up to 30% of inventions used for medical diagnosis (e.g. eye testing or general medical examinations) incorporate embedded AI-related components.

8. Patents for top technologies that embed artificial intelligence, 2000-05 and 2010-15

Number of IP5 patent families in AI by non-AI patent classes

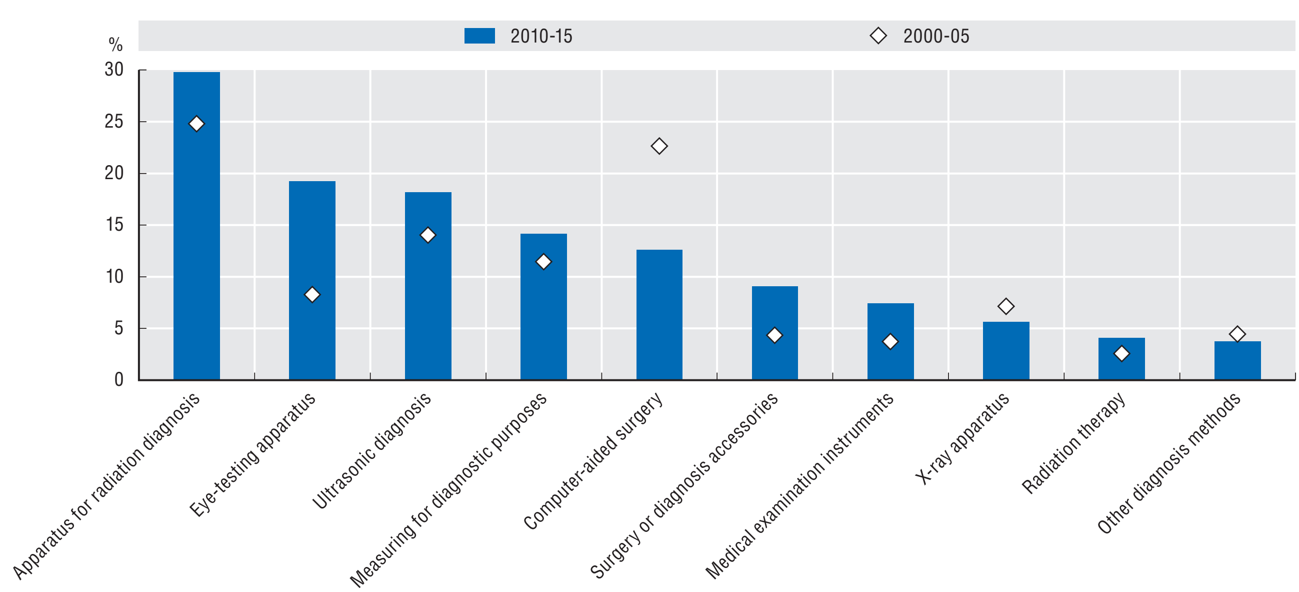


Source: OECD, STI Micro-data Lab: Intellectual Property Database, *http://oe.cd/ipstats*, June 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933616997

9. Top 10 medical technologies combined with artificial intelligence, 2000-05 and 2010-15

Share of AI-related patents in IP5 patent families related to medical technologies



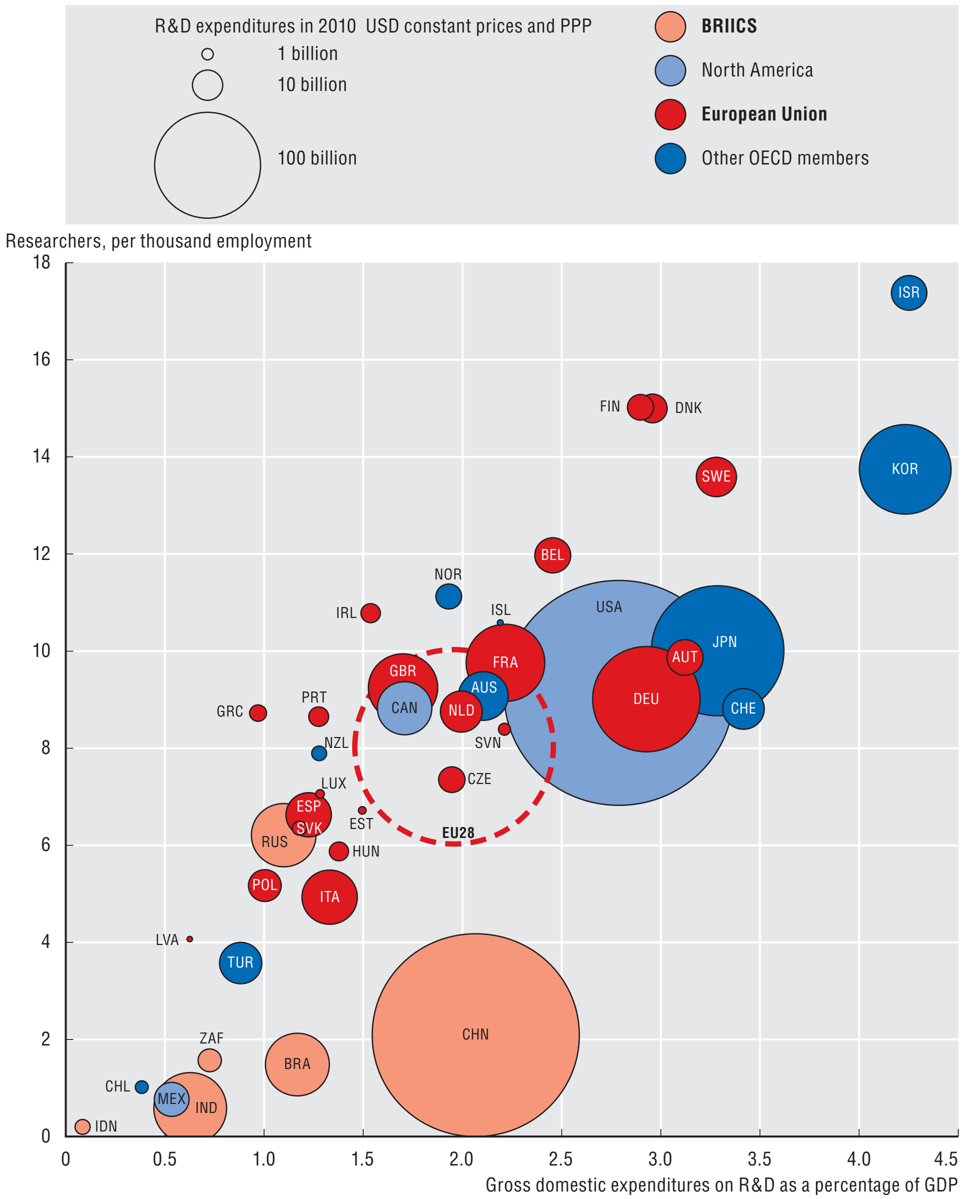
Source: OECD, STI Micro-data Lab: Intellectual Property Database, *http://oe.cd/ipstats*, June 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933617016

Science landscape

The world's top R&D performer is the United States, which surpassed USD 500 billion of domestic R&D expenditure in 2015. The second biggest performer of R&D is China (USD 409 billion PPP), which overtook the combined EU28 area (USD 386 billion PPP) in 2015. Israel and Korea have the highest ratio of R&D expenditures to GDP owing to rapid increases in recent years. OECD partner economies account for a growing share of the world's R&D, measured in terms of total researchers and R&D expenditures. In most economies personnel costs, including researchers, account for the bulk of R&D expenditures. This explains the close relationship between R&D as a percentage of GDP and the number of researchers as a percentage of total employment. Variations can be related to differences in the relative prices of different R&D inputs (including researcher remuneration), the degree of R&D specialisation in each economy, and R&D capital expenditures relating to research infrastructures being developed for the future.

10. R&D in OECD and key partner countries, 2015



Note: Owing to methodological differences, data for some OECD partner economies may not be fully comparable with figures for other countries.
Source: OECD, Main Science and Technology Indicators Database, *http://oe.cd/msti* and UNESCO Institute for Statistics, Research and experimental development (full dataset), July 2017. See chapter notes.

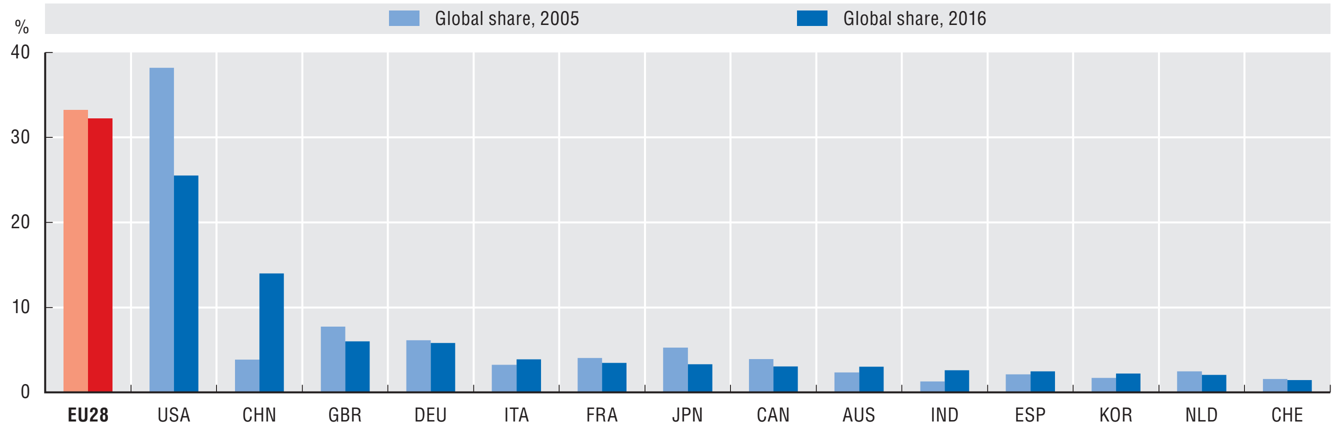
StatLink http://dx.doi.org/10.1787/888933617035

Top science

The global volume of scientific production, as indexed in the private bibliometric database Scopus, grew significantly over the 2005-16 period. Indicators of "scientific excellence" focus on the changing contributions of countries to the top cited publications. China increased its production of highly-cited scientific output and so its share in the world's top 10% most-cited publications from less than 4% in 2005 to 14% in 2016, making it the second largest country behind the United States. The combined EU area maintained its global share of high quality scientific production, surpassing the United States as a scientific powerhouse. However, as the second figure shows, the average "excellence" of EU research is still lagging at about 12%, lower than both the United States and the United Kingdom, which maintain their status as countries with high shares of high-quality scientific research (14%). Starting from a low base, the Russian Federation also saw its average performance increase to over 4% over the period.

11. Economies with the largest volume of top-cited scientific publications, 2005 and 2016

As a percentage of the world's top 10% most-cited publications

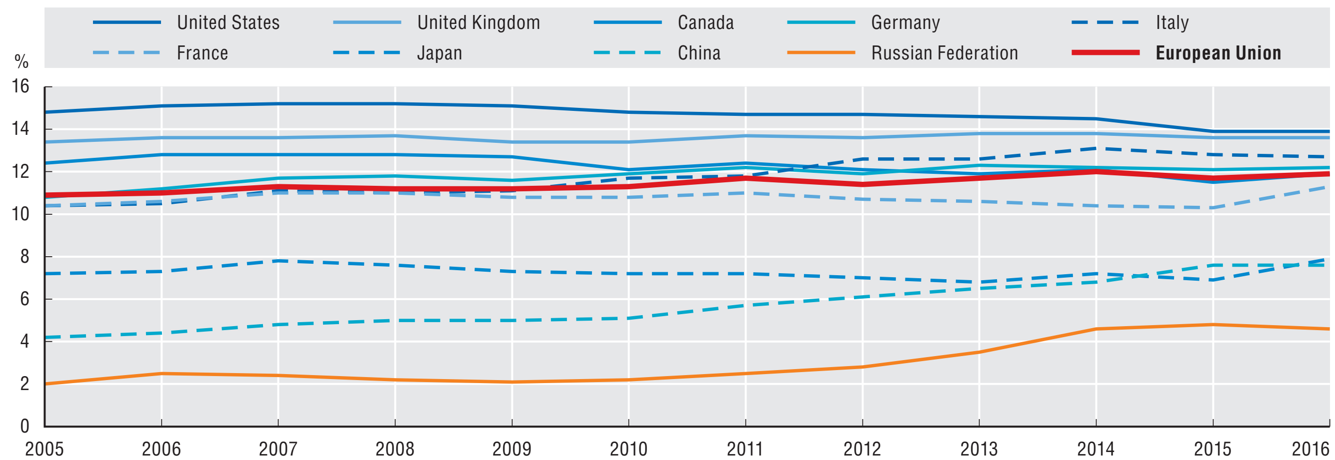


Source: OECD calculations based on Scopus Custom Data, Elsevier, Version 4.2017, July 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933617054

12. Recent trends in scientific excellence, selected countries, 2005-16

As a percentage of domestic documents in the world's top 10% most cited



Source: OECD calculations based on Scopus Custom Data, Elsevier, Version 4.2017, July 2017. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933617073

How to read these figures

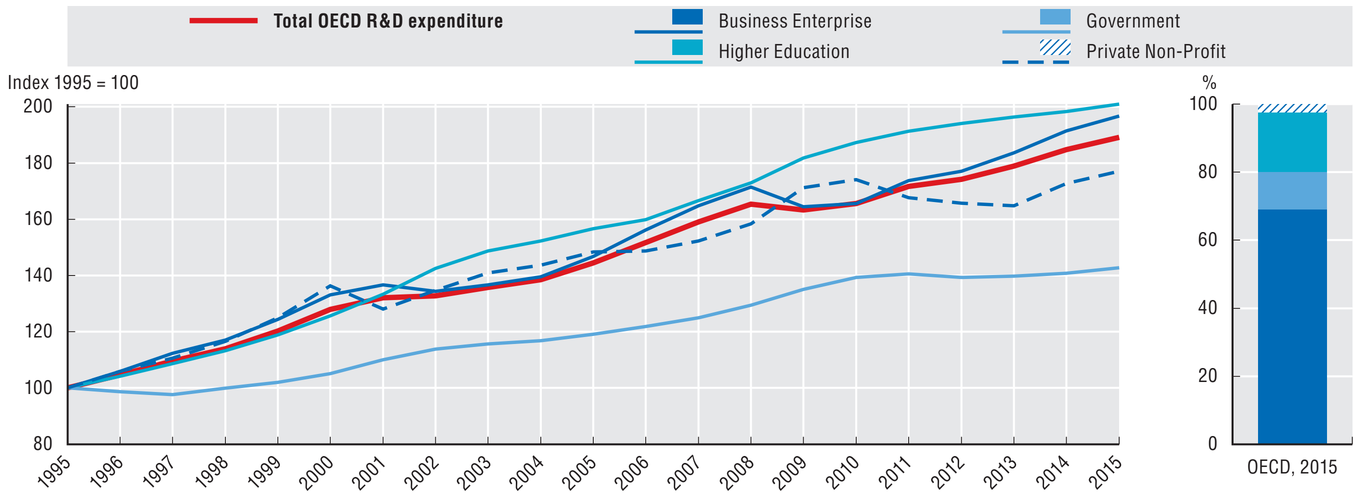
Figure 11 depicts the area or country share of the world's top 10% most-cited documents within their class (articles, reviews and conference proceedings) and publication year. For example, more than 30% of top-cited documents are produced by EU-based authors. Figure 12 illustrates the percentage of documents produced within each country that attain a top 10% cited status. For the EU area, this is close to 12%. A citation-based measure of journal influence, the Scimago Journal Rank, has been used to rank documents with identical numbers of citations. Because more recent documents attract fewer citations, values for recent years will be more influenced by this adjustment. The same applies to fields where citations take longer to occur.

R&D trends

Gross domestic expenditure on R&D (GERD) in the OECD area grew 2.3% in real terms from 2014-15 to reach USD 1.14 trillion. This increase furthered the recovery of R&D expenditure in the aftermath of the 2008-09 global and financial crisis. Since 2013, OECD GERD has remained stable as a percentage of GDP at 2.4%. Recent growth has been driven primarily by businesses, which account for around 70% of all R&D. Private non-profit institutions' R&D (which includes most charities) also grew strongly over 2013-15, although this represents only a small share of total R&D (2.4%). Government-performed R&D rebounded slightly, while the pace of growth of R&D undertaken by higher education (the second biggest R&D performing sector) slowed. Among countries covered in the OECD Main Science and Technology Indicators (*http://oe.cd/msti*), R&D intensity was highest in Israel and Korea, the latter of which has experienced fast growth since 2002 – driven primarily by increasing business R&D. This is also the case in China where GERD as a share of GDP surpassed the EU28 share in 2012 and continued to grow towards the OECD level (2.4%), reaching 2.07% in 2015. The higher education sector is a significant contributor to R&D performance in most countries, particularly with respect to fundamental basic research. However, in China, higher education institutions' R&D accounts for only 7% of GERD, markedly below the OECD and EU28 levels (18% and 23%, respectively).

13. R&D expenditures by performing sector, OECD area, 1995-2015

Constant price index (USD PPPs 1995 = 100) and share of GERD in 2015

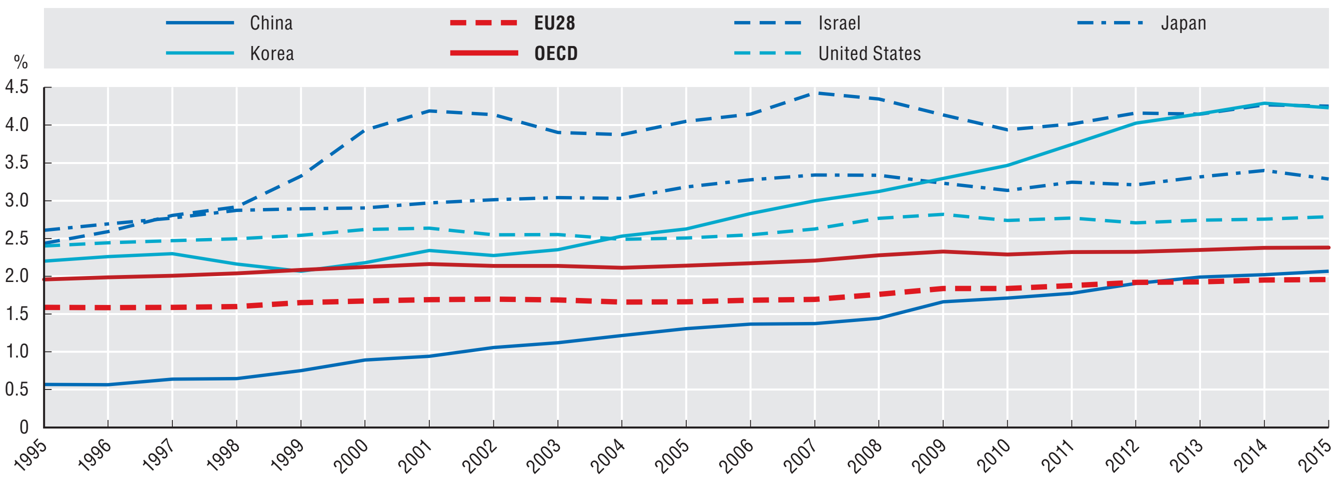


Source: OECD, Main Science and Technology Indicators Database, *http://oe.cd/msti*, July 2017. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933617092

14. Trends in total R&D performance, OECD and selected economies, 1995-2015

As a percentage of GDP



Source: OECD, Main Science and Technology Indicators Database, *http://oe.cd/msti*, July 2017. See chapter notes.

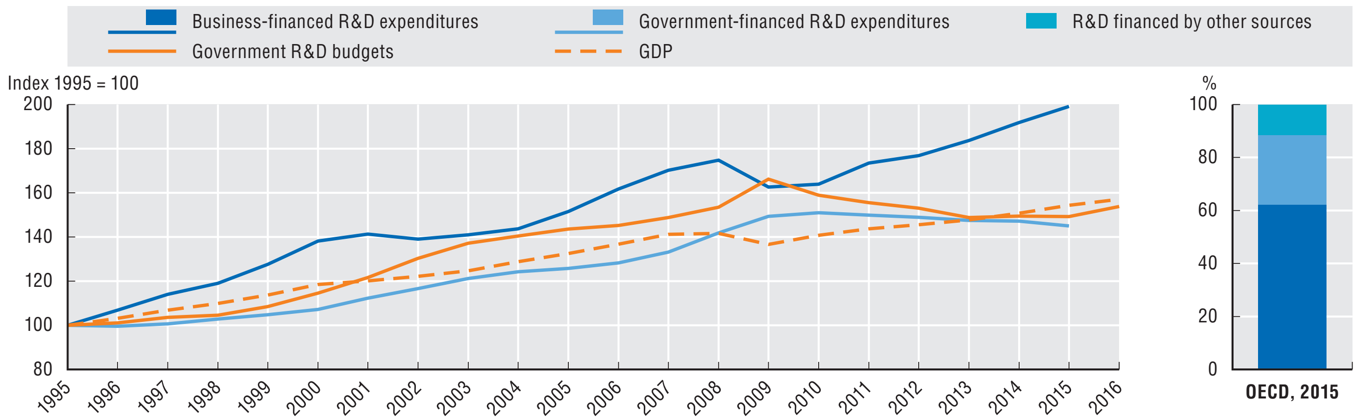
StatLink http://dx.doi.org/10.1787/888933617111

R&D trends

As with other types of investment, expenditures on R&D and innovation are pro-cyclical (positively related to economic performance). Business-financed R&D is particularly affected by varying finance availability and aggregate demand. The major drop in GDP and business R&D in 2008-09 was partly balanced by growing government-funded R&D. Since 2010, business-funded R&D has recovered, while direct government funding of R&D has declined – mainly due to budget consolidation policies. Since 1985, the three types of R&D have evolved differently: applied research and experimental development, which account for most of R&D expenditure (21% and 62% of GERD, respectively, in 2015; reaching a combined 95% in China) have more than doubled in real terms since 1985. Basic research (17%) has nearly quadrupled over the same period, driven by sustained growth in R&D within higher education. Considerable differences across sectors and countries underlie the general trends presented. For example, relative increases in business-performed basic research are also a factor in some countries including the United States, which has seen this rise from 3% to 5% of GERD between 2005 and 2015.

15. R&D expenditures over the business cycle by source of financing, OECD area, 1995-2016

Constant price index (USD PPPs 1995 = 100) and share of GERD in 2015

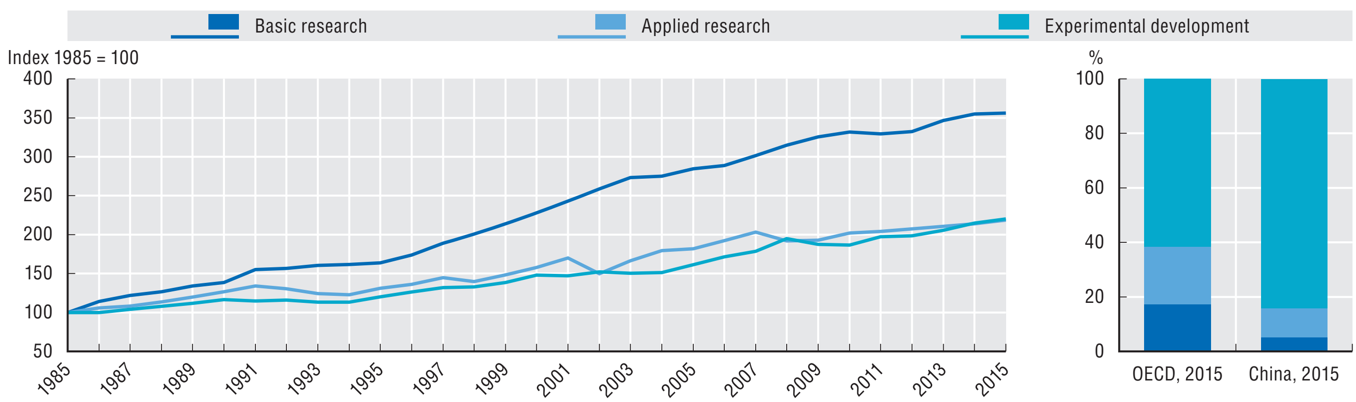


Source: OECD, Main Science and Technology Indicators Database, *http://oe.cd/msti*, July 2017. See chapter notes.

StatLink *http://dx.doi.org/10.1787/888933617130*

16. Trends in basic and applied research and experimental development in the OECD area, 1985-2015

Constant price index (USD PPPs 1985 = 100) and share of GERD in 2015



Note: The index has been estimated by chain-linking year-on-year growth rates that are calculated on a variable pool of countries for which balanced data are available in consecutive years and no breaks in series apply.

Source: OECD, calculations based on Main Science and Technology Indicators Database, *http://oe.cd/msti* and Research and Development Statistics database *http://oe.cd/rds*, June 2017. See chapter notes.

StatLink *http://dx.doi.org/10.1787/888933617149*

Measuring R&D and its components

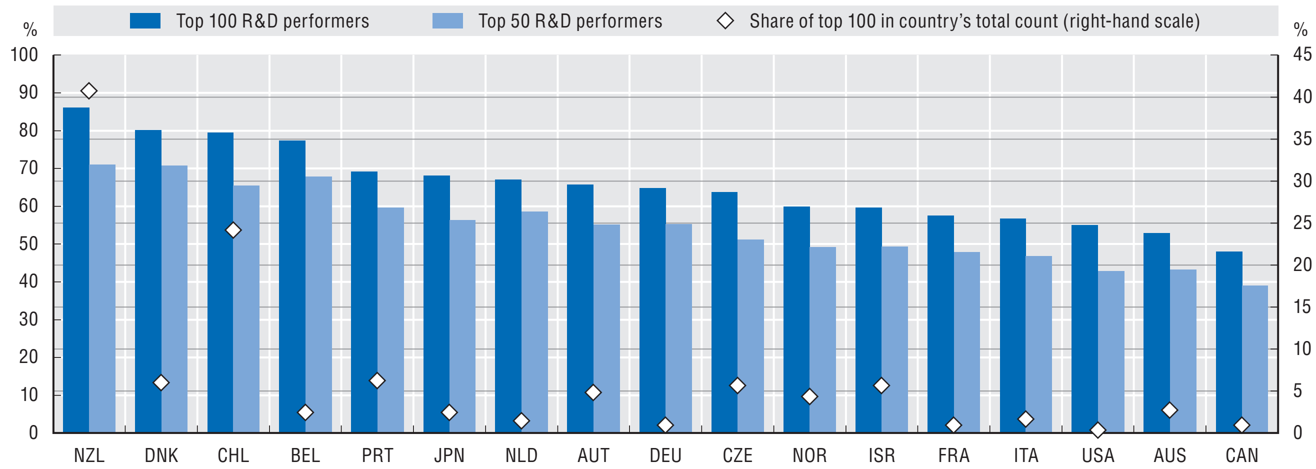
R&D activity is measured by summing all relevant expenditures incurred in performing R&D as defined in the *Frascati Manual* (OECD, 2015a). R&D comprises basic research (creating new knowledge with no specific application in view), applied research (creating new knowledge with a specific practical aim), and experimental development (of new products or processes). Separating these components is challenging in some countries and sectors, leading to coverage gaps. Financial incentives, especially government funding decisions and priorities, may also affect survey respondents' reporting of R&D projects as basic or applied research, impacting measures of sector and/or industry specialisation in different types of R&D.

Concentration of business R&D

R&D is a highly concentrated activity: within countries a small number of firms are responsible for a large proportion of total business R&D (BERD). This is corroborated by a new analysis of R&D performance across a number of OECD countries at the enterprise level. The 50 largest domestic R&D performers account for 40% of BERD in Canada and the United States, 55% in Germany and Japan, and 70% in Denmark and New Zealand. Broadening the analysis to the top 100 R&D performers leads to a relatively moderate increase in the cumulative share of BERD accounted for by large R&D performers. These figures should be considered in relation to the size of the country and the total number of business R&D performers. In New Zealand, for example, the top 50 performers represent 4% of all R&D performing enterprises, whereas in France or Germany they represent a much smaller fraction. Understanding the concentration of business R&D has immediate implications for the allocation and potential targeting of public support for business R&D, which is prone to be skewed towards large R&D performers.

17. Concentration of business R&D: top 50 and top 100 performers, 2014

As a percentage of domestic business R&D expenditure and of total count of performers



Source: OECD, based on preliminary results from the OECD microBeRD project, *http://oe.cd/microberd*, July 2017. See chapter notes.

StatLink *http://dx.doi.org/10.1787/888933617168*

microBeRD: the OECD microdata project on impact and incidence of public support for business R&D

The OECD has launched the microBeRD project to analyse the extent and impact of public support for business R&D at the micro level. microBeRD seeks to facilitate policy learning by exploring the wide heterogeneity in companies' eligibility and use of government support – both within and across countries. The project adopts a coordinated, distributed approach to the analysis of microdata across different jurisdictions, undertaken in collaboration with national experts with access to R&D and public support microdata. The majority of these experts already collaborate with the OECD on longstanding activities to set measurement standards for R&D and develop internationally comparable aggregate R&D indicators.

The use of a common, adaptable code facilitates consistent, multi-country analysis of heterogeneity in the uptake and impact of public support for business R&D across firms. This approach also preserves data confidentiality (only aggregated, non-disclosive data are shared with OECD), while addressing questions that cannot be explored through analysis within a single country or with publicly available data sources alone.

A series of indicators derived from R&D microdata can inform the policy analysis of markets and policy drivers of R&D performance and their impacts. Indicators on the concentration of R&D performance within OECD countries can help understand the role of competition, for example, through comparison with other measures of economic concentration at industry or country level. Furthermore, a comparison of the actual concentration of R&D performance with microdata-based measures of the concentration of public support for R&D can help identify the existence of potential biases and consistency with the stated rationales for allocating support. While it is broadly acknowledged that R&D is a highly concentrated activity, there is only limited internationally comparable evidence available on the degree of R&D concentration within OECD countries. microBeRD seeks to help close this evidence gap.

For more information on the microBeRD project, see *http://oe.cd/microberd*.

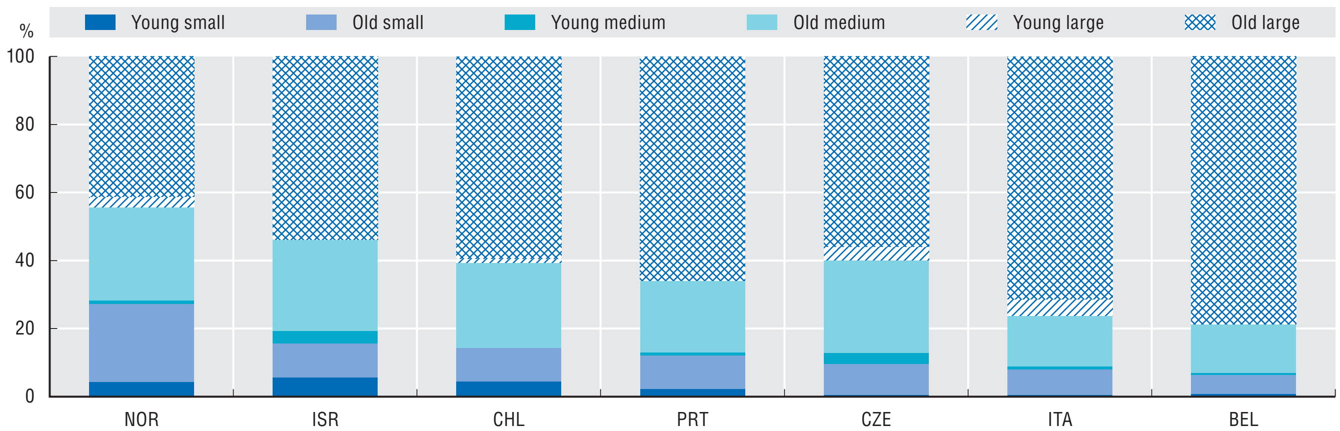
Concentration of business R&D

While large firms account for the bulk of business R&D in most of the countries considered, small and medium-sized firms still account for a significant share of BERD, ranging from 21% in Belgium to 56% in Norway. Within each size category, most R&D is performed by firms established five or more years ago. With the exception of the Czech Republic and Italy, most of the R&D performed by younger firms (established less than five years ago) is attributable to small companies with 10-49 employees, *vis-à-vis* medium-sized (50-249 employees) and large (250 and more employees) enterprises. The countries with the largest share of R&D performed by younger firms are Israel (9.3%), Norway (8.6%) and the Czech Republic (7.6%).

Across countries, there are significant differences in the extent to which firms of different size and age rely on external sources of R&D funding. In Belgium and Norway, external sources of funding account on average for at least 15% of R&D expenditure in every size and age category, while in the Czech Republic and Israel, external sources make up less than 7%. Overall, small R&D performers tend to rely more heavily on external R&D funding. Government funding is particularly important for small R&D performers, while its relative importance for young versus old small companies varies across countries. Funds from abroad play a more important role for medium-sized and large R&D performers.

18. Business R&D performance by size and age, 2014

As a percentage of domestic business R&D expenditure

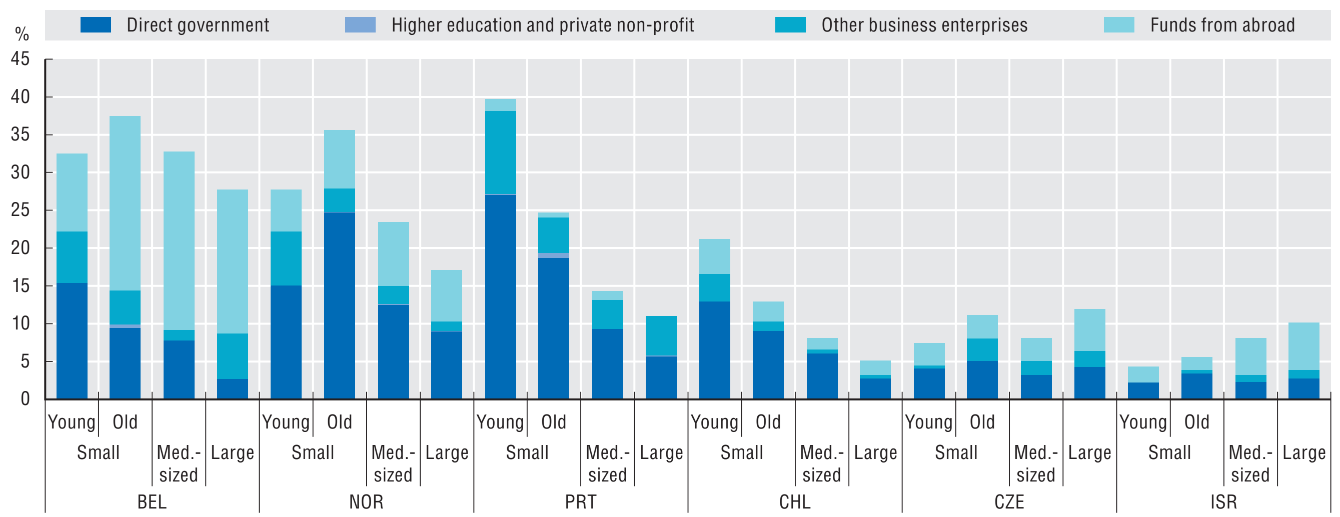


Source: OECD, based on preliminary results from the OECD microBeRD project, *http://oe.cd/microberd*, July 2017. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933617187

19. External sources of R&D funding by firm size and age, 2014

Share in intramural R&D expenditure, weighted average



Source: OECD, based on preliminary results from the OECD microBeRD project, *http://oe.cd/microberd*, July 2017. See chapter notes.

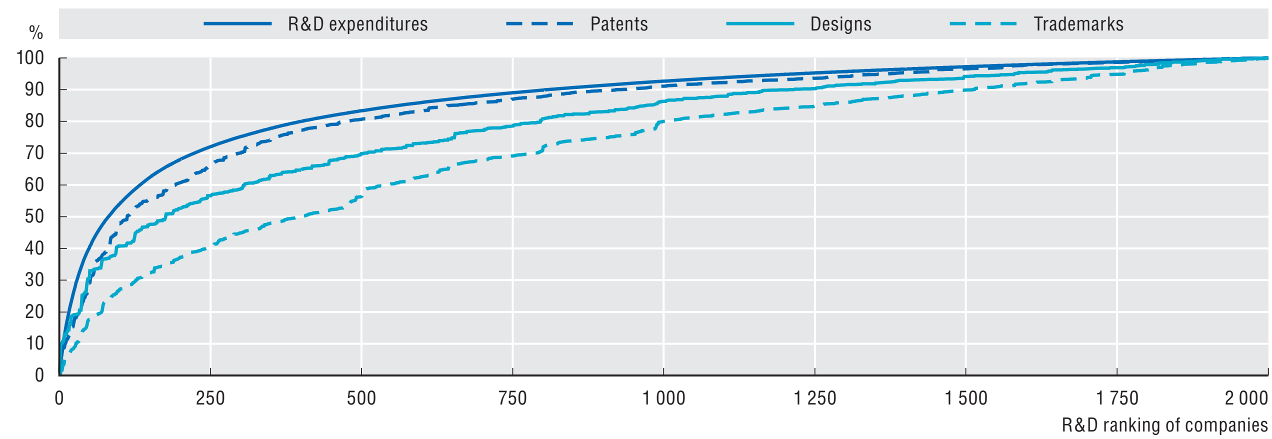
StatLink http://dx.doi.org/10.1787/888933617206

Top corporate R&D players

Top corporate R&D investors are companies at the technology frontier that account for a substantial amount of innovation-related investment and output. Their headquarters are concentrated in a few economies, in particular the United States, Japan and China. On average, each top 2 000 R&D investor has affiliates in 21 economies and is active in 9 different industries. R&D expenditure as well as innovative output in the form of patents and trademarks also appears to be highly concentrated. In 2014, the top 10% of these corporate R&D investors (i.e. the top 200 companies with their affiliates) accounted for about 70% of R&D expenditure, 60% of IP5 patent families (inventions patented in the five top IP offices), 53% of designs and 38% of trademarks. Industry-specific dynamics, product complexity and market differentiation strategies, among others, help to explain differences among companies in the use of intellectual property types. Top R&D investors play a leading role in the development of digital technologies. They account for the ownership of about 75% and 55% of global ICT-related patents and designs, respectively, while about 21% of their affiliates operate in ICT industries, on average. Patents protecting ICT-related developments represent 44% of the total patent portfolio of top R&D investors in the ICT sector. However, the share of ICT-related patents owned by non-ICT corporations varies substantially, reaching 70% or more in the case of companies operating in the "Finance and insurance" and the "Administrative and support services" industries.

20. R&D expenditures and the IP bundle of top R&D companies, 2014

Cumulative percentage shares within the top 2 000 R&D companies

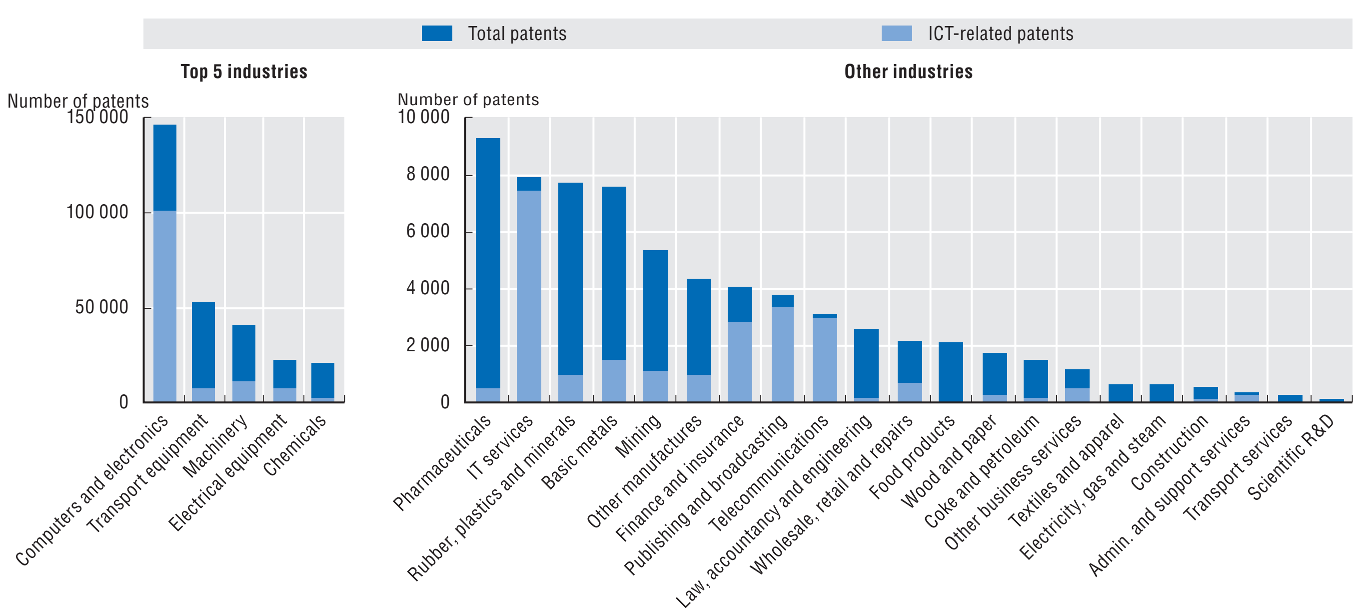


Source: OECD calculations based on JRC-OECD, COR&DIP© Database v.1, July 2017. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933617225

21. Patent portfolio of top R&D companies, by industry, 2012-14

Total and ICT-related IP5 patent families



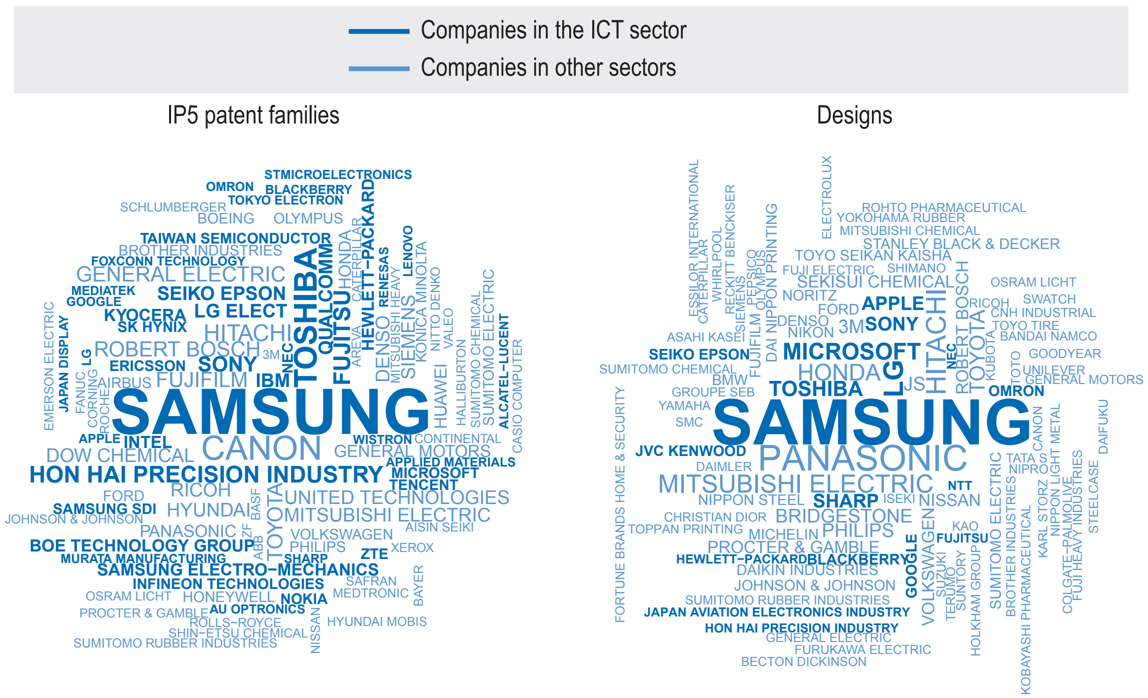
Source: OECD calculations based on JRC-OECD, COR&DIP© Database v.1, July 2017. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933617244

Top corporate R&D players

Top corporate R&D investors in the "Computers and electronics" industry are, by far, the most reliant on intellectual property (IP) rights and account for about one-third of total patent filings by top R&D investors. "Transport equipment", "Machinery and Chemicals" are also emerging as patent-intensive industries. Companies differ in the extent to which they rely on various IP assets. Among ICT corporations, top R&D investors such as Samsung or Sony rely on patents and designs to almost the same extent, while others such as Fujitsu and Toshiba rely more on technological developments than design, and yet others, e.g. Microsoft and Apple place a greater emphasis on design than patents.

22. Top corporate R&D with IP, 2012-14



Source: OECD calculations based on JRC-OECD, COR&DIP© Database v.1, July 2017. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933617263

How to read the word clouds

The word clouds are assembled using information about the distribution of patent and design portfolios of top corporate R&D investors. The font size of the company names reflects the relative size of the patent or design portfolios of the company *vis-à-vis* those of other companies in the sample. The names of top corporate R&D investors active in the ICT sector appear in dark blue bold characters, whereas those from other sectors are shown in light blue. The position and orientation (i.e. vertical vs horizontal) of names in the word clouds has no meaning, aside from ensuring that the names are clearly visible.

Who are the world's top corporate R&D investors?

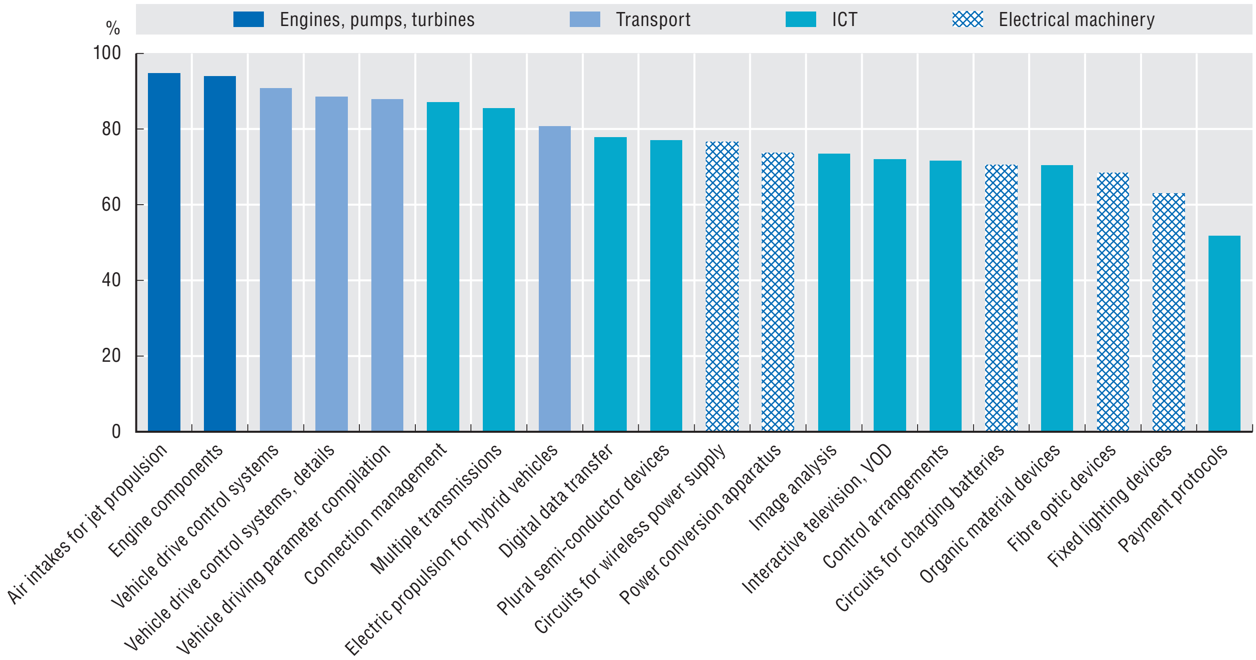
Top R&D investors worldwide are companies that are either parents of (a number of) subsidiaries or independent entities. In the former case, the R&D spending figure used for the ranking is that which appears in consolidated accounts and includes spending made by subsidiaries. Among top R&D investors in 2014, 82% of the companies also appear in the 2012 list (see Dernis et al., 2015). Notable differences between the lists include a smaller number of 'Computer and electronics' companies and a higher number of 'Pharmaceuticals' corporations in 2014, as compared to 2012. Asia-based companies emerge as the biggest patent assignees among the sample. Out of the top 50 IP5 assignees, 30 are headquartered in Asia of which 19 are located in Japan and 6 in Korea. Top R&D investors headquartered in the European Union, the United States and Japan specialise in a relatively broad number of technologies. EU and US companies often focus on technologies that play a fundamental role in addressing key societal challenges, such as health or the environment. Companies headquartered in China and Korea specialise almost exclusively in ICT-related technologies. More than half of top R&D investors employ the full IP bundle (patents, trademarks and designs). However, IP strategies vary depending on the target market and the industry in which the companies operate. More information about these companies and their patenting, design and trademarking activities can be found in Daiko et al. (2017).

Technology at the global frontier

Top corporate R&D investors worldwide lead the development of many emerging technologies. This is evident from an examination of the technology fields in which these companies intensified their inventive activities during 2012-14 and the contribution of top R&D investors to the overall development of these fields. Top corporate R&D investors accelerated their inventive activities in areas such as engines, automated driving systems, and information and communication technologies (ICT) related to connectivity, transmission and digital data transfer. In many of these fields, top R&D corporate investors own 80% or more of the worldwide portfolio of patents related to these technologies.

23. Top 20 emerging technologies developed by top R&D companies, 2012-14

Share of patents owned by top 2000 R&D companies in total IP5 patent families in the field, percentages



Source: OECD calculations based on JRC-OECD, COR&DIP© Database v.1. and OECD, STI Micro-data Lab: Intellectual Property Database, *http://oe.cd/ipstats*, July 2017. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933617282

In which technologies are top R&D companies leading?

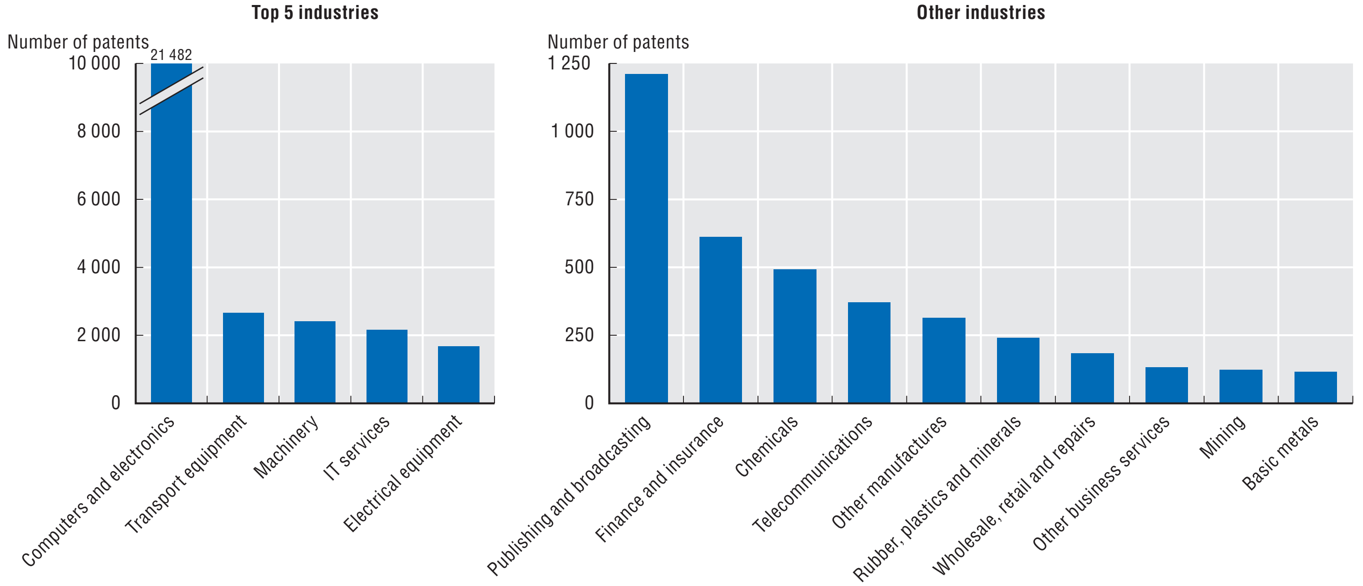
R&D activities undertaken by the world's top corporate R&D investors result in the development of new technologies. The DETECTS methodology (see Dernis et al., 2016, for details) was applied to the portfolio of top 2000 R&D players to highlight technology fields experiencing an accelerated ("bursting") development, compared to other technologies. Patent bursts are sudden and persistent increases in the number of patents in a given field, as compared to those observed in other fields, and are characterised here at the level of International Patent Classification (IPC) groups. The top emerging technologies are defined according to the IPC codes that follow open-ended bursting behaviour, i.e. a rapid acceleration in patenting, from the early 2010s onwards. Artificial intelligence refers to the "Human interface" and "Cognition and meaning understanding" categories in the ICT patent taxonomy as described in Inaba and Squicciarini (2017).

Top players in artificial intelligence

Top 2000 corporate R&D investors own 75% of the IP5 patent families related to artificial intelligence (AI). These investors are not necessarily global companies in the ICT sector; firms in each and every industry contribute to advancing AI, albeit to different extents. In addition to "Computers and electronics", which accounts for 64% of the AI portfolio of top R&D players, corporations operating in "Transport equipment" and "Machinery" are responsible for high levels of inventive activities in the AI domain over the period considered (almost 1000 patents a year, on average). The development of AI technologies is fairly concentrated. R&D corporations based in Japan, Korea, Chinese Taipei and China account for about 70% of all AI-related inventions belonging to the world's 2000 top corporate R&D investors and their affiliates, and US-based companies for 18%.

24. Artificial intelligence patents by top 2 000 R&D companies, by sector, 2012-14

Number of IP5 patent families, top 20 industries

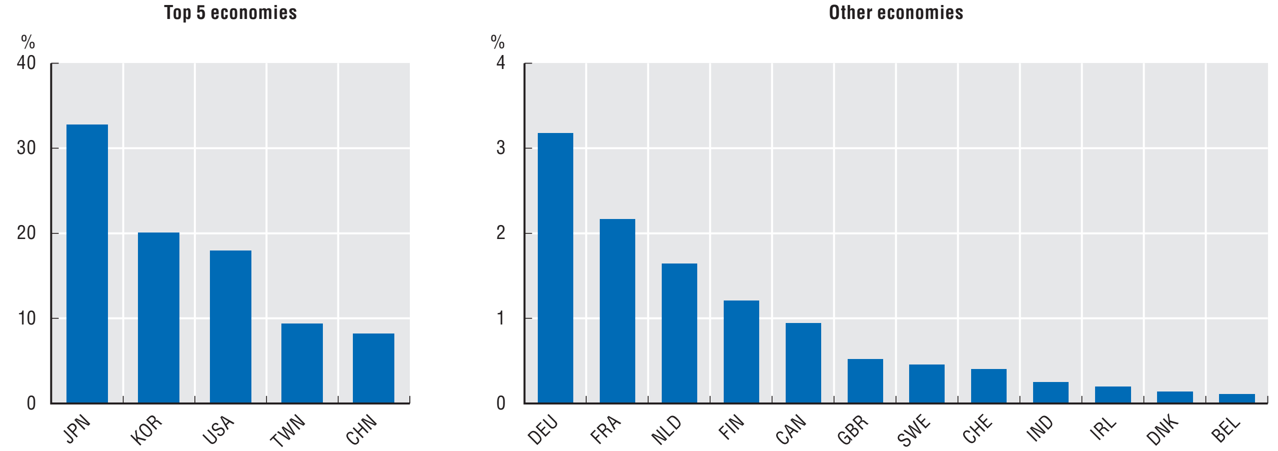


Source: OECD calculations based on JRC-OECD, COR&DIP© Database v.1. and OECD, STI Micro-data Lab: Intellectual Property Database, *http://oe.cd/ipstats*, July 2017. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933617301

25. Artificial intelligence patents by top R&D companies, by headquarters' location, 2012-14

Share of economies in total AI-related IP5 patent families owned by top 2 000 R&D companies



Source: OECD calculations based on JRC-OECD, COR&DIP© Database v.1. and OECD, STI Micro-data Lab: Intellectual Property Database, *http://oe.cd/ipstats*, July 2017. StatLink contains more data. See chapter notes.

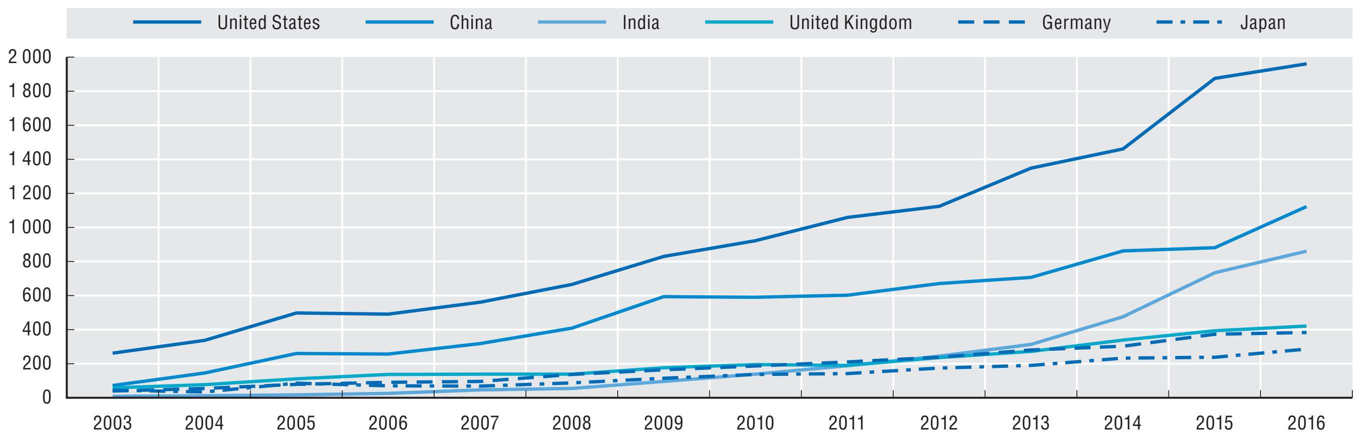
StatLink http://dx.doi.org/10.1787/888933617320

Research in machine learning

Research in the field of artificial intelligence (AI) has aimed for decades to allow machines to perform human-like cognitive functions. Breakthroughs in computational power and systems design have raised the profile of AI, with its outputs increasingly resembling those of humans. Such advances enabled IBM's Deep Blue computer to beat world chess champion Garry Kasparov in 1997 and allowed computers to distinguish between objects and text in images and videos. A key driver has been the development of machine learning (ML) techniques. ML deals with the development of computer algorithms that learn autonomously based on available data and information. Drawing on the power of "big data" sources, algorithms can deal with more complex problems that were assailable only to human beings. Experimental bibliometric analysis shows remarkable growth in scientific publications related to ML, especially during 2014-15. The United States leads in this area of research both in terms of total publications and highly cited ones. Also worthy of note is the fast growth experienced by India, now the third largest producer of scientific documents on ML after China and fourth behind the United Kingdom on a quality-adjusted basis.

26. Trends in scientific publications related to machine learning, 2003-16

Economies with the largest number of ML documents, fractional counts

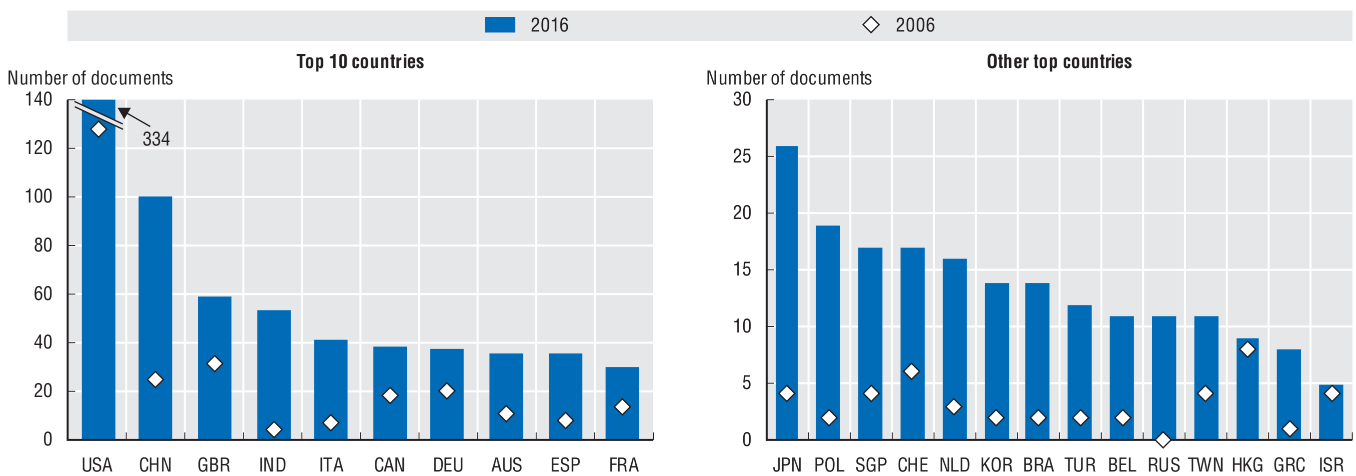


Source: OECD calculations based on Scopus Custom Data, Elsevier, Version 4.2017, July 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933617339

27. Top-cited scientific publications related to machine learning, 2006 and 2016

Economies with the largest number of ML documents among the 10% most cited, fractional counts



Source: OECD calculations based on Scopus Custom Data, Elsevier, Version 4.2017; and 2015 Scimago Journal Rank from the Scopus journal title list (accessed June 2017), July 2017. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933617358

Which scientific documents have been identified as related to machine-learning?

These experimental estimates are based on a search for the text item "*machine learn*" in the abstracts, titles and keywords of documents published up to 2016 and indexed in the Scopus database. The accuracy of this approach depends on the comprehensiveness of abstract indexing, which implies a bias towards English-speaking journals. In a survey by Kalantari et al. (2017) of 142 big data experts asking for relevant keywords on big data research, "machine learning" was identified as relevant in 29% of cases. From the identified list of keywords, machine learning was retrieved in 40% of the 11 000 documents identified in the Web of Science database, covering the period 1980–2015, making this the most frequent category above "Data centre", "Big data" and "Data warehouse".

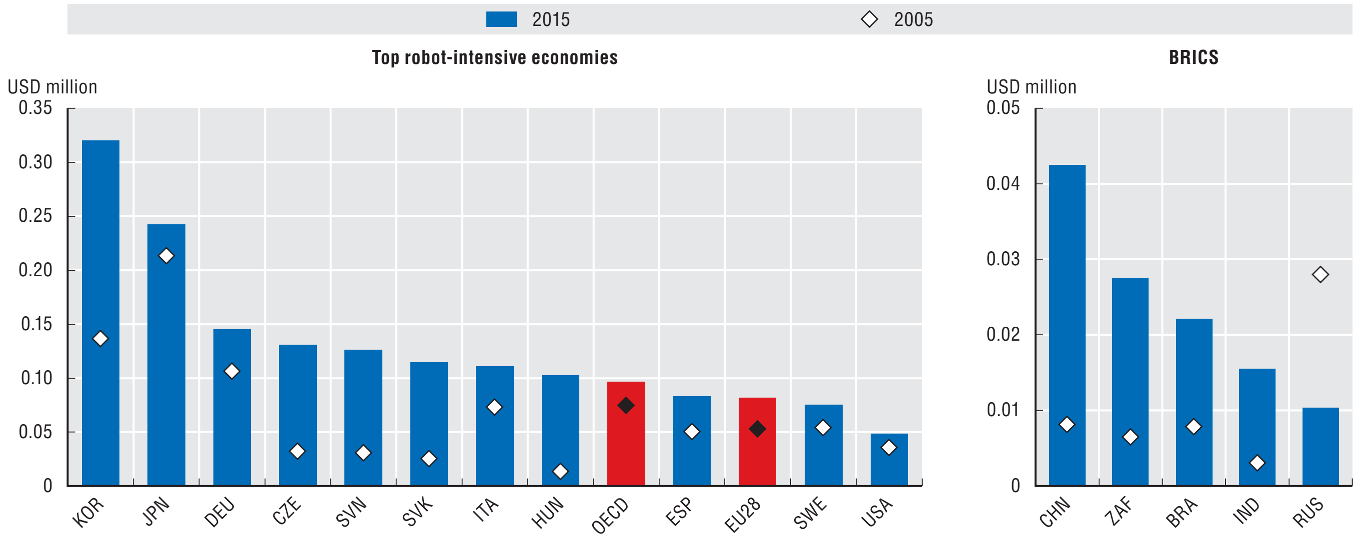
2. Growth, jobs and the digital transformation

Robotisation in manufacturing

Production is being transformed by advances in fields such as big data, 3D printing, machine-to-machine communication and robots. Comparable and representative data for 2015 on the deployment of industrial robot technologies, for example, show that Korea and Japan lead in terms of robot intensity (i.e. the industrial stock of robots over manufacturing value added). Robot intensity in these economies is about three times that of the average OECD country. Selected Eastern European countries also emerge as intensive robot users, perhaps mirroring their specialisation within manufacturing value chains and their possible role as suppliers of large multinational corporations. Robot intensity in Czech Republic, Hungary, the Slovak Republic and Slovenia has increased three to six times since 2005, considerably above the average growth rate for OECD or EU28 countries (+29% and 54%, respectively). Robot intensity in BRICS economies has also increased, while remaining relatively low compared to OECD countries. In particular, robot intensity in China increased from 23% to 88% of that of the United States. However, these figures should be interpreted with caution, since the indicators are based on the quantity of robots active in an economy at a specific moment and do not capture changes in the effectiveness or quality of robots over time.

28. Top robot-intensive economies and BRICS, 2005 and 2015

Industrial robot stock over manufacturing value added, millions USD, current values



Source: OECD calculations based on International Federation of Robotics data, and the World Bank, Word Development Indicators Database, September 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933617377

What is an industrial robot?

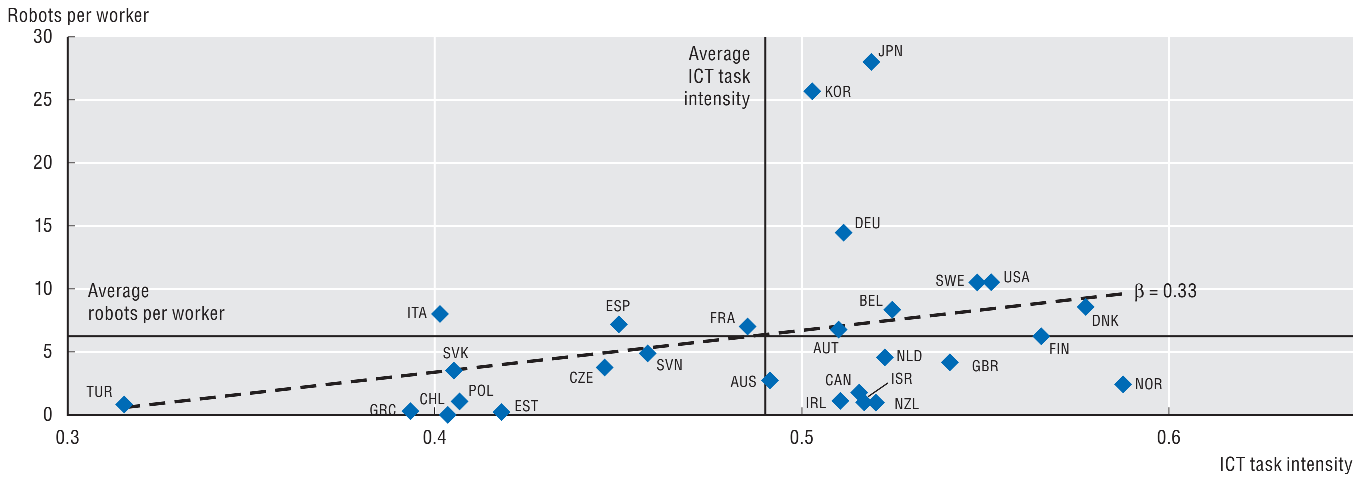
An industrial robot is defined by ISO 8373:2012 as "an automatically controlled, reprogrammable, multipurpose manipulator programmable on three or more axes, which can be either fixed in place or mobile for use in industrial automation applications". The International Federation of Robotics (IFR) collects information on shipments (counts) of industrial robots from almost all existing robot suppliers worldwide. The measure of the stock of robots displayed above has been calculated by taking the first-year stock value from the IFR, adding the sales of robots for subsequent years and assuming an annual depreciation rate of 10%. As a consequence, these metrics do not capture increases in the value of robots or their ability to perform tasks (i.e. no equivalent for horsepower exists for robots). These figures are restricted to manufacturing, mining, construction and utilities, as IFR data obtained by the OECD do not include robots used in services industries other than the R&D sector.

Robotisation in manufacturing

In addition to catalysing growth, technological innovations may have disruptive effects with far-reaching consequences on many domains, including productivity, employment and well-being. Some fear that the increasing use of robots may result in significant loss of jobs, particularly in the case of industrial robots which are designed to carry out tasks otherwise performed by humans. Recent studies find that robots do improve productivity, but that their impact on employment and wages is ambiguous. The figure below shows that the use of robots may complement the use of other technologies, because robots (while not classified as ICT tools) rely on ICT, e.g. software, for their functioning. Workers will therefore need the ICT skills to be able to operate them. The correlation between ICT use on the job and robot intensity emerges as positive, albeit not strong, and points to complementarity between technological and human capital investment to implement transformative industrial processes. As these data relate to the use of robots in manufacturing, economies characterised by relatively larger manufacturing sectors have higher than average robot intensities. Some, including Japan, Korea, Germany and the United States, display above average intensities for both robots and ICT tasks. Conversely, economies where services sectors are relatively more important (e.g. the United Kingdom, Ireland and the Netherlands) tend to display above average ICT task intensities, but a lower than average number of robots per worker.

29. Robot intensity and ICT task intensity of manufacturing jobs, 2012 or 2015

Correlation of robots per worker and average ICT task intensity



Source: OECD calculations based on OECD Programme for International Assessment of Adult Competencies (PIAAC) Database and International Federation of Robotics, September 2017. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933617396

How to measure ICT task intensity

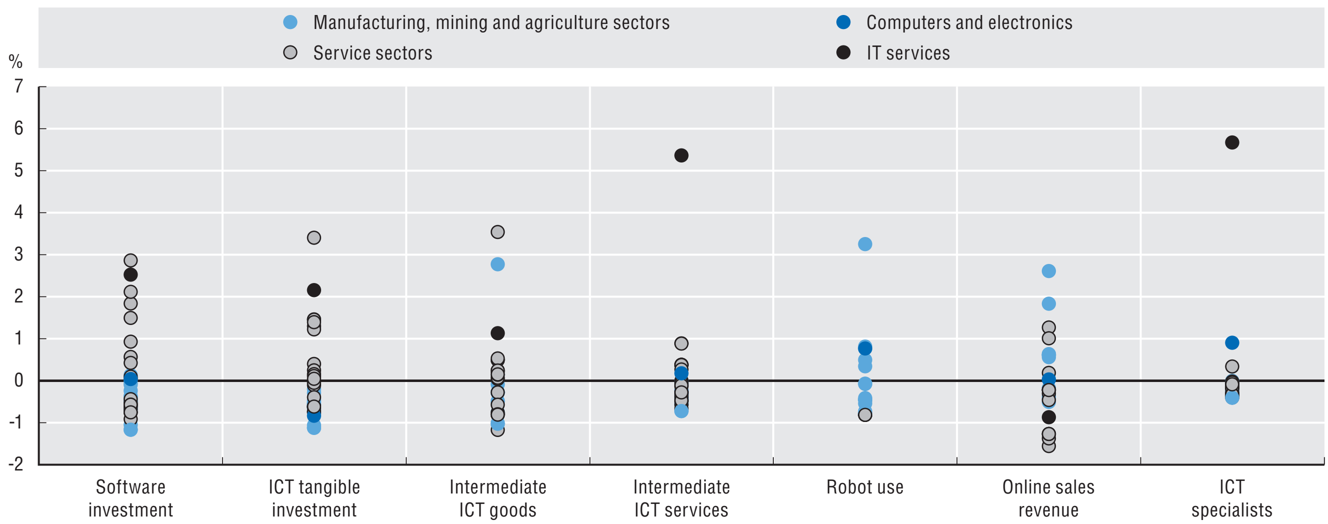
Recent OECD analysis has developed an indicator of the ICT task intensity of occupations (Grundke et al., 2017), based on information from the OECD Programme for the International Assessment of Adult Competencies (PIAAC). Compared to earlier studies, this approach helps to distinguish between the tasks that workers perform on the job and the skills with which they are endowed. The indicator reflects the extent to which workers perform tasks ranging from simple use of the Internet to the use of Word or Excel software or a programming language. Not all countries in Figure 28 are reported in Figure 29, because they do not appear in the PIAAC dataset and consequently lack a corresponding measure of ICT task intensity.

Industries' digital maturity

Due to their pervasive nature, digital technologies are profoundly transforming economies and societies. The innumerable ways in which the digital transformation is affecting production activities, manufacturing and services impede efforts to provide an encompassing definition of this multifaceted phenomenon. Recent OECD work assesses the digital content of sectors by looking at digitalisation in its technological component (tangible and intangible ICT investment, purchases of intermediate ICT goods and services, robots), the human capital required to embed technology in production (ICT specialist intensity), and the ways in which it changes how firms interface with the market (online sales). While the digital transformation progressively touches all sectors in the economy, it does so in different ways and to various extents across sectors. Some sectors, however, stand out across several dimensions. "IT and other information services" ranks among the top three sectors for all indicators, where such information is available, with the exception of online sales. However, its manufacturing equivalent (i.e. the Computer, electronic and optical equipment sector), does not stand out from other sectors.

30. Dispersion of sectors in each considered dimension of digitalisation, 2013-15

Values averaged across countries and years, and standardised across sectors



Source: OECD calculations based on Annual National Accounts, STAN, ICIO, PIAAC, International Federation of Robotics, World Bank, Eurostat Digital Economy and Society Statistics, national Labour Force Surveys, US CPS, INTAN-Invest and other national sources. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933617415

How to read this figure

Each dot represents a sector. For each indicator, a sector's value is obtained averaging the values across years and countries. The graph then plots the standardised values across sectors, so that the average sector has value zero. The blue dots represent manufacturing sectors, and the grey ones represent services industries. The darker blue and grey dots represent ICT manufacturing and ICT services sectors, respectively.

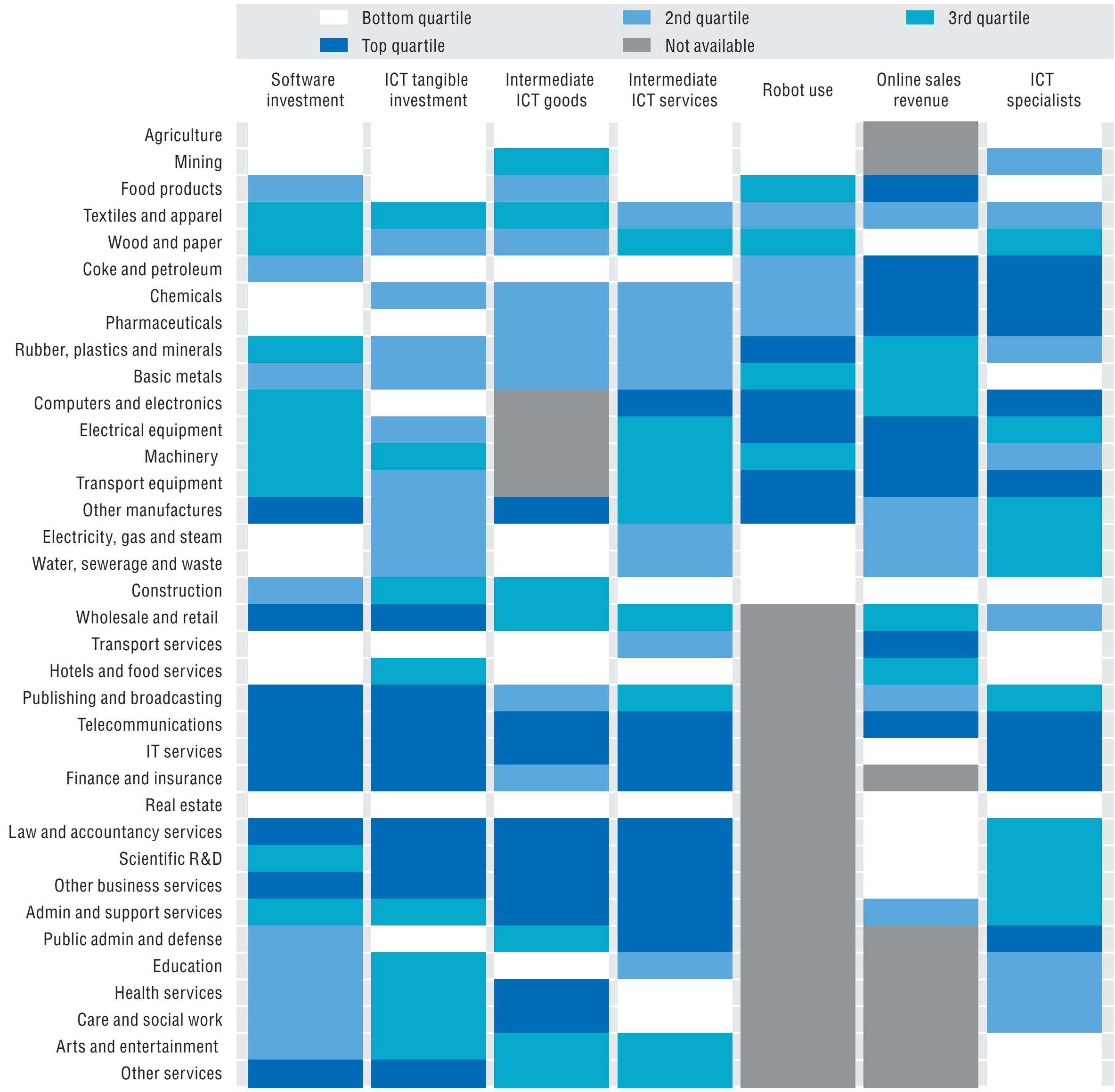
Measuring the digital transformation in sectors: A multidimensional approach

Recent OECD work (Calvino et al., forthcoming) develops a taxonomy of sectors by their digital content, taking into consideration a multiplicity of dimensions. All indicators are expressed as sectoral intensities. "Software and ICT tangible investment" is the ratio of Gross Fixed Capital Formation (GFCF) in ICT and software over total GFCF, both in volumes. "Intermediates" represents the ratio of intermediate ICT goods or services purchased by the sector to the purchasing sector's output, both in real terms. "Robot use" refers to the stock of robots divided by employment in the sector. "Online sales" measures the proportion of turnover coming from online sales. "ICT specialists" relates to the proportion of ICT specialists in total employment. The taxonomy is based on information for the following countries: Australia, Austria, Denmark, Finland, France, Italy, Japan, the Netherlands, Norway, Sweden, the United Kingdom and the United States, for which values for all indicators in all considered sectors and years are non-missing, with the exception of "Robot use" and "Online sales", where some sectors are not sampled.

Industries' digital maturity

Sectors generate, adopt and use technologies at different paces and vary in the extent to which they rely on different types of skills. This is true for the wide array of technologies and skills shaping the digital transformation across economies and societies. OECD analysis shows that some sectors are lagging behind others in terms of the pace of are undergoing digital transformation, regardless of the type of indicator used to measure such a transformation. Agriculture, mining and real estate rank in the bottom quartile of digital intensity across all available indicators. Conversely, telecom and IT services rank consistently at the top of the distribution. Sectors in the middle of the overall ranking often display a large heterogeneity, suggesting that they are engaged in the transformation at different rates, depending on the aspects considered.

31. Taxonomy of sectors by quartile of digital intensity, 2013-15



Source: OECD calculations based on Annual National Accounts, STAN, ICIO, PIAAC, International Federation of Robotics, World Bank, Eurostat Digital Economy and Society Statistics, national Labour Force Surveys, US CPS, INTAN-Invest and other national sources. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933617434

How to read this figure

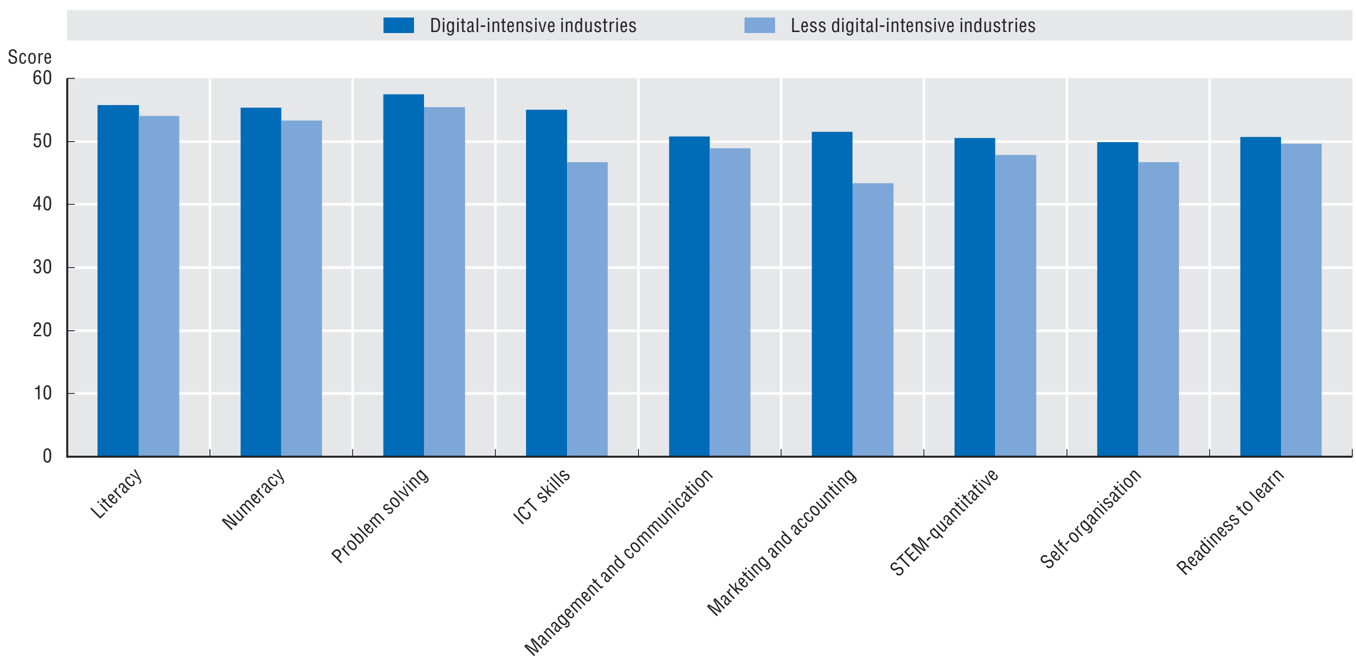
For each indicator, sectors are ranked by their value as an average across countries and years. The sectors with the highest intensity (top quartile) are coloured dark blue, while those with the lowest intensity are coloured white. Data on robot use are not available for services other than utilities and constructions (i.e. all ISIC Rev.4 services above 43), while online sales data are not available for "Agriculture" (Division 1-3), "Mining" (5-9), "Financial services" (64-66) and all sectors numbered above 84 in ISIC. Purchases of ICT intermediate goods by the machinery manufacturing sectors are not considered, to avoid mismeasurement.

What skills for the digital future?

Digitalisation is bringing change to jobs and labour markets across the OECD and beyond. Some jobs are being lost to automation, others will change in their nature and tasks, while new jobs will also emerge as technologies such as artificial intelligence (AI), the Internet of Things (IoT) or big data develop. Workers in industries that are currently most affected by the digital transformation exhibit higher levels of cognitive, as well as non-cognitive and social skills. As the digital transformation unfolds, and increasingly affects other industries that are at present less impacted, the need for solid cognitive skills combined with a good endowment of social skills will continue to increase and extend to the rest of the economy.

32. Skill levels in digital and less digital-intensive industries, 2012 or 2015

Cross country averages



Source: OECD calculations based on the OECD Programme for International Assessment of Adult (PIAAC) Database, June 2017. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933617453

Mapping skills and identifying digital-intensive sectors

This analysis encompasses both cognitive and non-cognitive skills, i.e. skills that are generally only partially learnt at school and that relate to people's attitudes and personality. Measures for non-cognitive skills and social skills have been developed using information about the tasks that workers perform on the job from the OECD Programme for International Assessment of Adult (PIAAC). The mapping exercise has identified six task-based skills that relate to performance on the job and to economic performance, namely: information and communication technologies (ICT)-related skills; science, technology, engineering and mathematics (STEM) and quantitative skills; non-cognitive skills such as managing and communication and self-organisation; and socio-emotional skills such as readiness to learn and creative problem solving (see Grundke et al., 2017)

Digital-intensive and non-digital-intensive industries have been identified by benchmarking sectors across a number of dimensions: the ratio of Gross Fixed Capital Formation (GFCF) in ICT and software over total GFCF; the ratio of intermediate ICT goods or services purchased by the sector to the purchasing sector's output; the stock of robots per employed person; the proportion of sectoral turnover coming from online sales; and the proportion ICT specialists over total employment, by sector (see Calvino et al., forthcoming, for details).

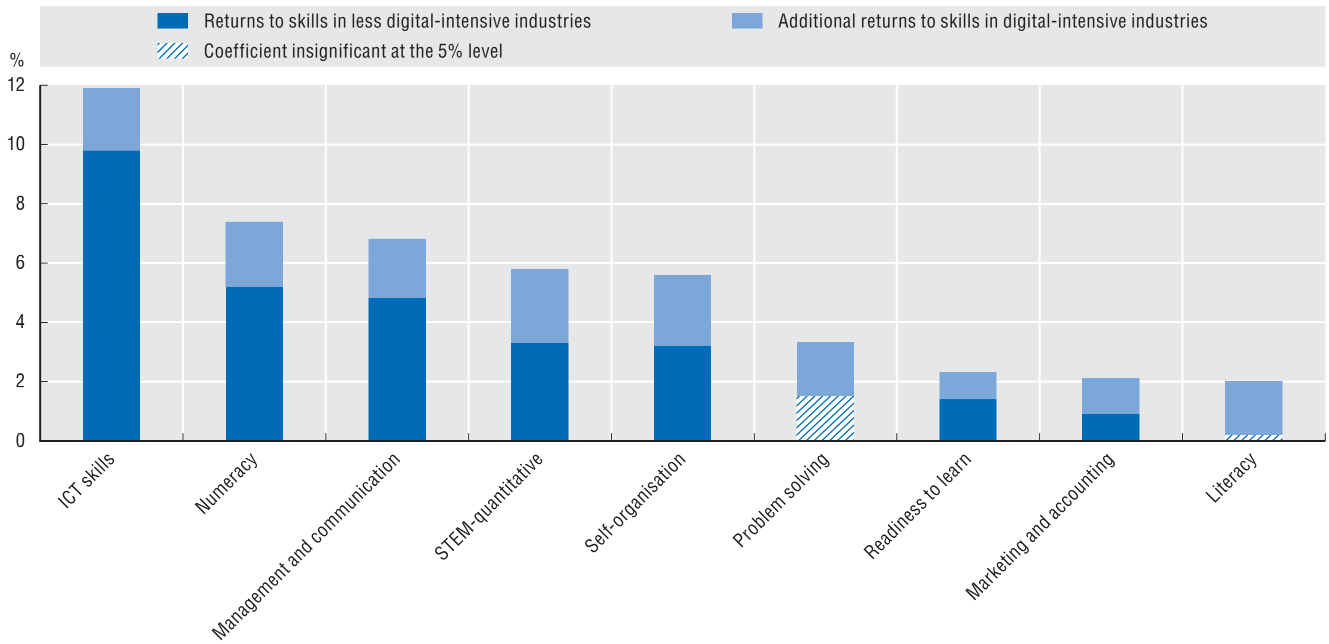
What skills for the digital future?

Understanding which skills are in short supply (and/or high demand) and command a wage premium in digital- or less-digital-intensive industries can help understand what skills matter for the digital transformation.

For a number of skills that are important to firm performance, labour market returns are higher in digital-intensive industries than in less digital-intensive industries. Furthermore, quantitative skills, ICT skills, numeracy and STEM skills as well as self-organisation and management and communication skills seem to be especially important in digital-intensive industries. This may be because workers in those industries operate in a more independent and decentralised fashion (e.g. through teleworking), perform relatively more non-routine tasks, or have to deal with continuously changing settings for which technical skills coupled with communication and organisational skills are increasingly important.

33. Additional labour market returns to skills in digital-intensive industries, 2012 or 2015

Percentage change in hourly wages for a standard deviation increase in skills



Source: OECD calculations based on the OECD Programme for International Assessment of Adult Competencies (PIAAC) Database, June 2017. See chapter notes.

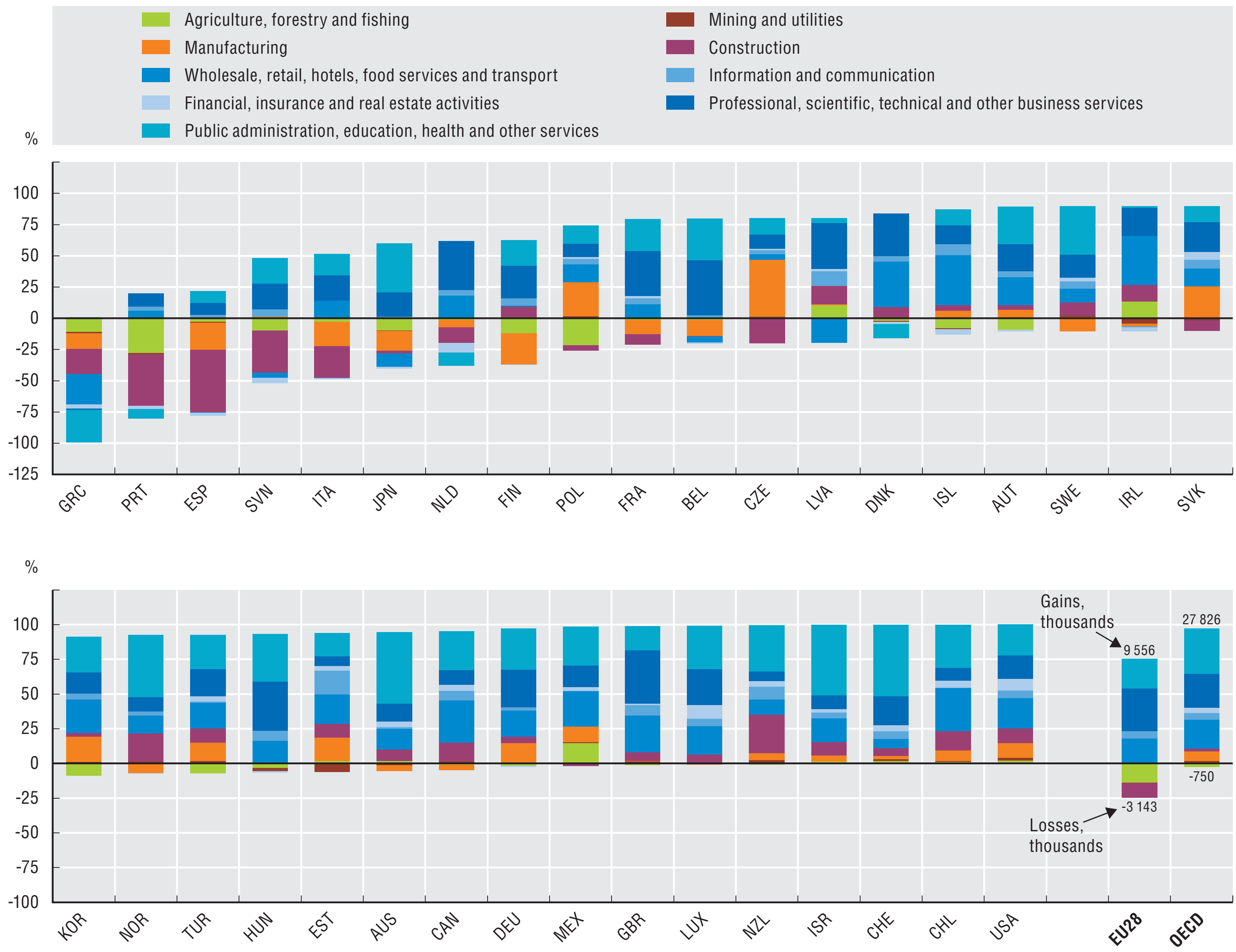
StatLink http://dx.doi.org/10.1787/888933617472

Jobs gained, jobs lost

Between 2010 and 2015, total employment in the OECD area grew by 4.9% (a net gain of about 27 million jobs). This increase was driven mainly by non-EU countries, with NAFTA alone experiencing a net gain of 12.9 million compared to a more modest gain of 3.6 million in the European Union. OECD service sectors accounted for the majority of net gains with an increase of 24.8 million, while manufacturing activities added a further 2 million jobs. In 2016, the European Union experienced solid gains for the third year running, with an overall net gain for the period 2010-16 of 6.4 million jobs, including a notable rise in "Professional, scientific, technical and other business services" (3.9 million jobs). However, this trend masks significant variation with Germany and the United Kingdom both experiencing net gains of about 2.5 million jobs, while Greece, Portugal and Spain struggled to return to pre-crisis levels of employment collectively suffering a net loss of 1.5 million jobs over the same period.

34. Where people gained and lost jobs, 2010-16

Relative contribution to change in total employment by major sectors of economic activity



Note: Data refer to 2010-15 for Israel, Japan, Korea, Mexico, New Zealand and the OECD area aggregate.
Source: OECD calculations based on Annual National Accounts Database, *www.oecd.org/std/na*, Structural Analysis (STAN) Database, *http://oe.cd/stan* and national sources, September 2017. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933617491

How to read these figures

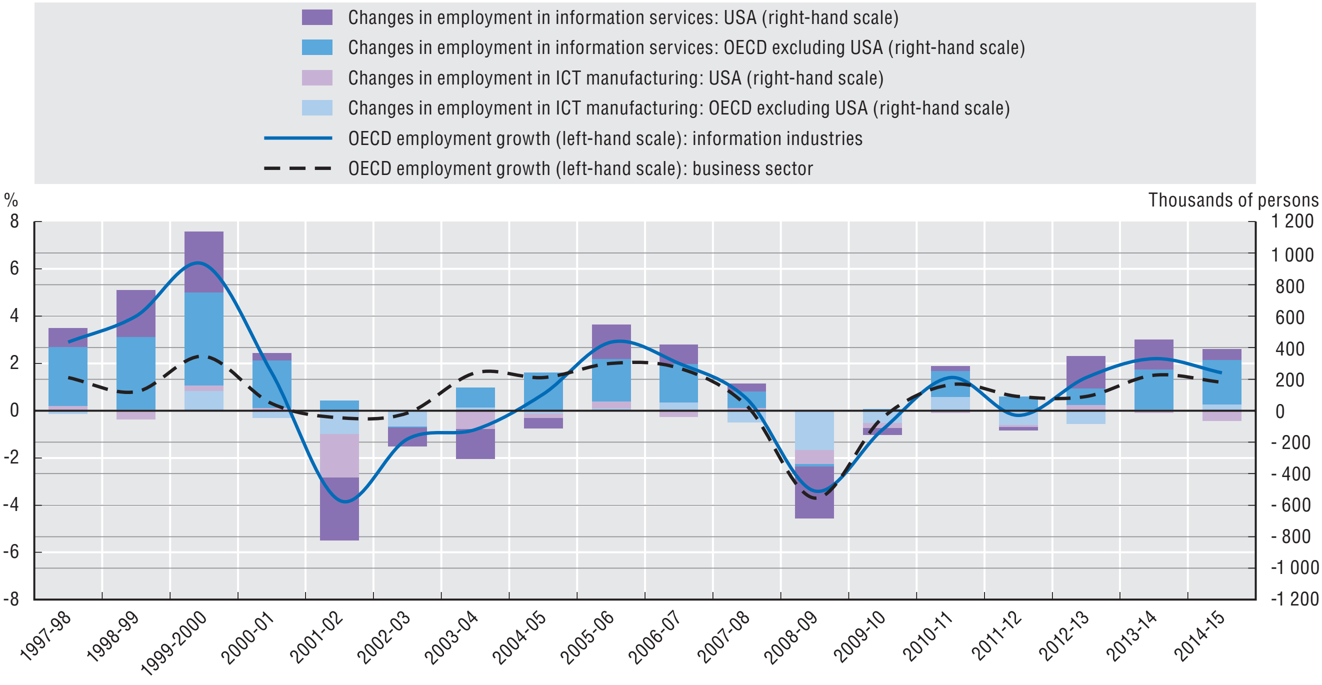
Changes in employment levels by economic activity can be "normalised" to highlight their relative contributions, in each country, to the total change in employment between two periods. This is achieved by expressing the sectoral changes in each country as a percentage of the sum of the absolute changes. The aggregate activity groups are defined according to ISIC Rev.4 classes. The gains and losses represent the sum of those aggregate sectors with positive changes and the sum of those aggregate sectors with negative changes, respectively. Using a finer activity breakdown (e.g. ISIC Rev.4 2-digit Divisions) would produce different estimates for total gains and losses, although the total net change would remain the same.

Jobs gained, jobs lost

The information industries are considered an important source of growth in OECD countries despite accounting for only 5.5% of business sector employment in the OECD area. Between 1997 and 2015, OECD employment in the information industries grew by 18%, higher than growth in business sector employment over the same period (13%). However, employment in the information sector has been susceptible to relatively high volatility over the business cycle since 1997. After the financial crisis, for example, employment in the information industry fell 4.2% between 2008 and 2010 in the OECD area, shedding over 800 000 jobs. The United States now accounts for about 30% of OECD employment in the information industries (from a peak of about 35% prior to 2001), and remains an important driver of changes in OECD information sector employment. Information services dominate in terms of jobs gained, while the ICT manufacturing sector has experienced a reduction in workforce in many OECD countries, including the United States, over the past decade.

35. Employment growth in information industries, OECD, 1997-2015

Annual change in percentage and in thousands of persons



Source: OECD calculations based on Annual National Accounts Database, *www.oecd.org/std/na*, Structural Analysis (STAN) Database, *http://oe.cd/stan* and national sources, June 2017. StatLink contains more data. See chapter notes.

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Definition of information industries

"Information industries" are defined according to ISIC Rev.4 and cover ICT manufacturing: "Computer, electronic and optical products" (Division 26) and, information services: ISIC Rev.4 Divisions 58 to 60 ("Publishing, audio-visual and broadcasting activities"), 61 ("Telecommunications") and 62 to 63 ("IT and other information services"). This definition includes both the ICT sector and the Content and Media sector as defined in OECD (2011). The business sector corresponds to ISIC Rev. 4 Divisions 05 to 66 and 69 to 82 (i.e. Total economy excluding "Agriculture, forestry and fishing" (Divisions 01 to 03), "Real estate activities" (68), "Public administration" (84), "Education" (85), "Human health and social work activities" (86 to 88) and "Arts, entertainment, repair of household goods and other personal services" (90 to 99)).

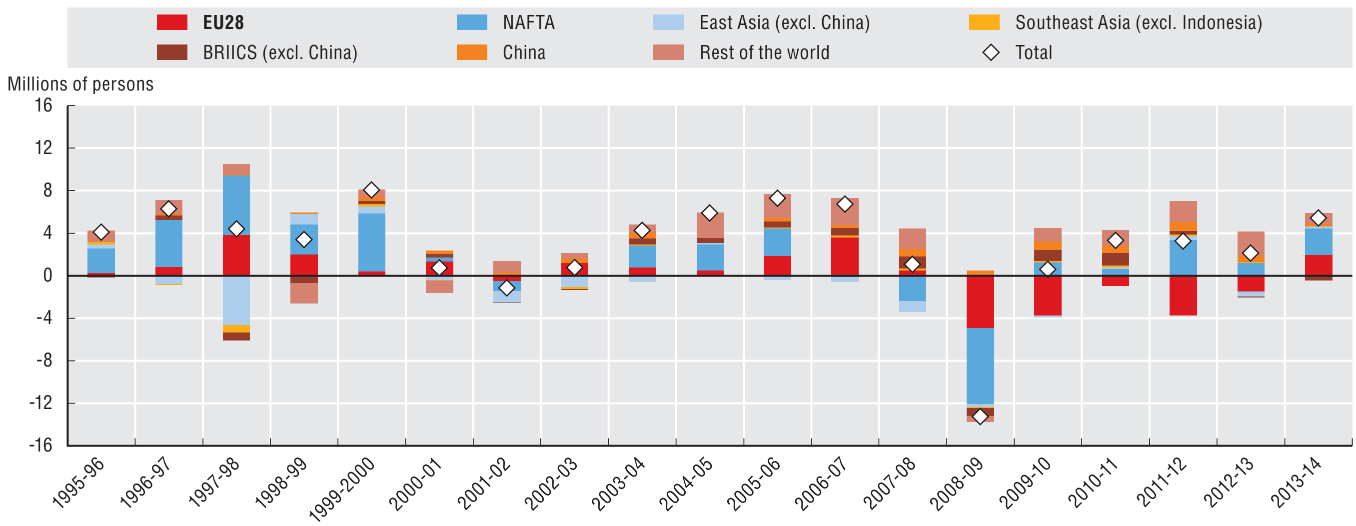
Employment data are drawn mostly from National Accounts (SNA) sources and are measured in terms of persons, except for Canada, Japan and Mexico, which provide figures for jobs. Care should be taken when comparing changes in structural employment in these three countries with the other countries.

Your job depends on my demand for products

Growing economic and political integration worldwide has increased the reliance of employment in one country or region to changes in demand in other countries or regions. The OECD's Inter-Country Input-Output (ICIO) database enables the decomposition of annual changes in OECD employment to account for changes in final demand for goods and services across different countries and regions. For example, the apparent overall increase of about 9.2 million business sector jobs in the OECD area, between 2009 and 2013, masked a fall of about 10 million jobs due to reduced demand in the European Union, which was more than offset by an increase of about 19.2 million to meet demand in non-EU economies. By 2014, EU demand had picked up sufficiently to exert a positive effect on OECD business sector jobs. In recent years, changes in OECD employment have been increasingly influenced by changes in demand in OECD partner economies.

36. Origin of demand sustaining business sector jobs in the OECD, 1995-2014

Millions of persons, annual changes by region of demand



Source: OECD calculations based on the Inter-Country Input-Output (ICIO) Database, the Structural Analysis (STAN) Database, the Annual National Accounts Database, Trade in Employment (TiM) and national sources, June 2017. See chapter notes.

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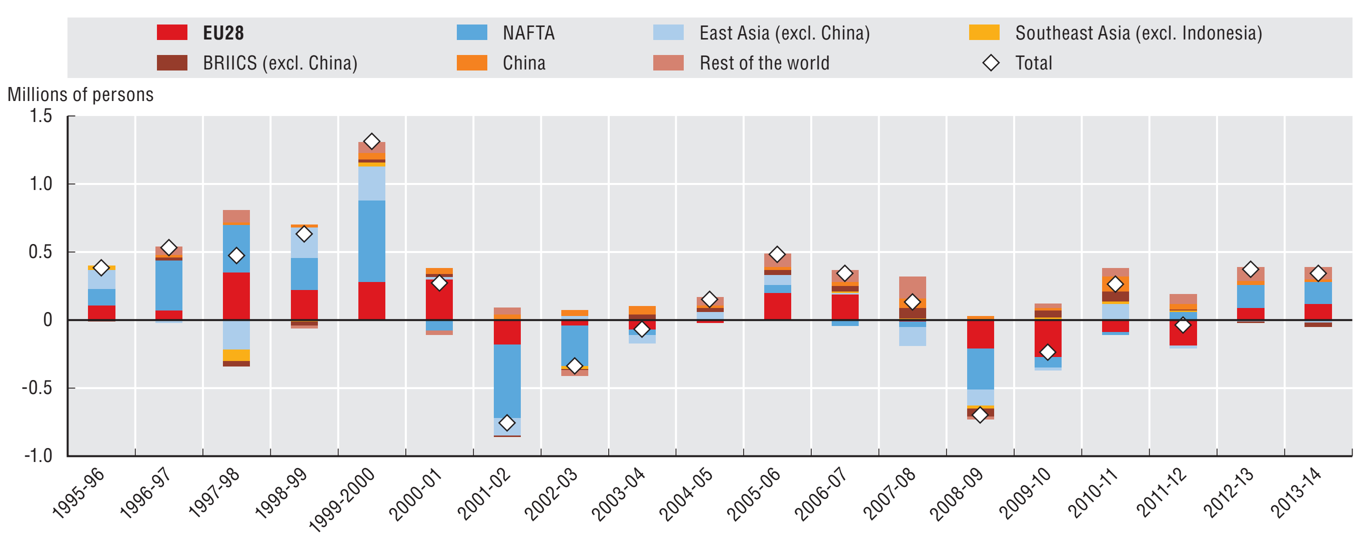
37. Origin of demand sustaining jobs in OECD information industries, 1995-2014

Millions of persons, annual changes by region of demand



Source: OECD calculations based on the Inter-Country Input-Output (ICIO) Database, the Structural Analysis (STAN) Database, the Annual National Accounts Database, Trade in Employment (TiM) and national sources, June 2017. See chapter notes.

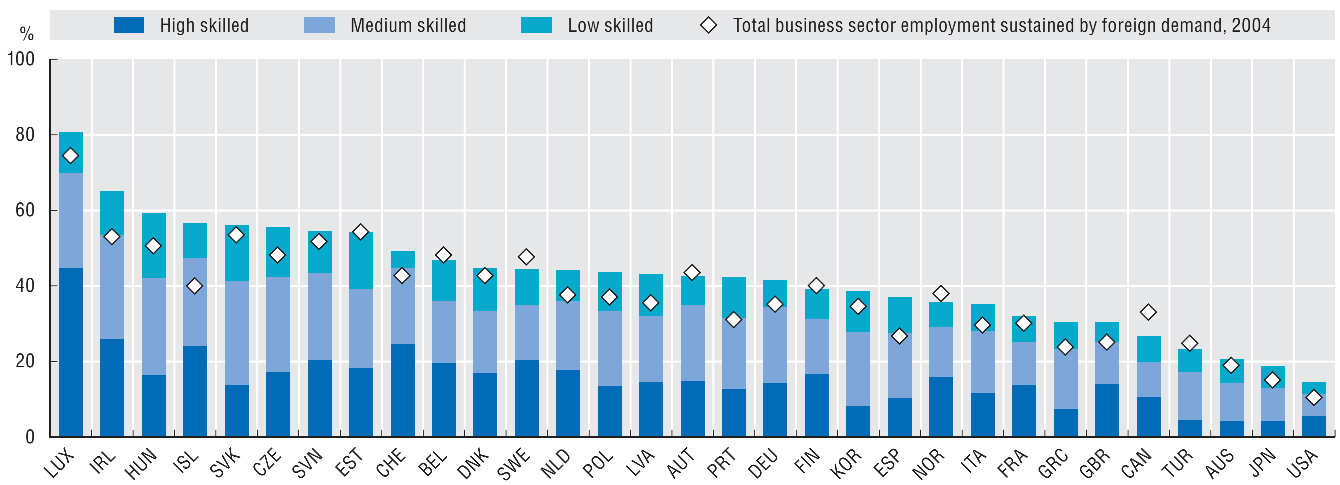
StatLink http://dx.doi.org/10.1787/888933617548

Your job depends on my demand for products

Greater integration in global value chains has implications for the demand for skills in countries. In 2014, in the United States, an estimated 38% of approximately 13 million business sector workers engaged in production to satisfy foreign final demand were high skilled. A similar share (36%) was apparent for the 54 million workers engaged in meeting foreign demand in the 22 EU countries of the OECD, although the bulk of foreign demand originated from other EU countries. Such shares varied across EU countries, ranging from about 25% in Greece and the Slovak Republic to over 40% in countries with large service sectors such as Luxembourg (56%), the United Kingdom (47%), Sweden (46%), Finland (43%) and France (43%). For other OECD countries, the share of high-skilled workers engaged in meeting foreign demand varied between 40% in Canada to about 21% in Australia and Korea. Variations reflect differences in the skills required in production for domestic consumption versus exports, differences in the skill profiles of workers in foreign versus domestic companies, and differences in the structural composition of domestic versus foreign final demand.

38. Business sector jobs sustained by foreign final demand, by skill intensity, 2014

As a percentage of total business sector employment



Note: Estimates for jobs sustained by foreign final demand are derived directly from OECD's Inter-Country Input-Output (ICIO) table for 2004, while estimates for 2014 are preliminary projections or nowcasts. This experimental indicator decomposes total employment sustained by foreign final demand into three groups of skill intensity defined according to major groups of the International Standard Classification of Occupations 2008 (ISCO-08): high-skilled occupations (ISCO-08 major groups 1 to 3), medium-skilled (4 to 7) and low-skilled (8 and 9).

Source: OECD calculations based on OECD's Inter-Country Input-Output (ICIO), Annual National Accounts, Structural Analysis (STAN) and Trade in Employment (TiM) databases, the World Input-Output Database, European Labour Force Surveys, national Labour Force surveys and other national sources, June 2017. See chapter notes.

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Measuring jobs sustained by foreign final demand

The goods and services people buy are composed of inputs domestically produced or imported from various countries around the world. However, the flows of goods and services within these global production chains are not always apparent from conventional international trade statistics, or from national Input-Output or Supply and Use tables, which reveal flows of intermediate goods and services between industries (or product groups) within a country for production to meet domestic and foreign demand. Building on these data sources and other sources, the OECD's Inter-Country Input-Output (ICIO) database provides estimates of flows of goods and services between 63 economies and 34 economic activities (based on ISIC Rev.3 and including 16 manufacturing and 14 service sectors) for 1995-2011. In this analysis, ICT industries are defined according to ISIC Rev.3 and consist of "Computer, electronic and optical products" (ISIC Rev.3 Divisions 30, 32 and 33), "Post and telecommunications services" (Division 64), and "Computer and related activities" (Division 72).

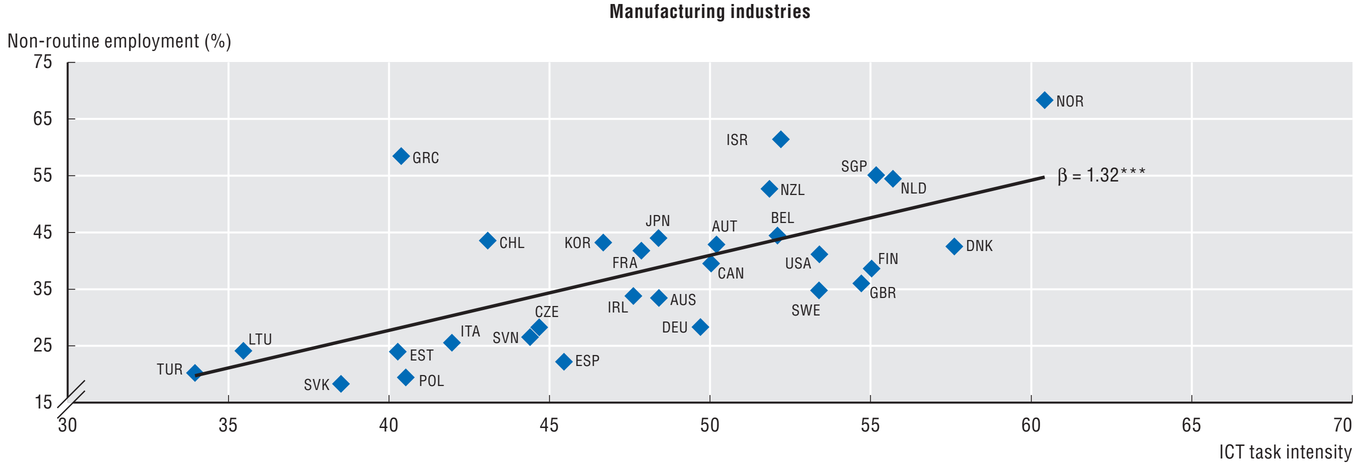
The most visible use of the ICIO is the development of Trade in Value Added (TiVA) indicators, which highlight the value-added origin (both domestic and foreign) of countries' exports and final demand. Estimates of jobs embodied in (or sustained by) foreign final demand, can be calculated in a manner similar to estimates of domestic value added embodied in foreign final demand. However, experimental jobs-related indicators rely on some broad assumptions. In particular, they assume that within each industry labour productivity in exporting firms is the same as firms producing goods and services for domestic use only, and that all firms use the same share of imports for a given output, whether exporters or domestic producers only. However, evidence suggests that exporting firms have a higher level of labour productivity and use more imports in production. More effort is required to account for firm heterogeneity within the ICIO framework, in order to reduce the potential upward biases resulting from these current assumptions.

The changing nature of jobs

Innovation and new technologies – especially information and communication technologies (ICTs) – coupled with changes in the way firms organise production, both locally and globally, are changing the jobs and skills profile of the workforce. Economies where workers use ICT more intensively at work are also characterised by a higher share of "non-routine jobs". These jobs entail the performance of relatively more complex tasks that cannot be easily codified or sequenced (e.g. programming or decision making). This is the case for both services and manufacturing jobs. While jobs in services industries appear relatively more "ICT task intensive", the positive relationship between non-routine content and ICT task intensity is generally stronger in manufacturing. Firms' organisational structure, technology adoption, participation in global value chains, and the extent to which routine manufacturing jobs might already have been automated, relocated and offshored are among the factors contributing to these patterns.

39. Share of non-routine employment and ICT task intensity, 2012 or 2015

Correlation of average industry values in the macro sector



Source: OECD calculations based on the OECD Programme for International Assessment of Adult Competencies (PIAAC) Database, June 2017. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933617586

The routine and ICT task content of jobs

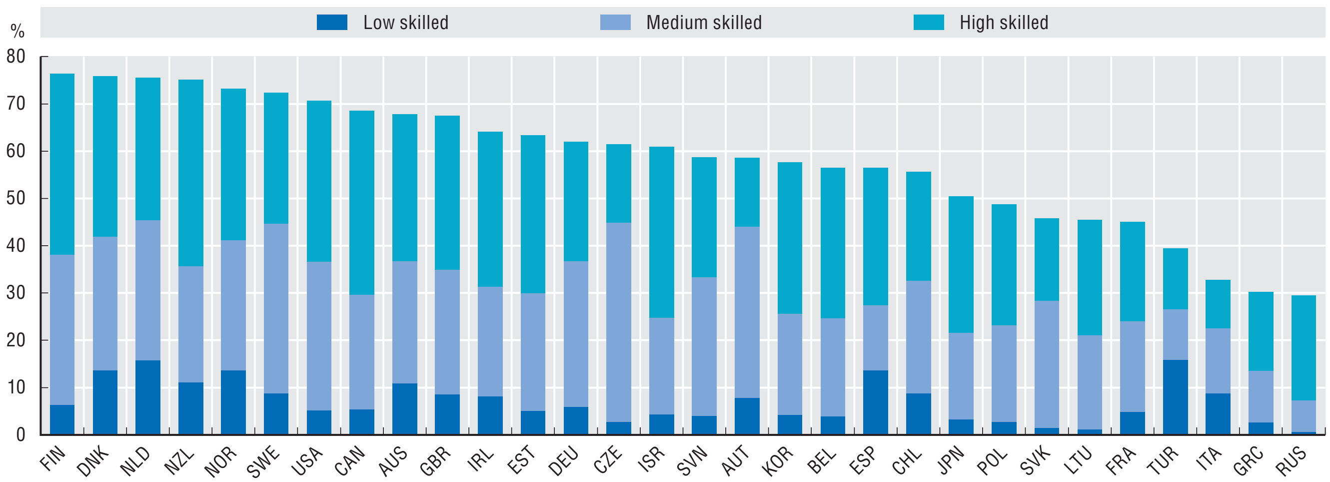
Recently, OECD has developed task-based indicators to measure the "routine intensity" (Marcolin et al., 2016) and "ICT task intensity" of occupations (Grundke et al., 2017). Both sets of indicators are built using information from the OECD Programme for the International Assessment of Adult Competencies (PIAAC). The "routine intensity of jobs" captures the degree of independence workers have to plan and organise their activities and time, as well as their freedom to decide what to do on the job and in what sequence. The "ICT task intensity of jobs" reflects the extent to which workers perform tasks ranging from simple use of the Internet to the use of Word or Excel software or a programming language. Compared to earlier studies, these task-based approaches help to distinguish between the tasks that workers perform while at work and the skills with which they are endowed.

Training in firms

Workers performing non-routine tasks or ICT-intensive tasks are generally endowed with relatively higher skills. Firm-based training helps to motivate and reward employees, and align workers' competences to firms' needs. Training may also help to reduce inequality and provide low-skilled workers with the skills needed to navigate the digital transformation. Evidence nevertheless suggests that training has been used mostly to further upskill medium and high-skilled workers. On average, in the countries considered, between 30% (the Russian Federation and Greece) and 76% (the Netherlands, Denmark and Finland) of workers receive some training from their employers. With the exception of Turkey, only a quarter or less of workers receiving training are low skilled, whereas high-skilled workers account for between one-quarter (Austria) and three-quarters (the Russian Federation) of those receiving training.

40. Workers receiving firm-based training, by skill level, 2012 or 2015

As a percentage of total employed persons



Source: OECD calculations based on the OECD Programme for International Assessment of Adult Competencies (PIAAC) Database, June 2017. See chapter notes.

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How to measure training?

Firm-based training endows workers with the skills needed to perform on the job and to transition between jobs – especially in an era of fast technological change. In the absence of internationally agreed methodologies on how to measure investment in firm-based training, the OECD (Squicciarini et al., 2015) has developed a new methodology to estimate different types of training. These include formal training which consists of organised training conducted outside the work environment resulting in the attainment of a degree at an education institution, and on-the-job training which can take place both inside and outside a firm but does not typically lead to the attainment of a formal degree. Training figures are based on the number of employees in the OECD Programme for International Assessment of Adult Competencies (PIAAC) that reported having received training at least once in the year, for both public and private sectors. Numbers are weighted to obtain country-wide representativeness. Frequencies may hide differences in the length of the training period across individuals and countries.

Women in the workplace

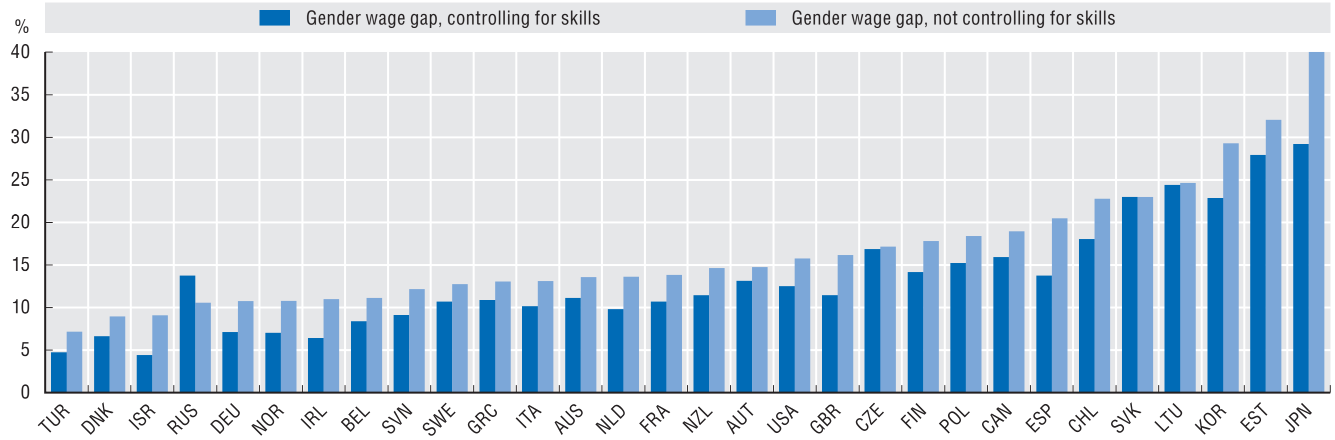
The speed, scale and scope of digital transformation are shaping all aspects of life including work. New and atypical work arrangements may lead to increased flexibility but at the cost of reduced job quality. The ways in which knowledge is generated and shared may help to overcome possible cultural or institutional barriers, but also create others. In a time of heightened uncertainty predictions are difficult to make; therefore, skills endowment and upgrading are key to navigating and benefitting from the digital transformation.

Women often earn significantly less than men, even after individual and job-related characteristics are taken into consideration. Skills partially explain the gender wage gap across countries. For example, men tend to have a relatively higher level of STEM-related skills which are positively rewarded by labour markets. The gender wage gap narrows if skills are taken into account, but differences remain and point to other sources of wage inequality, including firms' organisational choices about project responsibilities, and employees' tenure or even discrimination.

ICT skills play a significant role in explaining the gender wage gap. Estimates suggest that, other things being equal, returns on ICT tasks are larger for women than for men. Training women and endowing them with additional ICT skills may therefore contribute to increasing their wages and help to bridge the gender wage gap.

41. Gender wage gap by country, 2012 or 2015

Differences in hourly wages, in percentages (controlling vs. not controlling for various types of skills)



Source: OECD calculations based on the OECD Programme for International Assessment of Adult Competencies (PIAAC) Database, September 2017. See chapter notes.

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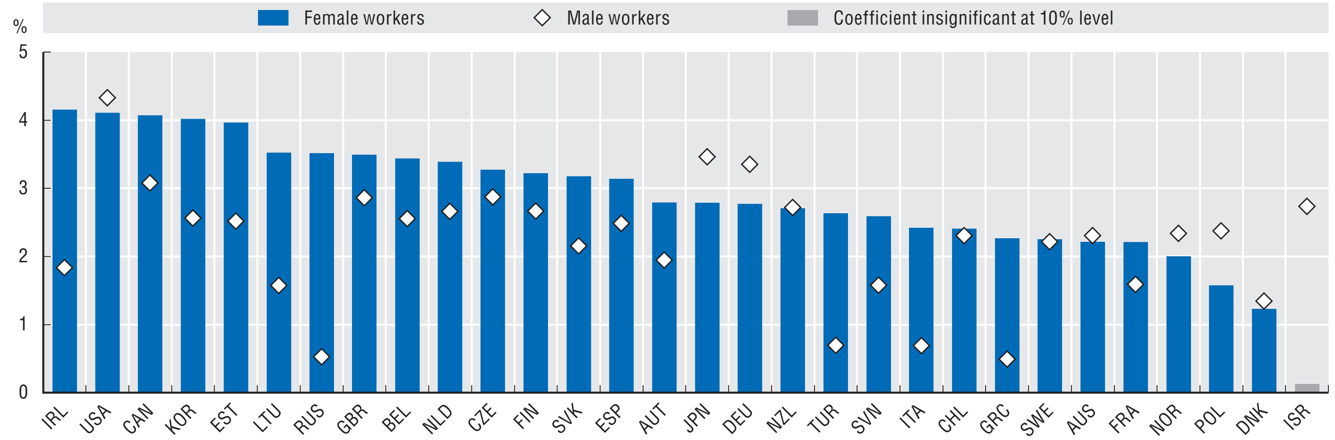
42. Labour market returns to ICT tasks by gender, 2012 or 2015

Percentage change in hourly wages for 10% increase in ICT task intensity (at the country mean, by gender)



Source: OECD calculations based on the OECD Programme for International Assessment of Adult Competencies (PIAAC) Database, September 2017. See chapter notes.

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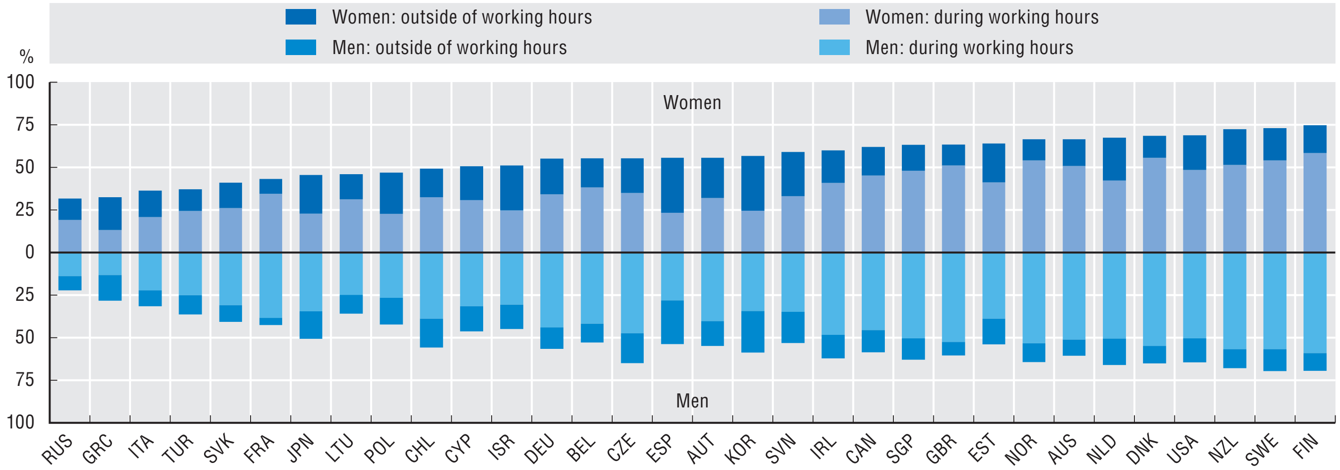
Women in the workplace

Training plays a key role in upskilling the workforce and thus augments an economy's human capital base. According to OECD research, a larger share of women participate in on-the-job training, but the proportion that undertakes training during working hours is significantly lower than that of men. However, this may depend on factors such as differences in the propensity of men and women to engage in part-time work or upskilling, employers' choices regarding whom to train and expected returns to firms from training.

43. Employees participating in on-the-job training, by gender, 2012 or 2015

As a percentage of total employees of a given gender in the economy



Source: OECD calculations based on the OECD Programme for International Assessment of Adult Competencies (PIAAC) Database, September 2017. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933617662

Investing in skills to close the gender wage gap

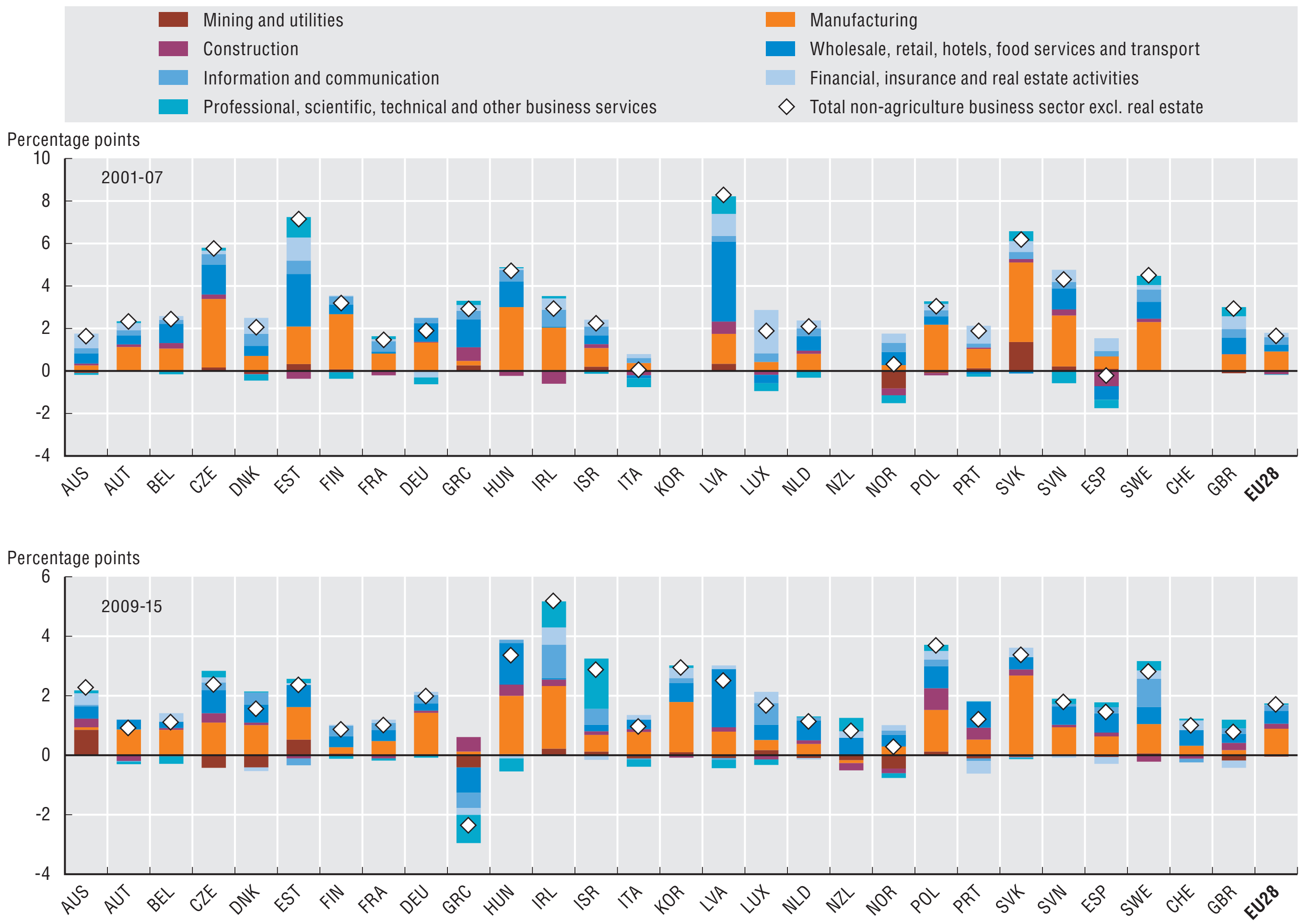
In the absence of internationally agreed measures for investment in training, the OECD proposes an experimental methodology to estimate investment in different types of training. *Formal training* refers to organised training undertaken outside the work environment that results in the attainment of a degree. *On-the-job training* may take place both inside and outside a firm but does not typically lead to a formal degree (Squicciarini et al., 2015). In order to assess which skills are relatively more rewarded in the labour markets, the OECD (Grundke et al., forthcoming) estimates returns on skills, analysing the extent to which work compensation in the form of salaries can be explained by the skill endowment of workers. Estimating returns on skills by gender can help identify the types of training more likely to reduce the associated wage gap. Estimates rely on indicators of cognitive skills such as literacy and numeracy, and skills that emerge from an analysis of tasks carried out by individuals on the job (for details see Grundke et al., 2017), as well as PIAAC data. The indicator of ICT tasks is based on job tasks that range from simple use of the Internet to the use of Word or Excel software or a programming language.

Sectoral productivity

Understanding the drivers of productivity growth at the total economy level requires an awareness of the contribution made by each industry. In the years up to the economic crisis (2001-07), productivity growth in most OECD countries was driven almost entirely by increased productivity in manufacturing and the increasing share of business services in overall activity. For most OECD countries for which data are available, labour productivity growth decreased following the onset of the financial crisis in 2008, with this decline spread broadly across sectors. The Czech Republic, Estonia, Finland, Greece, Latvia, the Slovak Republic, Slovenia and the United Kingdom experienced marked reductions (greater than 2%) in average productivity growth between 2009 and 2015 compared to the period 2001-07 with declines in manufacturing productivity growth particularly evident. However, some countries – such as Australia, Ireland, Israel, Italy, Poland and Spain – registered modest gains.

44. Decomposition of labour productivity growth by industry, 2001-07 and 2009-15

Contributions to average annual percentage change in the non-agriculture business sector



Source: OECD, Productivity Database, *www.oecd.org/std/productivity-stats*, September 2017. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933617681

Measuring labour productivity by sector

Labour productivity growth is defined as the rate of growth in real value added per hour worked. Differences in labour productivity growth across sectors may relate, for instance, to the intensity with which sectors use capital (including knowledge-based capital) and skilled labour in their production, the scope for product and process innovation, the degree of product standardisation, the scope for economies of scale and their involvement in global value chains. The comparability of productivity growth across industries and countries may be affected by problems in measuring real value added. For example, most countries assume no change in labour productivity for public administration activities; this sector is not included here. Real estate services are also excluded, as the output of this sector reflects mainly the imputation made for the dwelling services provided and consumed by home owners. In addition, sectors such as construction and several services (for example, hotels and restaurants) are characterised by a high degree of part-time work and self-employment, which can affect the quality of estimates of actual hours worked. See OECD (2017a) for more discussion of productivity measurement issues.

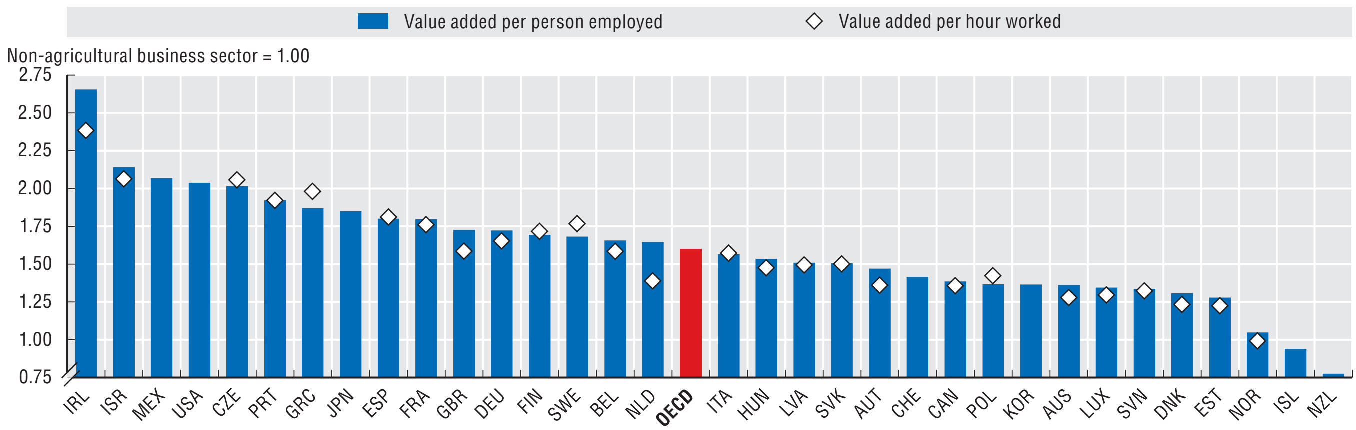
Sectoral productivity

For most OECD countries, the contribution of information industries to total labour productivity growth is relatively small. However, these sectors have significantly higher than average levels of labour productivity, reflecting their relative intensity in fixed (tangible) capital and knowledge-based capital. In 2015, across the OECD area, labour productivity in the information sector was, on average, 60% higher than other industries in the business sector. Ireland had the highest labour productivity level, driven in particular by high growth in the productivity of ICT services, and in part by the presence of several US multinational headquarters in the sector, with high value added but relatively few employees.

Labour productivity reflects changes in the use and efficiency of both fixed capital investment and knowledge-based capital (intangible assets). Estimates of multifactor productivity, by accounting for "measured" capital's contribution to GDP (including software and R&D that are capitalised in national accounts) capture the impact of "non-measured" intangible assets such as organisational capital or investment in firm-specific training. In general, total economy multifactor productivity in the six-year period following the economic crisis was significantly lower than in the two six-year periods (1995-2001 and 2001-07) preceding the crisis. Of the countries presented, only Denmark and Japan experienced higher multifactor productivity during 2009-15 than in the earlier six-year periods.

45. Labour productivity levels in the information industries, 2015

Relative to aggregate labour productivity of other industries in the non-agriculture business sector



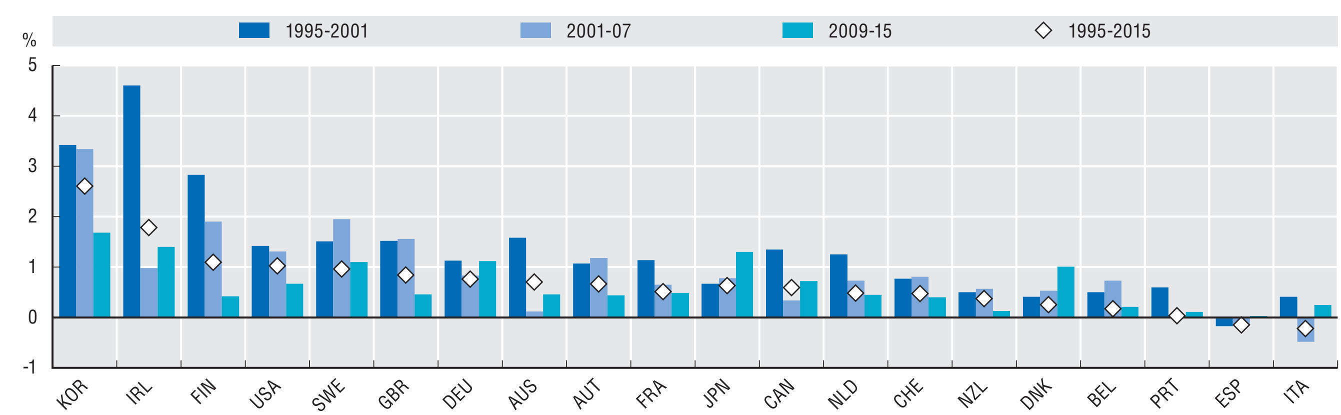
Note: While the preferred measure of labour productivity is value added per hour worked, limited availability of data on hours worked at a detailed level of industry means that value added per person employed is sometimes used as a substitute. Differences between the two measures reflect average hours worked per person. In this chart, higher relative value added per person employed reflects higher hours worked per person in the information industries. Information industries are defined according to ISIC Rev.4: "Computer, electronic and optical products" (Division 26), "Publishing, audio-visual and broadcasting" (58 to 60), "Telecommunications" (61) and "IT and other information services" (62, 63).

Source: OECD, Structural Analysis (STAN) Database, *http://oe.cd/stan*, and Annual National Accounts (SNA) Database, *www.oecd.org/std/na*, September 2017. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933617700

46. Multifactor productivity growth, 1995-2015

Total economy, percentage change at an annual rate



Source: OECD calculations based on OECD Productivity Database, *www.oecd.org/std/productivity-stats*, September 2017. StatLink contains more data. See chapter notes.

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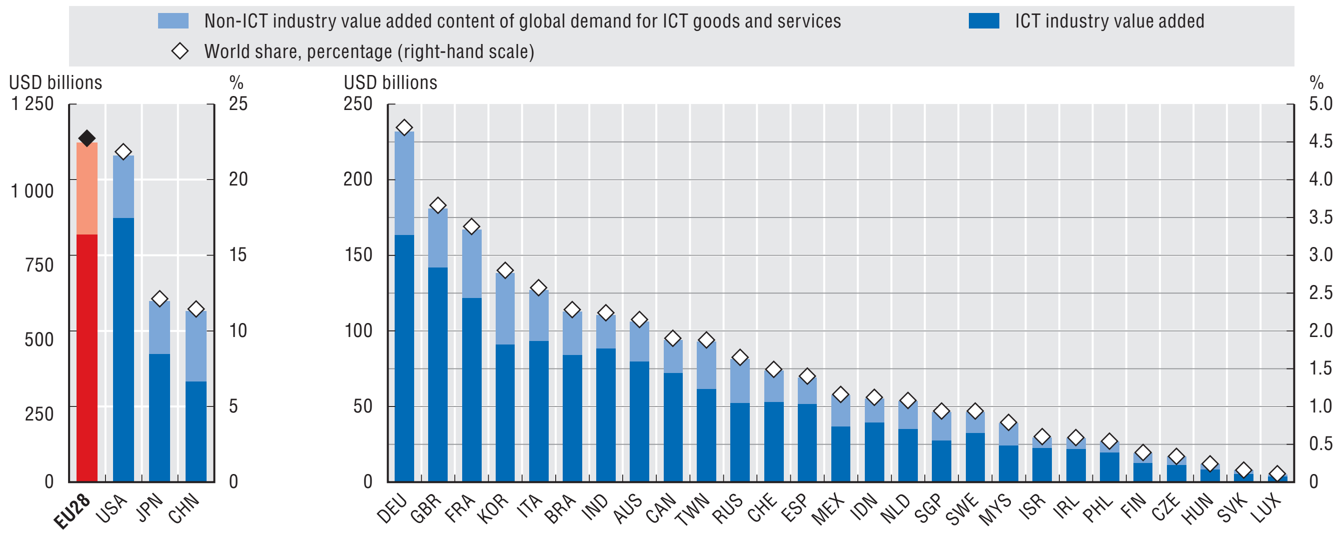
The extended ICT footprint

Measuring the value added generated by information and communication technology (ICT) industries only provides a partial view of the importance of ICT to a country's economy. In addition to final ICT products, the output from domestic ICT industries is also embodied (via intermediate products) in a wide range of goods and services meeting final demand (business capital investment, household and government consumption), both domestically and abroad. Similarly, the output from domestic non-ICT industries is present in many ICT goods and services consumed worldwide through domestic interconnections and participation in global value chains (GVCs). Global demand for ICT goods and services through international trade and investment can drive the activities of many upstream domestic non-ICT industries. Combining the value added generated by domestic ICT industries with the domestic non-ICT industry value added embodied in global demand for ICT goods and services could be a first step towards defining an extended ICT footprint, or "ICT-EF".

In 2011, the United States, Japan and China together accounted for about 45% of the world's extended ICT footprint. The European Union as a whole accounted for 23%, a share only marginally higher than that of the United States. Neglecting the value added generated in other sectors of the economy to meet global demand for ICT final goods and services can result in under-estimation of the role played by the "digital" economy. In OECD countries, 19% to 34% of the extended ICT footprint is accounted for by value added generated elsewhere, rising to 41% for China.

47. Extended ICT domestic value added footprint, 2011

USD billions and world share, percent



Source: OECD, Inter-Country Input-Output (ICIO) Database, *http://oe.cd/icio*, and Trade in Value Added (TiVA) database, *http://oe.cd/tiva*, July 2017. StatLink contains more data. See chapter notes.

StatLink *http://dx.doi.org/10.1787/888933617738*

ICT and the origin of value added

In this analysis, information and communication technology (ICT) industries are defined according to ISIC Rev.3 and consist of "Computer, electronic and optical products" (Divisions 30, 32 and 33), "Post and telecommunications services" (Division 64), and "Computer and related activities" (Division 72). Due to data availability this definition represents an approximation of the more detailed ISIC Rev.3 definition given in OECD (2011).

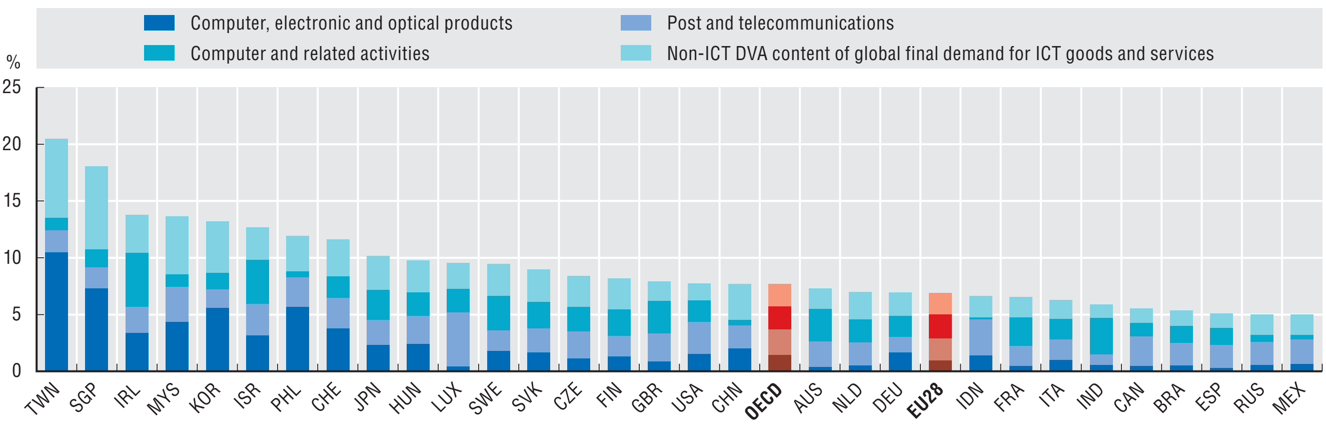
While ICT industry value added is generally available from official National Accounts (SNA) statistics, tracking the country and industry origins of value added embodied in final ICT goods and services requires the use of TiVA indicators, such as the "Origin of value added in final demand", based on the OECD's ICIO database. This provides estimates of inter-country, inter-industry flows of intermediate and final goods and services that allow for the development of a range of indicators to provide insights into countries' participation in the global economy. Such indicators are not otherwise apparent from conventional official statistics such as reported "gross" trade in goods and services and national Input-Output or Supply and Use tables.

The extended ICT footprint

The importance of the extended ICT footprint can be further illustrated by considering ICT-related domestic value added as a share of total economy value added (or GDP). East and Southeast Asian economies accounted for some of the highest shares in 2011. The ICT-EF measure reveals that ICT value added represented 20% of GDP in Chinese Taipei and 18% in Singapore, economies that are particularly reliant on the manufacture of ICT goods. Among OECD countries, Ireland, Israel, Japan, Korea and Switzerland all had shares over 10%, although, with the exception of Korea, the main contribution came from ICT service activities, as was the case for most other OECD countries. To determine how domestic demand generates ICT-related value added abroad, another dimension of ICT-EF can be considered. In particular, the combination of foreign ICT industry value added in final domestic demand for all goods and services, and the foreign non-ICT value added content of domestic demand for ICT goods and services, both of which are present due to importing activities. In the OECD area, on average, ICT-related foreign value added accounted for 2.4% of GDP in 2011.

48. ICT-related domestic value added, 2011

As a percentage of GDP



Source: OECD, Inter-Country Input-Output (ICIO) Database, *http://oe.cd/icio*, and Trade in Value Added (TiVA) database, *http://oe.cd/tiva*, July 2017. StatLink contains more data. See chapter notes.

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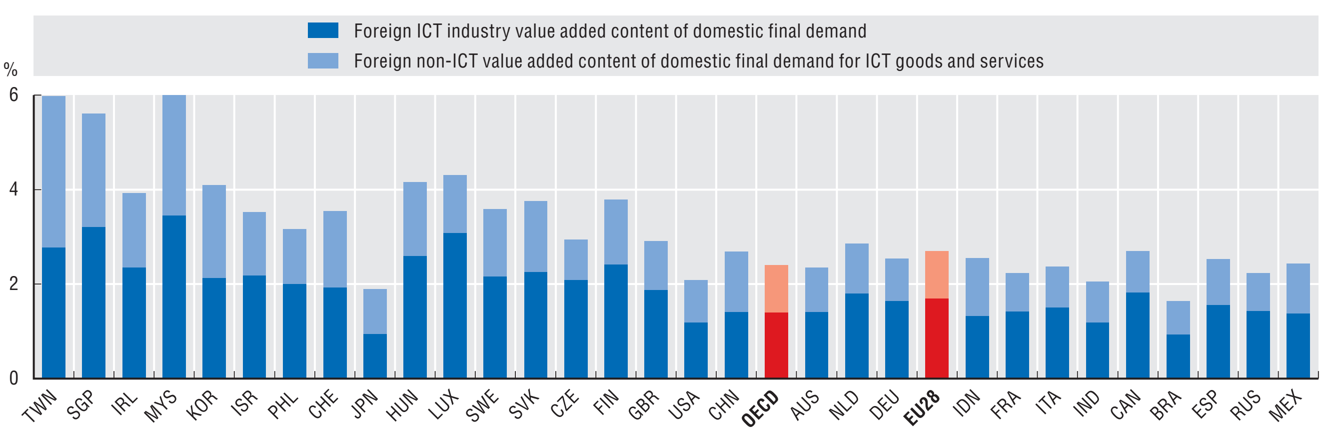
49. ICT-related foreign value added content of domestic final demand, 2011

As a percentage of GDP



Source: OECD, Inter-Country Input-Output (ICIO) Database, *http://oe.cd/icio*, and Trade in Value Added (TiVA) database, *http://oe.cd/tiva*, July 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933617776

Measuring ICT footprints further

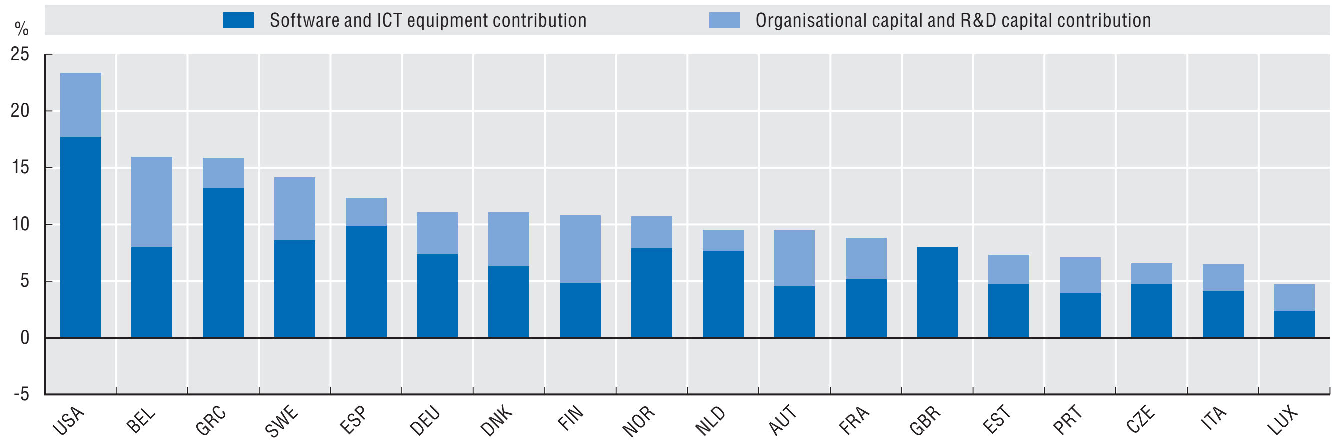
Due to ongoing development of the OECD's ICIO, the concept of extended ICT footprints can be further examined and improvements made to measurement. Notably, the use of an ISIC Rev.4-based industry list and, hence, a "refined" definition of ICT industries and ICIO tables for the years after 2011 to provide more timely indicators. Estimates of capital flow matrices, currently absent from the ICIO infrastructure, could also allow for the inclusion of non-ICT content of capital investment by ICT industries, such as the machinery and equipment used for manufacturing ICT parts and components. This would increase the size of ICT-EF. The ICT content of capital goods is already implicit in the analysis presented here.

Knowledge-based capital

Producing new and better products entails investing not only in research and development (R&D), but also in complementary assets such as software, design, human capital and firms' organisational capabilities (OC) – in short, knowledge-based capital (KBC). New OECD estimates for 2000-14 (Haines et al., forthcoming) reveal that selected KBC and tangible capital accounted on average for 6% and 14%, respectively, of labour productivity growth. The contribution of software and ICT equipment combined ranged between 2% (Luxembourg) and 18% (the United States) of labour productivity growth, whereas OC and R&D reached up to 8% (Belgium). The considered KBC assets also appear to have contributed indirectly to labour productivity growth; due to the positive relationship between KBC and multifactor productivity (MFP) (i.e. economies experiencing relatively higher MFP growth also exhibit higher KBC contribution). Factors that may explain these observed patterns include the industrial structure of economies and the extent to which investment in KBC generates knowledge spillovers and returns to scale.

50. Contribution of ICT equipment and knowledge capital assets to KBC-augmented labour productivity growth, 2000-14

Growth accounting estimates as a percentage of labour productivity growth, market sector



Source: OECD calculations based on ANBERD Database, Annual National Accounts Database, the OECD Programme for International Assessment of Adult Competencies (PIAAC), EUKLEMS, INTAN-Invest and the U.S. Bureau of Economic Analysis (BEA) Satellite Accounts, June 2017. See chapter notes.

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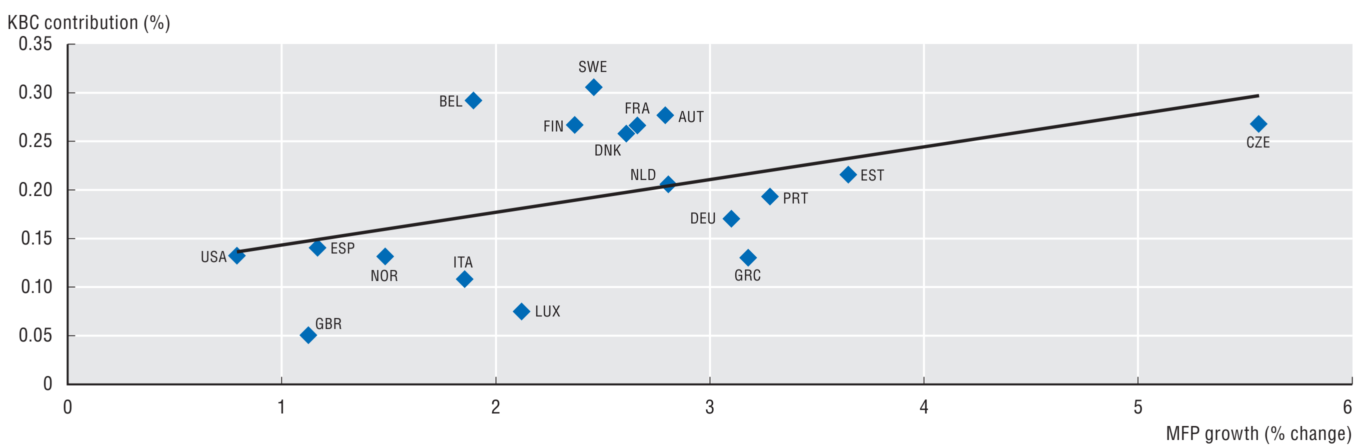
51. Contribution of KBC and MFP to KBC-augmented labour productivity growth, 2000-14

Growth accounting estimates, business sector



Source: OECD calculations based on data from OECD ANBERD, the OECD System of National Accounts (SNA), the OECD Programme for International Assessment of Adult Competencies (PIAAC), EUKLEMS, INTAN-Invest, www.intan-invest.net, U.S. BEA Satellite Accounts and the PIAAC Skills Survey. See chapter notes.

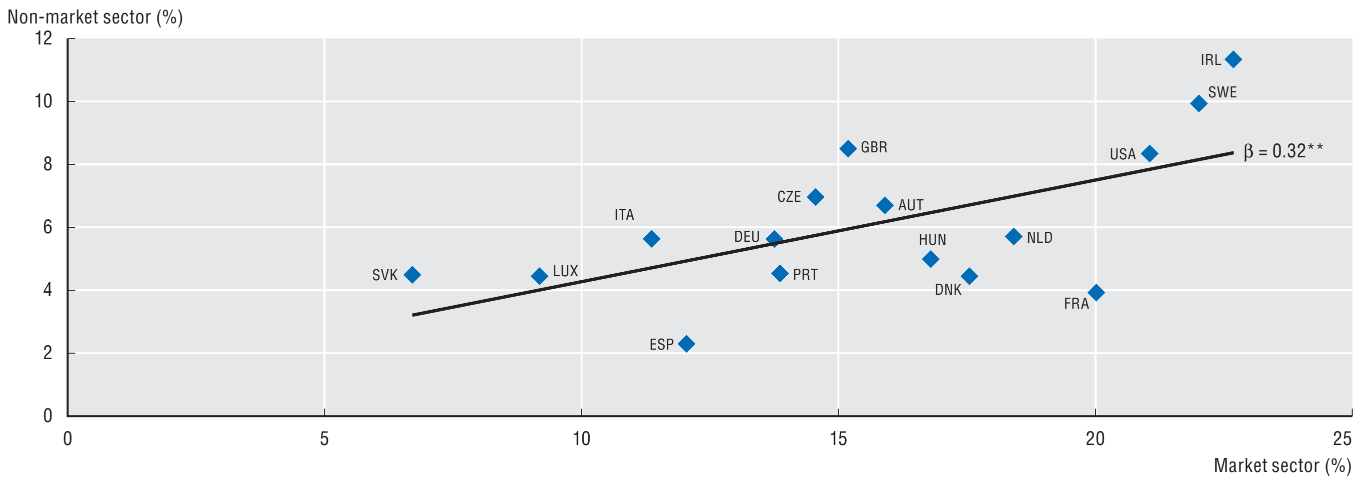
StatLink http://dx.doi.org/10.1787/888933617814

Knowledge-based capital

Growth accounting estimates usually focus on the market sector only, given that measuring productivity in the non-market sector can prove controversial. However, initial measurement of KBC in the non-market sector, produced in the context of the SPINTAN network, shows that investment in market and non-market sectors goes hand in hand across the countries considered. Hence, the contribution of KBC to economic growth might be even higher than suggested by market sector-based analysis if investment in KBC by the public sector were to be taken into account.

52. KBC intensity for the market and non-market sectors, 2015

Correlation of intensities, investment over gross value added



Source: OECD calculations based on Annual National Accounts Database, *www.oecd.org/std/ana*, INTAN-Invest data, *www.intan-invest.net*, and SPINTAN data, *www.spintan.net*, May 2017. See chapter notes.

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What is meant by "KBC-augmented" and "growth accounting"?

Knowledge-based capital (KBC) or "intangible assets", as they are often called, refer to assets that lack a physical nature. The value of KBC stems from its knowledge content and its capacity to add value to other assets. Corrado et al. (2009) list assets such as software and databases, scientific and non-scientific R&D, copyrights, designs, brand equity and marketing research, firm-specific training and organisational know-how among KBC. The international statistical community has recently recognised software, R&D, entertainment, literary and artistic originals, and mineral explorations as capital assets, and includes them within the System of National Accounts (SNA), 2008 Revision. Recent methodological advances have further proposed ways to measure other KBC assets, including design, brands, firm-specific training and organisational capital. While a consensus has yet to be reached on aspects such as prices and depreciation rates for these assets, the methodologies in question derive capital estimates from information reported as intermediate expenditures in National Accounts. Capitalising these assets therefore imposes an adjustment to the value added and labour productivity measures used in the growth accounting analysis (here called "KBC-augmented"). Such an adjustment is implemented with respect to the organisational capital investment in particular, which is estimated based on Le Mouel et al. (2016). Estimates about KBC investment in the non-market sector are sourced from the SPINTAN network.

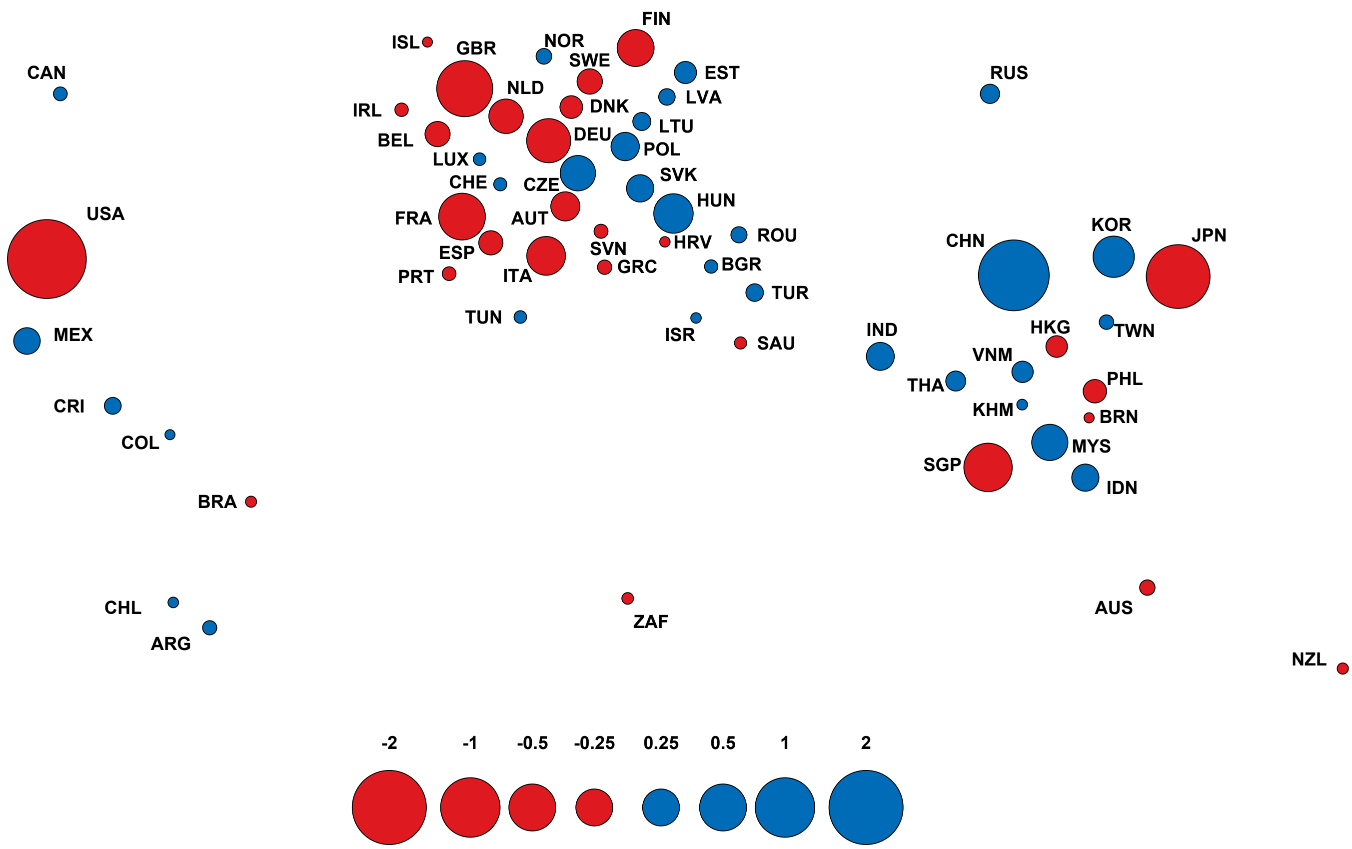
According to classical economic theory, growth can be achieved by increasing the amount of inputs or by improving the efficiency with which these inputs are used in production. Under a number of assumptions such as perfectly competitive markets and constant returns to scale in production, the growth accounting methodology separates the contributions of inputs accumulation and MFP to GDP or to labour productivity growth. Further details about the methodology and the solutions provided to the data constraints encountered can be found in Haines et al. (forthcoming).

ICT global production networks

Global production networks are complex webs consisting of flows of knowledge, goods and service inputs, combined at various stages of production. Firms and industries positioned at the centre of global value chains (GVCs) have access to a greater variety of foreign inputs, compared to those at the periphery. Hence, productivity gains are likely to be generated from positioning as well as participation in GVCs. Profound changes in the core/periphery structure of GVCs have taken place over recent decades, particularly in ICT sectors. In 1995, computing and electronics manufacturing value chains were organised around a handful of central hubs in high-income economies, notably Japan and the United States. However, the period 1995-2011 saw an almost universal and substantial decline in importance among these traditional centres of manufacturing (represented by the red circles in the Figure). Conversely, many Asian and Central and Eastern European countries witnessed large increases in centrality, especially in China, as well as the Czech Republic, Hungary, Korea and Malaysia (represented by the blue circles in the Figure). By 2011, global production of ICT electronics no longer centred around a few high-income economies and was shifting towards a more even distribution.

53. Change in the centrality of IT manufacturing across economies, 1995-2011

Centrality measured as total foreign centrality



Source: OECD, Inter-Country Input-Output (ICIO) Database, *http://oe.cd/icio*, July 2017. StatLink contains more data. See chapter notes.

StatLink *http://dx.doi.org/10.1787/888933617852*

How to read these figures

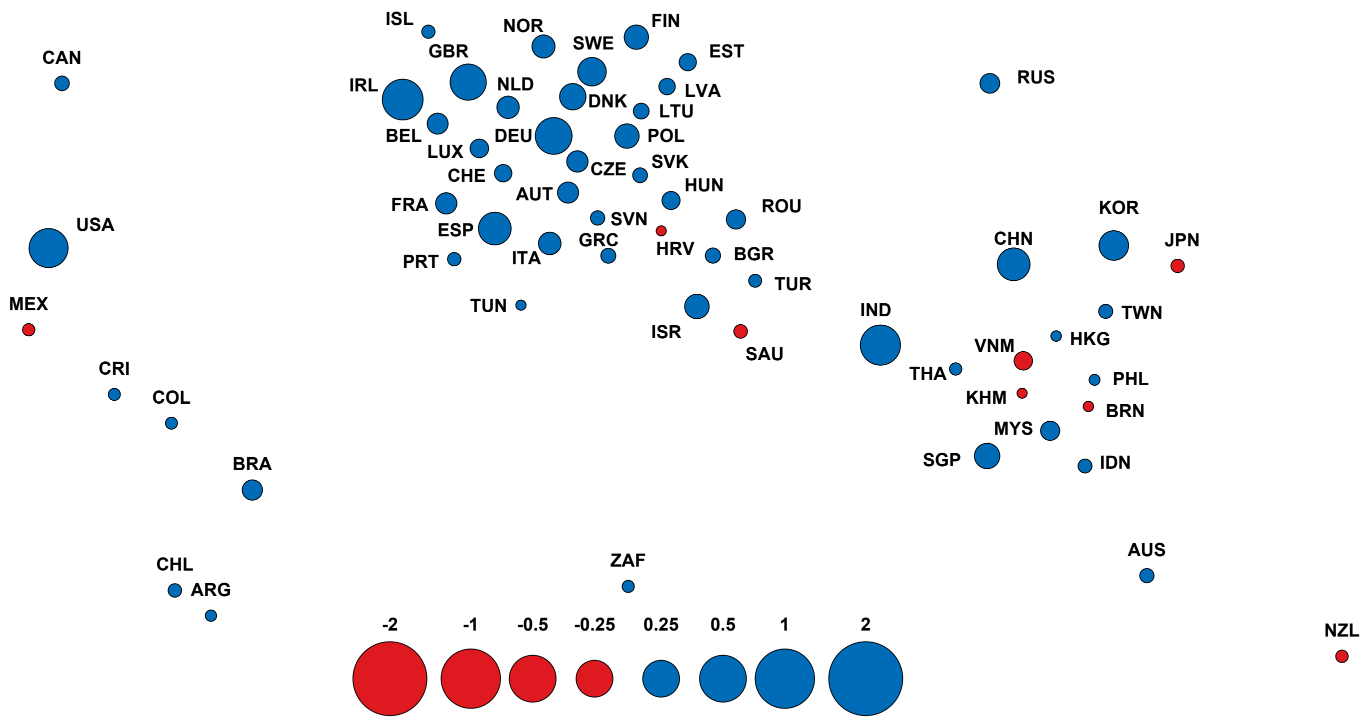
Economies are placed according to their geographical location. The size of the nodes reflects the magnitude of the change (in levels) of total foreign centrality over the period 1995-2011. As reflected in the key, these changes are graphed using a log scale for readability. Blue coloured nodes reflect increasing centrality and red denotes falling centrality.

ICT global production networks

Changes in the structure of global production networks are linked to a dramatic rise in the role of IT services. From a low starting point in 1995, the reliance of global production networks on IT services increased for almost every economy over the period 1995-2011 (represented by the blue circles in Figure 54). The increasing influence of IT services was particularly noticeable in countries that experienced the largest declines in computing and electronics manufacturing centrality, namely Germany, the United Kingdom and the United States. However, these changes to IT services were somewhat smaller in magnitude than the overall extent of the relocation of computing and electronics manufacturing. The rising importance of IT services does not only follow the restructuring of high-income economies, but extends to include a broad range of economies, such as Ireland, Korea and Spain, as well as many emerging economies, especially China, India and Singapore.

54. Change in the centrality of IT services across economies, 1995-2011

Centrality measured as total foreign centrality



Source: OECD, Inter-Country Input-Output (ICIO) Database, *http://oe.cd/icio*, July 2017. StatLink contains more data. See chapter notes.

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What does "centrality" mean and how is calculated?

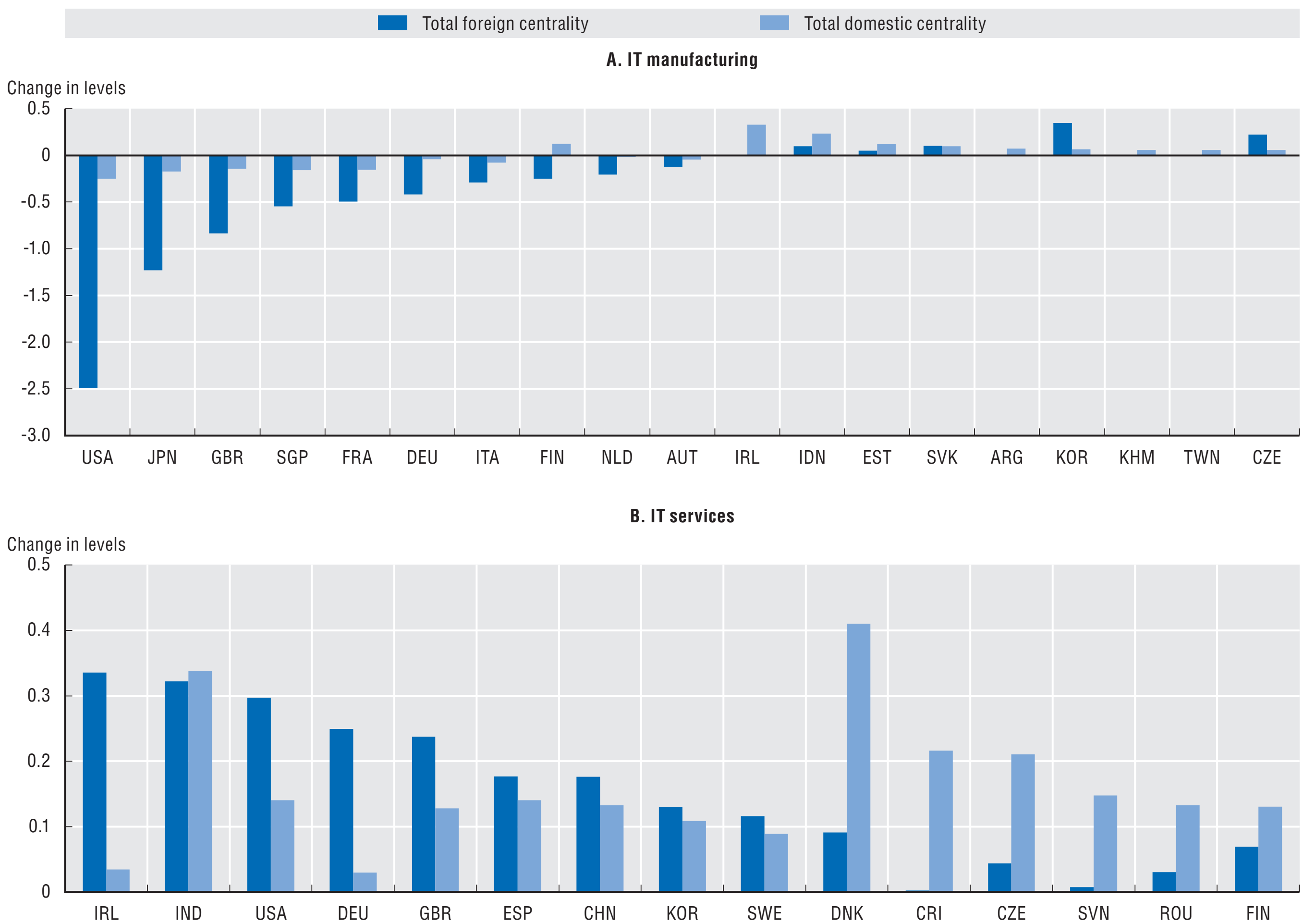
Centrality is a measure of influence or connectivity within the global production network. Central sectors reflect those that are highly connected (both directly and indirectly) and influential within global production networks.. Conversely, peripheral sectors exhibit weak linkages to other sectors and countries and so are less influential. This measure is calculated as a PageRank version of Bonacich-Katz eigenvector centralities using the network of input flows between countries and industries detailed in the OECD Inter-Country Input-Output (ICIO) Database, 2015 edition. Centrality is calculated for each country-industry as a baseline centrality, plus a weighted sum of centralities of their trade partners, where the weights are input shares. Thus, countries and industries are considered central if highly connected to other countries and industries both directly and indirectly as a result of trading with highly central trade partners. Total centrality is the average of centrality calculated using forwards linkages (exports of inputs) and backwards linkages (imports of inputs). Centrality is decomposed into foreign and domestic origins. Foreign centrality represents centrality due to (direct and indirect) linkages to foreign sectors, while domestic centrality relates to (direct and indirect) linkages to domestic sectors. *IT manufacturing* is defined as ISIC Rev.3 sectors 30, 32 and 33: "Computer, electrical and optical products". *IT services* consist of ISIC Rev.3 sector 72: "Computer and related activities". See Criscuolo and Timmis (forthcoming).

ICT hubs

Centrality is a measure reflecting influence relative to all other country-industries in the network. It can be observed within both international and domestic production networks. The relative positioning (centrality) of an industry within a global or domestic production network is likely to differ. The substantial reorganisation of IT manufacturing global production networks has often accompanied broadly similar changes domestically. Many of the high-income economies that have witnessed large declines in their influence in global IT manufacturing production networks (e.g. Japan, the United Kingdom and the United States) have also almost universally experienced a decline in the influence of this industry within their domestic production networks. However, the changes observed in domestic centrality are generally of a lesser magnitude than those linked to foreign centrality. In contrast, several Eastern European and Asian economies have experienced an increase in their centrality for IT manufacturing both in terms of global and domestic production networks (Panel A). However, the relationship here is somewhat weaker, with Indonesia, for example, experiencing much faster increases in domestic centrality than foreign centrality, while Korea has experienced the reverse.

Similarly, changes observed for IT services in terms of centrality within global production networks are often mirrored in domestic production networks. IT services industries in Ireland, India, the United States and several other economies have become increasingly central to global production, as reflected in their increased foreign centrality (Panel B). For many of these same economies, IT services have also become more influential in domestic production networks, and in some cases increasing domestic influence exceeds globally observed changes, for example, in the Czech Republic, Denmark and India.

55. Largest changes in foreign and domestic centrality: IT manufacturing and services, 1995-2011



Source: OECD, Inter-Country Input-Output (ICIO) Database, *http://oe.cd/icio*, July 2017. StatLink contains more data. See chapter notes.

StatLink *http://dx.doi.org/10.1787/888933617890*

How to read these figures

The bars represent the change (in levels) of total foreign and domestic centrality over the period 1995-2011. The Panel A represents changes in IT manufacturing ("Computer, electronic and optical products") and the Panel B represents IT services ("Computer and related activities").

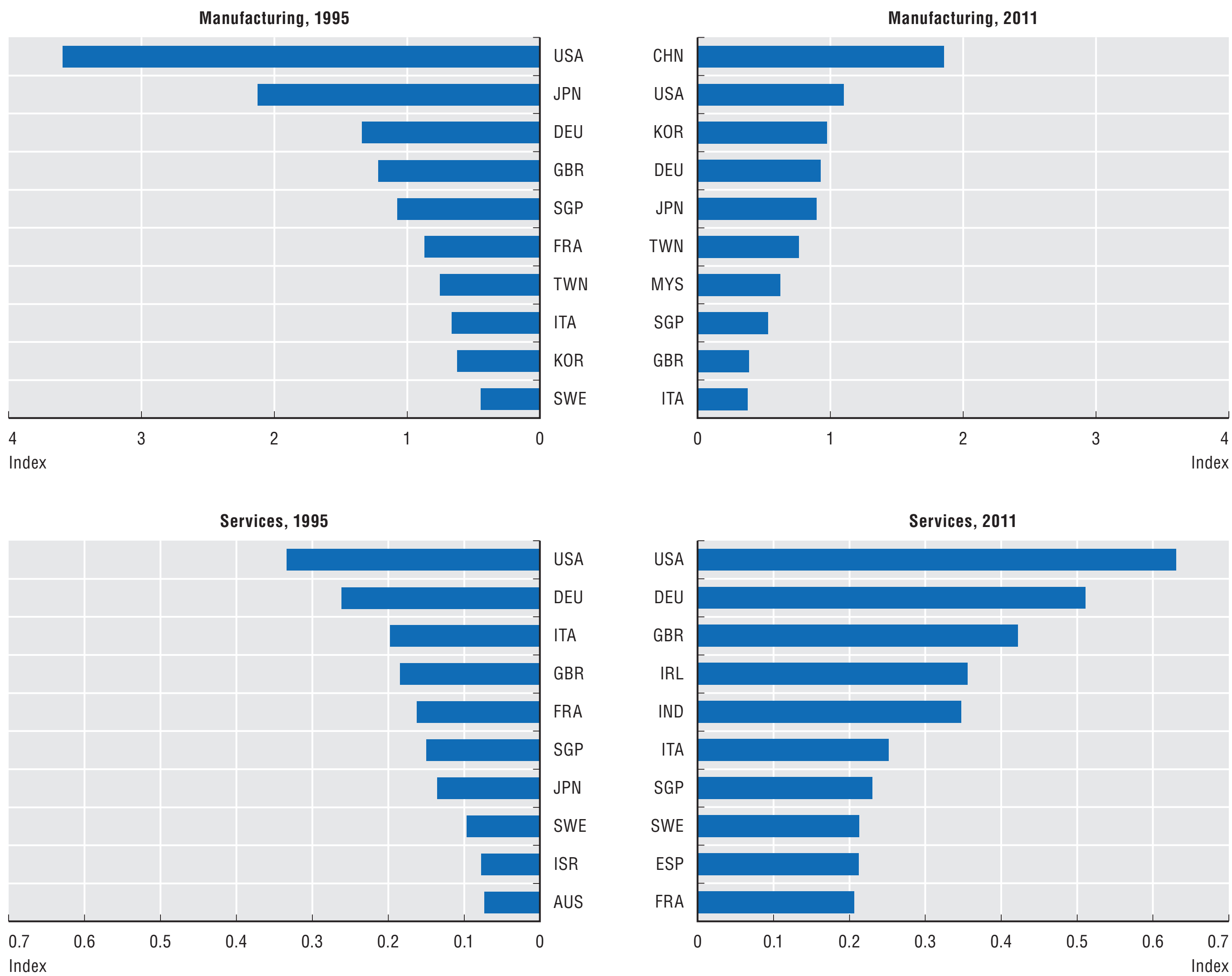
ICT hubs

Over the period 1995-2011, IT manufacturing shifted away from a few high-income hubs, with Asian economies gaining influence as central hubs. In 1995, global production centred largely around Japan and the United States (Figure 56, upper panel). The influence of these central hubs declined by 2011 with a shift eastwards in global production. Out of the top ten most central hubs in 1995, only Chinese Taipei and Korea were more influential in 2011. Extensive reorganisation of production saw emerging economies that were relatively peripheral in 1995 become key hubs by 2011. For example, China (20^{th} in 1995) replaced the United States as the most "central" country-industry in 2011.

In contrast, IT services have almost universally gained "centrality". In 1995, IT services were not particularly influential for global production (Figure 56, lower panel). Even central countries such as Germany and the United States had a low "centrality" compared to IT manufacturing. Over the period 1995-2011, IT services became relatively more influential globally. This is also true of many economies that were most central at the start of the period. For example, the United States, Germany and the United Kingdom remained in the top four most central economies for IT services throughout 1995-2011. The same period also witnessed the emergence of several new central hubs, such as India and Ireland.

56. Top 10 most central IT hubs, 1995 and 2011

Centrality measured as total foreign centrality



Source: OECD, Inter-Country Input-Output (ICIO) Database, *http://oe.cd/icio*, July 2017. See chapter notes.

StatLink *http://dx.doi.org/10.1787/888933617909*

How to read these figures

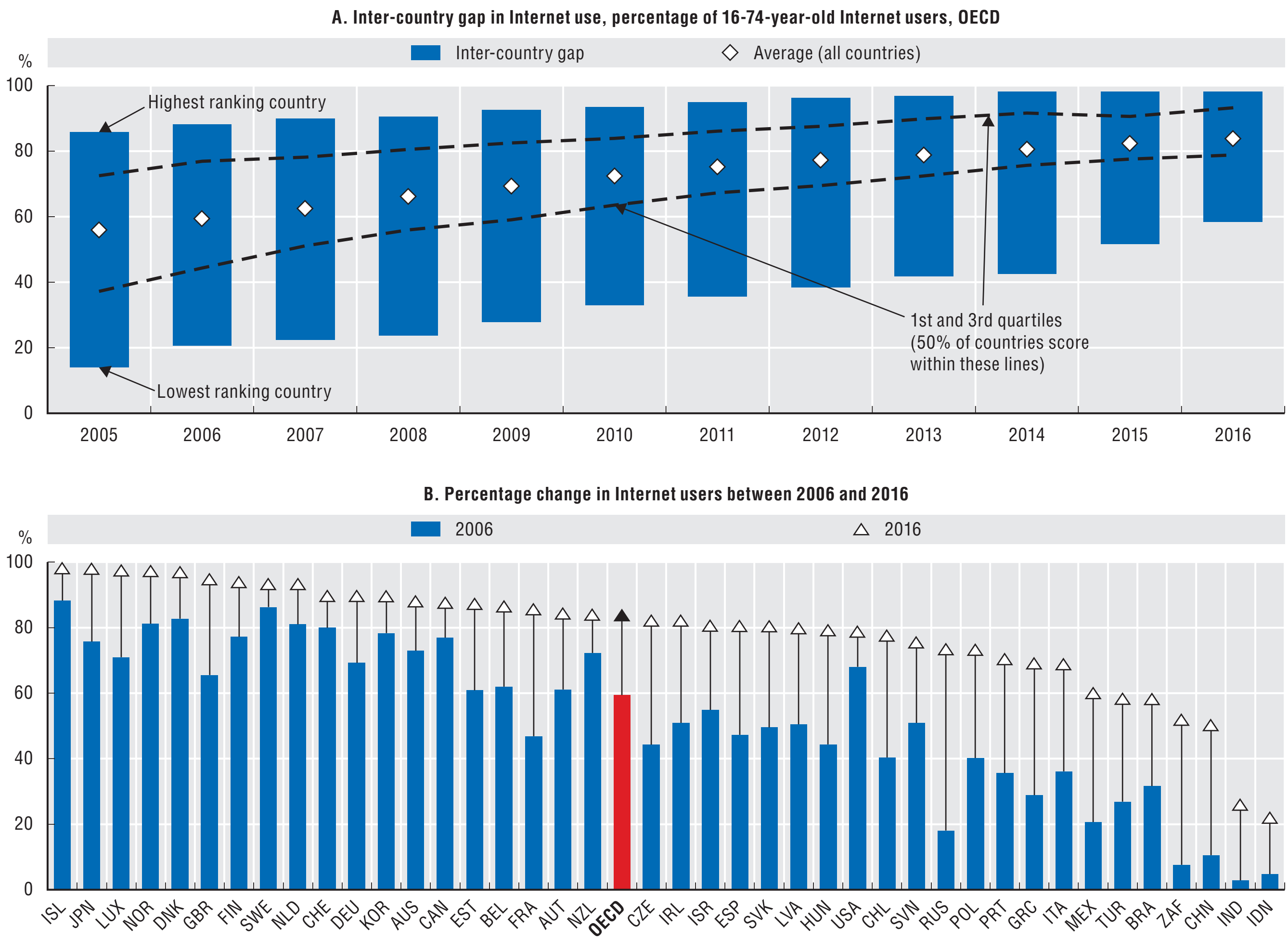
The bars represent total foreign centrality for those 10 economies with the highest level of total foreign centrality in 1995 (the left-hand figures) and 2011 (the right-hand figures). The upper panel represents IT manufacturing ("Computer, electronic and optical products") and the lower panel represents IT services ("Computer and related activities").

3. Innovation today: Taking action

Narrowing the digital divide

Today's digital economy is characterised by connectivity between users and between devices, as well as the convergence of formerly distinct parts of communication ecosystems such as fixed and wireless networks, voice and data, and telecommunications and broadcasting. The Internet and connected devices have become a crucial part of most individuals' everyday life in OECD countries and emerging economies. The share of Internet users in OECD countries grew on average by 30 percentage points over the last ten years (85% in 2016 as compared to 56% in 2005), and more than doubled in the cases of Greece, Mexico and Turkey. Over 50% of 16-74 year olds in Brazil, China and South Africa use the Internet today, narrowing the gap with OECD countries. Some economies are reaching saturation (uptake by nearly 100% of individuals), while there remains significant potential for catch-up in others, especially lower income countries.

57. Internet usage trends, 2005-16



Source: OECD calculations based on OECD, ICT Access and Usage by Households and Individuals Database, *http://oe.cd/hhind*; ITU, World Telecommunication/ICT Indicators Database and national sources, June 2017. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933617928

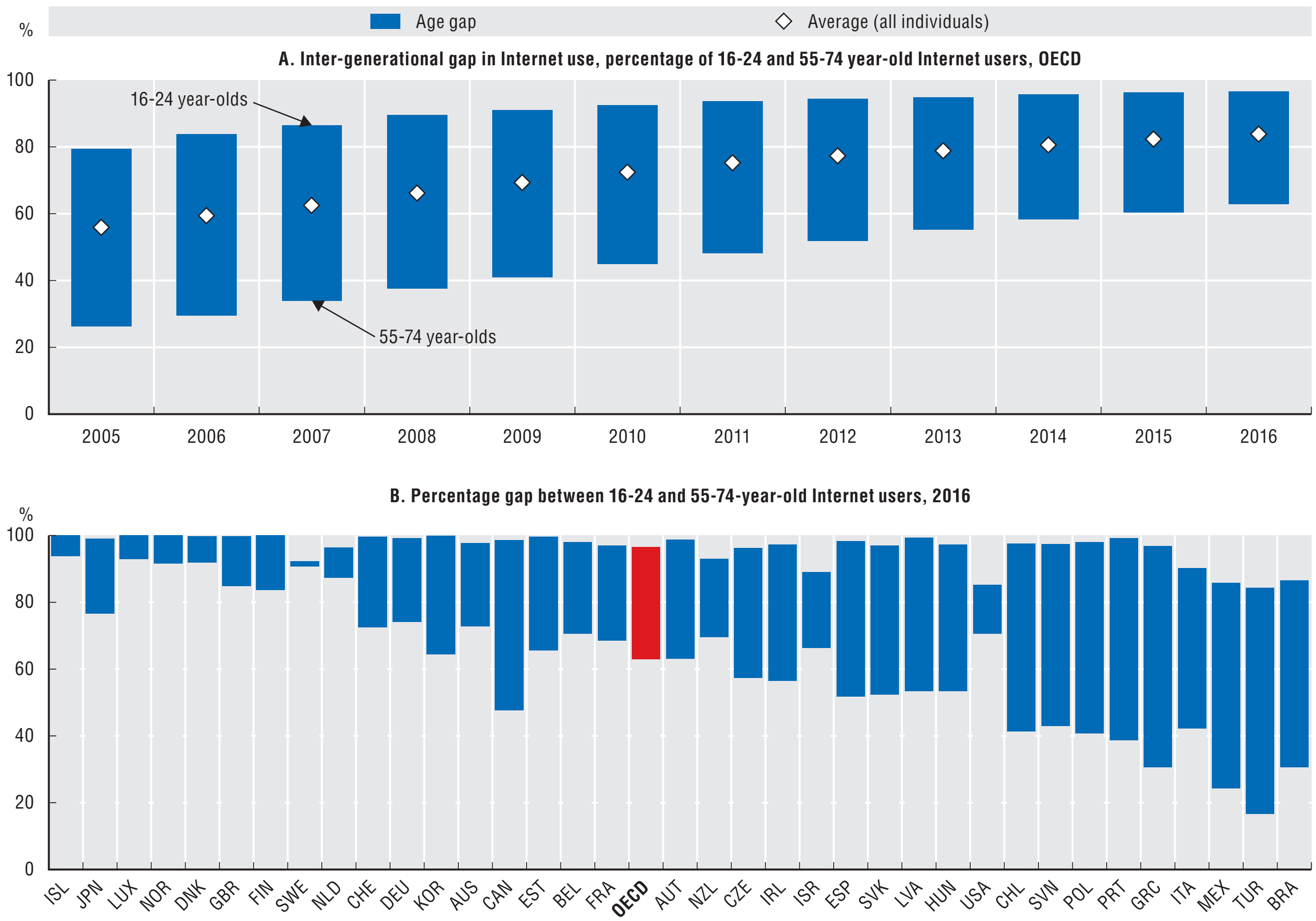
How to read these figures

Panel A shows the inter-country gap of 16-74-year-old Internet users between 2005 and 2016. In 2016, on average across all OECD countries, 84% of individuals aged 16-74 were Internet users with half of the countries ranging between the first (79%) and the third (93%) quartiles of the distribution. Internet users in the lowest-ranking country represented 58% of the population as opposed to 98% in the highest-ranking country. Panel B indicates the change in Internet use among 16-74 year olds between 2006 and 2016 for each country. In Greece, only about one-third of the population were Internet users in 2006 compared to 70% in 2016.

Narrowing the digital divide

The age gap among Internet users has been closing steadily since 2005. The near future is likely to see further narrowing as technology continues to reduce the cost of online access and today's "digital natives" become adults. However, there remain significant differences between younger and older generations in a majority of OECD countries, raising the policy issue of digital inclusion of the elderly. In 2016, Internet penetration was slightly above 60% for individuals aged 55-74 as opposed to more than 95% among 16-24 year olds in OECD countries. Cross-country differences remain wide in terms of Internet use by older generations. Over 90% of 55-74 year olds in Denmark, Iceland, Luxembourg, Norway and Sweden reported using the Internet in 2016, against less than 20% in Turkey.

58. Internet usage trends, by age, 2005-16



Source: OECD calculations based on OECD, ICT Access and Usage by Households and Individuals Database, *http://oe.cd/hhind*; ITU, World Telecommunication/ICT Indicators Database and national sources, June 2017. StatLink contains more data. See chapter notes.

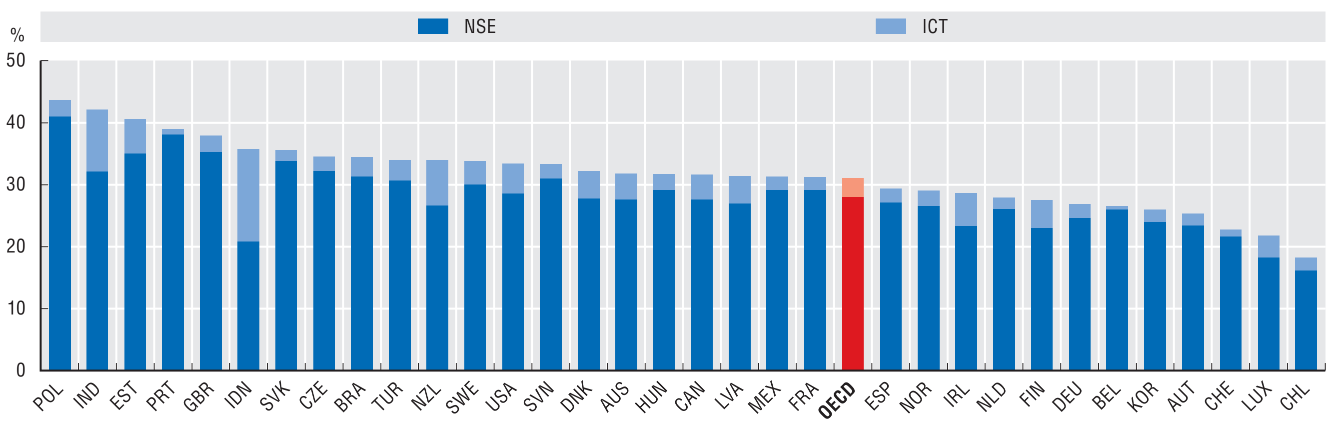
StatLink http://dx.doi.org/10.1787/888933617947

Empowering women in science and innovation

Gender equality is an objective of research and innovation policy in many countries and organisations. It aims to promote equal participation and opportunities for women and men, from compulsory education to achieving a better gender balance in research careers from entry positions through to more senior roles. It also entails the integration of the gender dimension in research content, taking into account the biological characteristics and social and cultural features of both women and men. In the OECD area, approximately 30% of graduates in the natural sciences, engineering and ICTs (NSE & ICT) are women, implying considerable under-representation. Women representation among the population of corresponding scientific authors, at close to 22%, is significantly lower than women's graduation rates at tertiary and doctorate level. Women's representation is even lower among subgroups of authors with "leadership" characteristics, reflected in high earnings, paid review, editorial activity, as well as a full dedication to research. One potential cause of concern is the relative under-representation of women in certain external engagement activities that are increasingly recognised in governmental research assessment exercises, such as the reported use of research in media reports or technical documents such as patents.

59. Women tertiary graduates in natural sciences, engineering and ICTs (NSE & ICT), 2015

As a percentage of all tertiary graduates in NSE & ICT

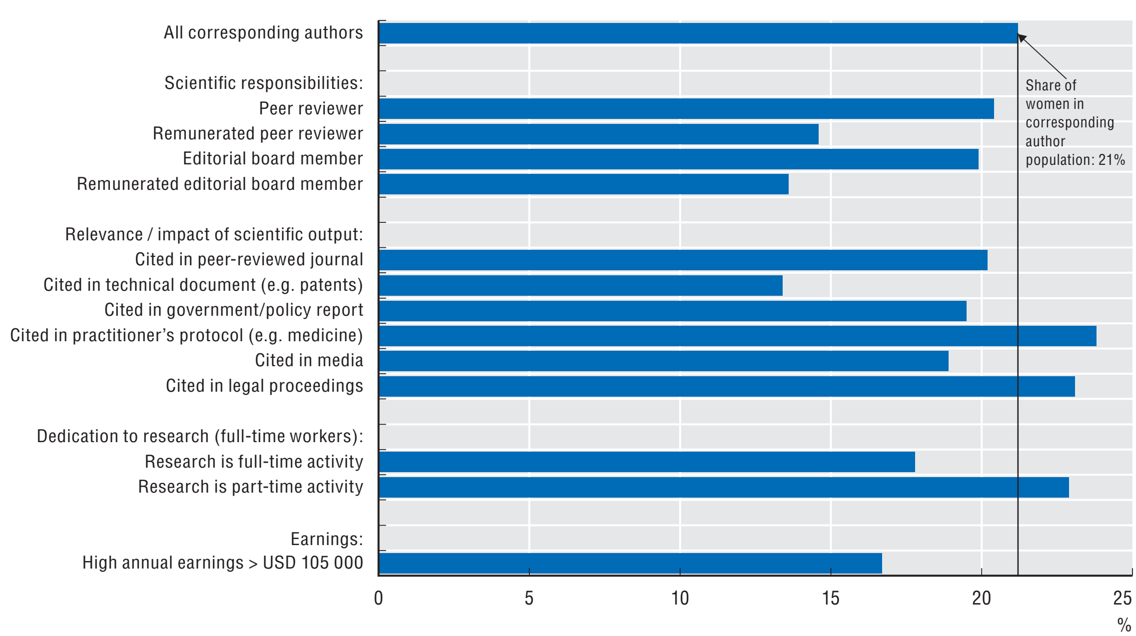


Source: OECD calculations based on OECD, Education Database, September 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933617966

60. Women in science, 2015

Share of women within the relevant group of corresponding scientific authors



Source: OECD analysis, based on OECD (2016), "International Survey of Scientific Authors: Public use microdata for 2015 pilot study – ISSA1", OECD, Directorate for Science, Technology and Innovation, *http://oe.cd/issa*, June 2017. See chapter notes.

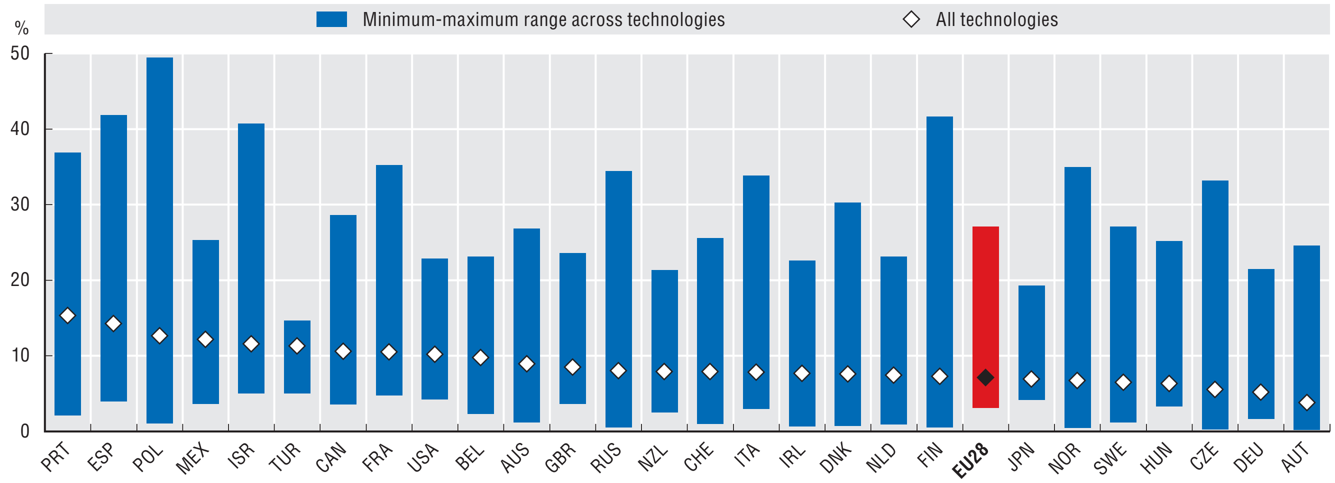
StatLink http://dx.doi.org/10.1787/888933617985

Empowering women in science and innovation

The contribution of women to the development of new technologies, as measured by the proportion of patents featuring women inventors, ranges between about 4% in Austria to over 15% in Portugal, on average. In 2012-15, in the United States, 10% of patents were invented by women, compared to 7% in Japan. Significant differences in the share of women inventors are also observed across technology fields. In most countries, the contribution of women to patented inventions is highest in pharmaceuticals (up to 42% in Spain) and biotechnology (49% in Poland), whereas the technology fields where the presence of women inventors is lowest are civil engineering and telecommunications (0.3% in the Czech Republic and Austria). Factors that may contribute to explain these observed patterns include differences in the technological and industry specialisation of countries and in the share of women graduating in science-related fields, and the participation of women in the labour market.

61. Patenting activity by women inventors, 2012-15

As a percentage of IP5 patent families by technology and inventors' country



Source: OECD, STI Micro-data Lab: Intellectual Property Database, *http://oe.cd/ipstats*, June 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933618004

How to identify women inventors?

Identification of women inventors is based on a methodology that relies on country-specific gender-name dictionaries applied to inventors' names listed in patent documents (for details, see Lax Martínez, Raffo and Saito, 2016). Statistics are available only for economies where more than 80% of inventors' names can clearly be attributed by gender. As names of inventors from Asian economies remain difficult to disentangle by gender, the indicator could not be compiled for economies such as China or Korea. Data refer to IP5 families by filing date and are grouped according to the inventors' residence and gender, using fractional counts. Patents are allocated to technology fields on the basis of the International Patent Classification's (IPC) codes listed in patent documents following the concordance provided by WIPO (2013).

How is women's representation in science measured?

Estimates of women's representation in science are based on authors' self-reported information in the online-based OECD Pilot Survey of Scientific Authors, carried out in 2015 (*http://oe.cd/issa*). The sample was drawn from documents published in 2011 and indexed in the Scopus database, focusing on the document's author designated as "corresponding author". The fields covered in this survey were: Arts and Humanities, Business, Chemical engineering, Immunology and Microbiology, Materials Science, Neuroscience, Physics and Astronomy. Weighted averages take into account the online survey sampling design and non-response patterns by fields, country and journal status. In the chart, women's absolute and relative representation along various dimensions of scientific research can be assessed through comparison with the 50% benchmark and the share of women in this specific population. Public use microdata files for the ISSA 2015 pilot survey are available for download from the project's site for research purposes.

Funding long-term, higher-risk research

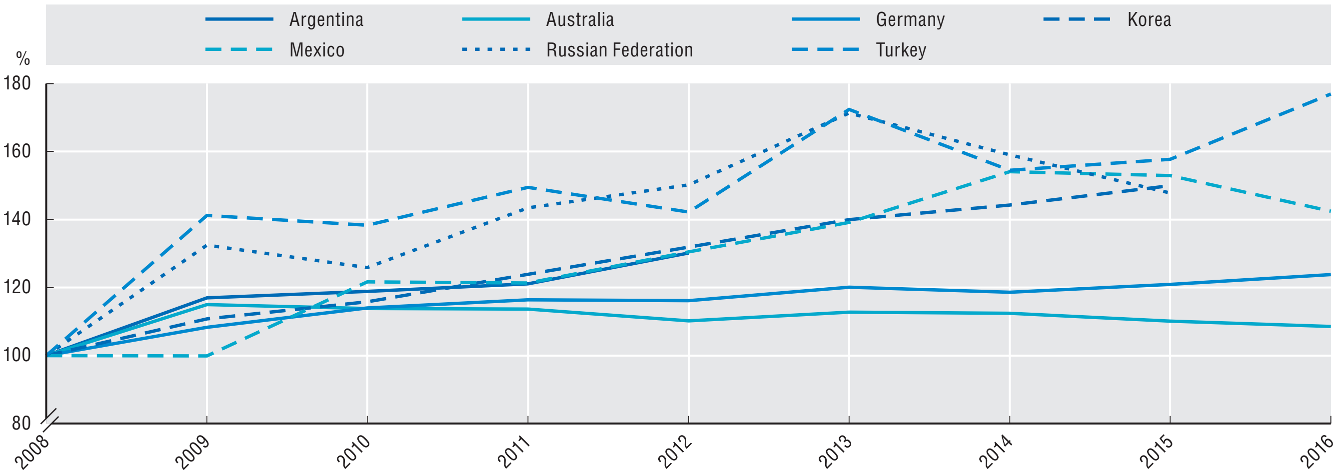
Research and development (R&D) is a key driver of long-term economic performance. Government plays an important role in supporting investment in this area, especially in cases where the private sector is reluctant to spend due to the scale of investment required, the non-excludability of the resulting assets, or the degree of uncertainty or risk involved.

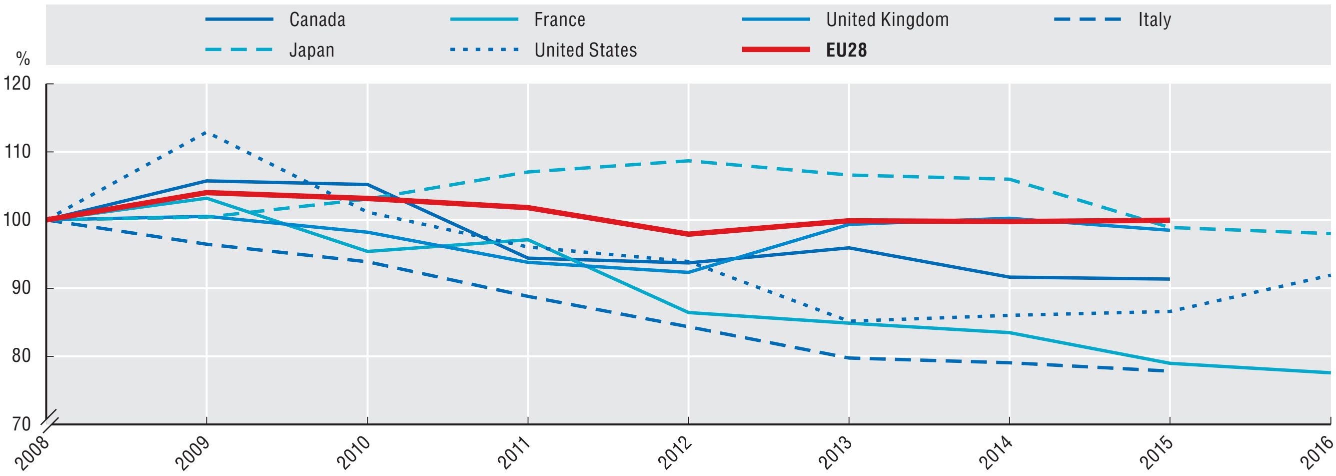
Over the period 2007-16, overall government investment fell both as a share of government spending and as a share of GDP in almost all OECD countries (OECD, 2017b). As a corollary to this, government R&D budgets have levelled-off or declined in many OECD countries and G20 economies. While the level of government R&D budgets in EU 28 countries remained roughly constant over the period 2008-15, France and Italy experienced a decline in real terms of over 20%, with a decrease of over 30% in Latvia and Spain. Government R&D budgets in the United Kingdom and the United States have begun to recover after declining between 2009 and 2012/13. Meanwhile, some countries have witnessed rises in the R&D budget, most notably Turkey (up by almost 80%) and Korea (up by 50%).

In some cases, a fall in government R&D budgets may be partially explained by a re-orientation towards other innovation support instruments, such as R&D tax incentives. However, changes in the R&D support policy mix may impact overall funding for long-term, higher-risk research as R&D tax incentives usually target businesses, which tend to perform less basic research than other sectors.

62. Government R&D budgets, selected economies, 2008-16

Constant price index (USD PPP 2008 = 100)





Source: OECD, Research and Development Statistics Database, *http://oe.cd/rds*; Eurostat, Statistics on Research and Development, July 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933618023

Funding long-term, higher-risk research

While governments fund a wide variety of research areas, there is increasing support for long-term and higher-risk research related to societal challenges such as climate change, feeding the growing world population and health conditions such as dementia. In 2016, the United States had a total government R&D budget of USD 149 billion – more than the next nine countries combined. Of this, 60% is allocated to defence and space-related R&D. Turkey and the United Kingdom are the only other OECD countries to devote 20% or more of their government R&D budgets to defence and space R&D. Such data are unavailable for China, Israel, and the Russian Federation.

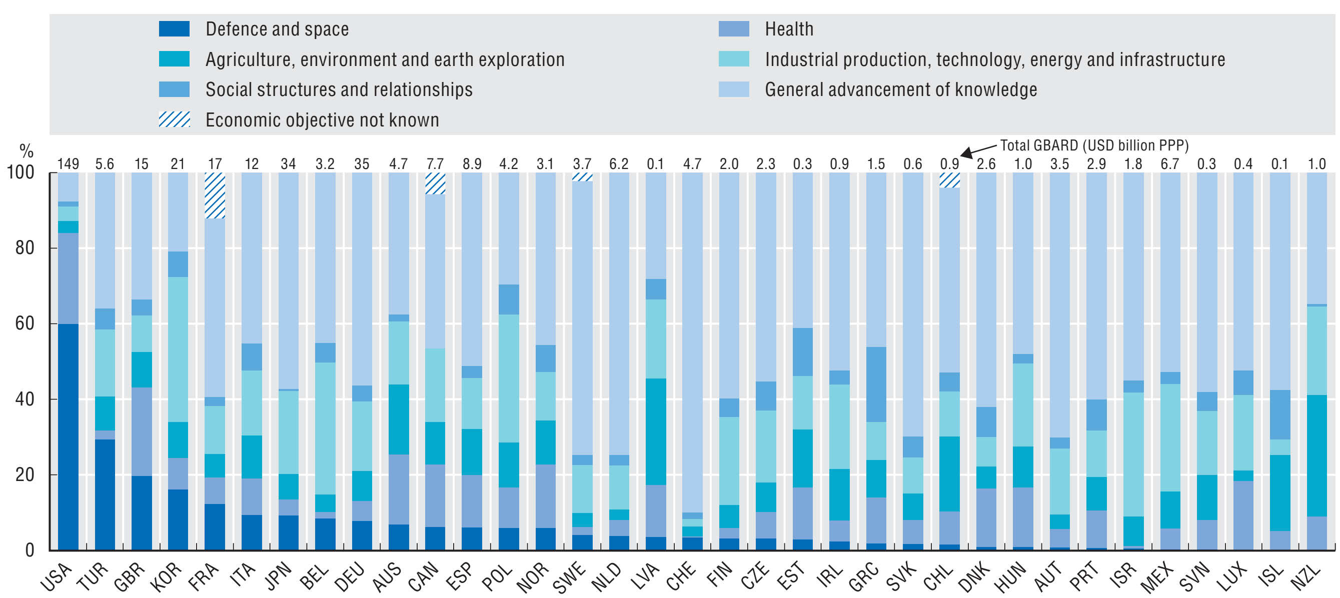
General advancement of knowledge (GAK) is the main socio-economic objective (SEO) in many countries because it includes all budget allocations earmarked for R&D but which cannot be attributed to a specific objective, as well as all R&D financed from general purpose grants from ministries of education. Further details are available for a subset of 15 European countries, with natural sciences being the main recipient of these funds for R&D.

In many countries, a sizeable proportion of funding is allocated to agriculture, environment and earth exploration, in order to address key societal challenges related to sustainably feeding the growing global population and mitigating climate change. Industrial production, technology, energy and infrastructure also accounts for a large share. The share earmarked for social structures and relationships, which includes R&D related to improving educational provision, is generally relatively small.

Across OECD countries, defence and space-related R&D budgets fell in real terms, from 32% in 2006 to 24% in 2016. Defence R&D bore the brunt of these reductions, most notably in France (-80%), and Sweden (-77%). Only Korea and Poland experienced rises in defence R&D budgets. GAK rose from 28% to 32% over the same period with other areas remaining relatively stable.

63. Government R&D budgets, by socio-economic objective, 2016

Share of total government budget allocations for R&D



Source: OECD, Research and Development Statistics Database, *http://oe.cd/rds*; Eurostat, Statistics on Research and Development, July 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933618042

How is direct government support of R&D measured?

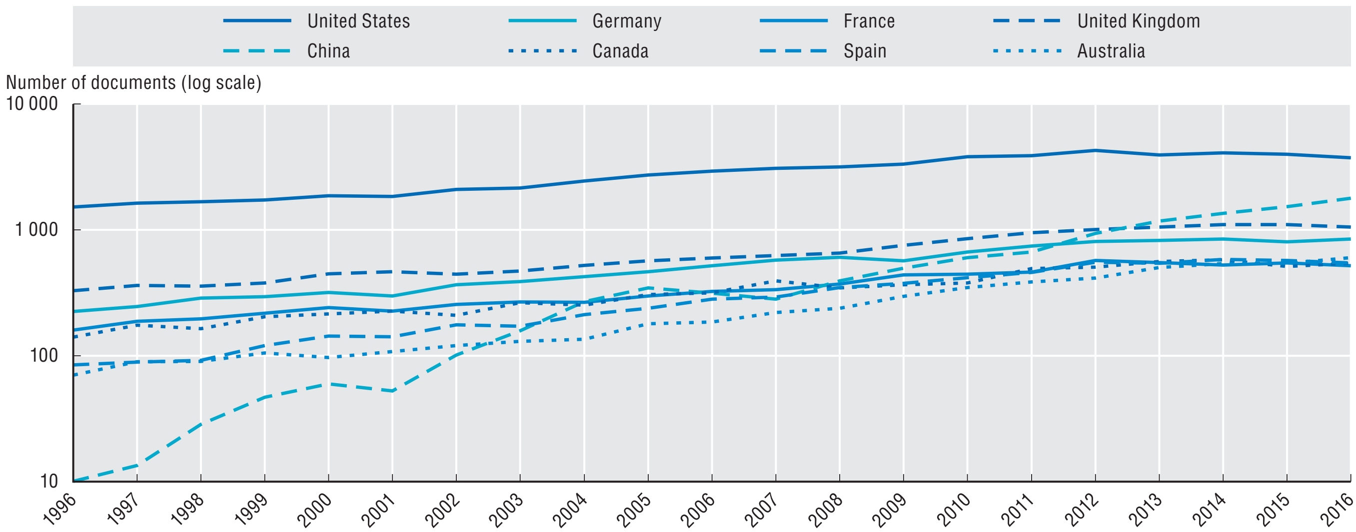
Data on "government budgetary allocations for R&D" (GBARD) encompass all allocations from sources of government revenue (e.g. taxes) foreseen within the budget. Only funds allocated through the government budgetary process are included; extra-budgetary units and public corporations' funds are excluded. These data are typically more timely than R&D survey data, but may not precisely follow the OECD *Frascati Manual* definition of R&D due to limited detail in budgetary systems. Likewise, allocating R&D-related items to socio-economic objectives (SEOs) can be challenging. In some cases, funding for a long-term R&D project may be allocated in a single year. For a number of G20 economies (e.g. China and the Russian Federation), it is not possible to distinguish budgetary support for R&D from other public investments in STI. Further data are available from *http://oe.cd/rds*.

Addressing global challenges: Dementia

As with many neurodegenerative diseases (NDDs), dementia is a debilitating condition for which there is currently no cure. Both the human and financial costs of dementia are of growing concern, especially given the ageing worldwide population. Scientific research is a cornerstone of efforts to address this global challenge, leading the OECD to issue a call for action to rebalance the risks and rewards of research in order to encourage a broader approach that helps target the disease from an early stage (OECD, 2015b). Experimental analysis of scientific publications' abstracts over two decades shows a steady increase in research related to dementia among leading countries up to 2012. Thereafter, the rising trend slowed in most leading countries including the United States, where 1.2% of the government's research budget was estimated to be allocated to NDDs in 2012 (OECD, 2015b). This cannot be accounted for by the incomplete indexing of publications in recent years that is common to bibliometric databases – which should only affect 2015 and 2016 values. However, China has made major strides in this area from a very low initial base.

64. Scientific research on dementia and neurodegenerative diseases, selected countries, 1996-2016

Total number of dementia-related documents in the Scopus database, fractional counts



Source: OECD calculations based on Scopus Custom Data, Elsevier, Version 4.2017, July 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933618061

Which documents are related to dementia?

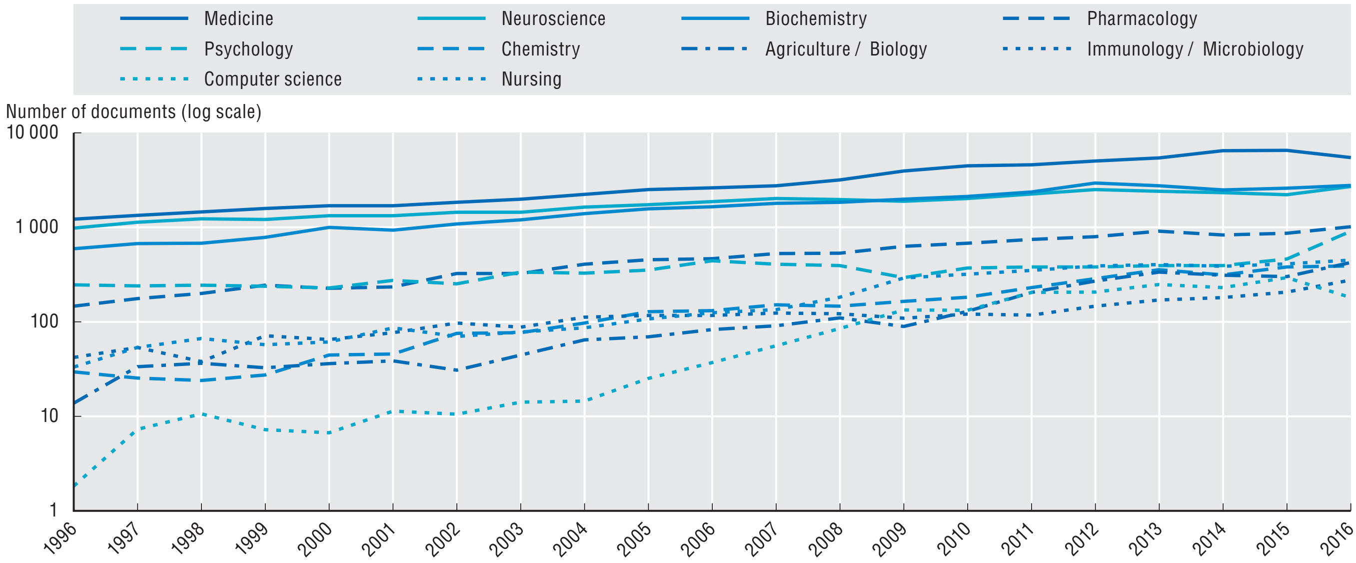
These experimental estimates are based on searches for the text items "neurodegenerat*", "dementia" and "Alzheimer" in the abstracts of articles published between 1996 and 2016 in the Scopus database. Neurodegenerative diseases include Alzheimer's disease and related dementia, Huntington's disease, Parkinson's disease and a range of motor neuron diseases. While there is a risk of capturing documents that are not strictly relevant (false positives), the main challenge is to capture all relevant documents with the chosen keywords, minimising the incidence of false negatives in the selection process. This risk is higher for basic brain research with no specific application in sight being alluded to in the abstract. The accuracy of this approach depends on the comprehensiveness of abstract indexing, which implies a bias towards English-speaking journals.

Addressing global challenges: Dementia

Data on the disciplinary areas of journals in which dementia-related papers are published show the contribution of a wide range of fields, from neuroscience and pharmacology to psychology and nursing. Consistent with a recent OECD analysis of government R&D budgets for research on neurodegenerative diseases (OECD, 2015b), a significant share of these efforts (as implied by publication outputs) is devoted to areas related to the understanding of the basic science behind the disease (e.g. neuroscience, biochemistry). Efforts in the areas of clinical or healthcare-related research for dementia can be implied from the fields of medicine (largest by number), nursing and psychology. The fast growth in the importance of computer science testifies to the crucial role of big data in addressing the complexity of dementia as a means to advance the understanding of risk reduction factors, care and treatment.

65. Disciplinary areas contributing to the scientific output on dementia and neurodegenerative diseases, 1996-2016

Total number of dementia-related documents in the Scopus database, by ASJC journal field, fractional counts



Source: OECD calculations based on Scopus Custom Data, Elsevier, Version 4.2017, July 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933618080

How are the disciplinary areas identified?

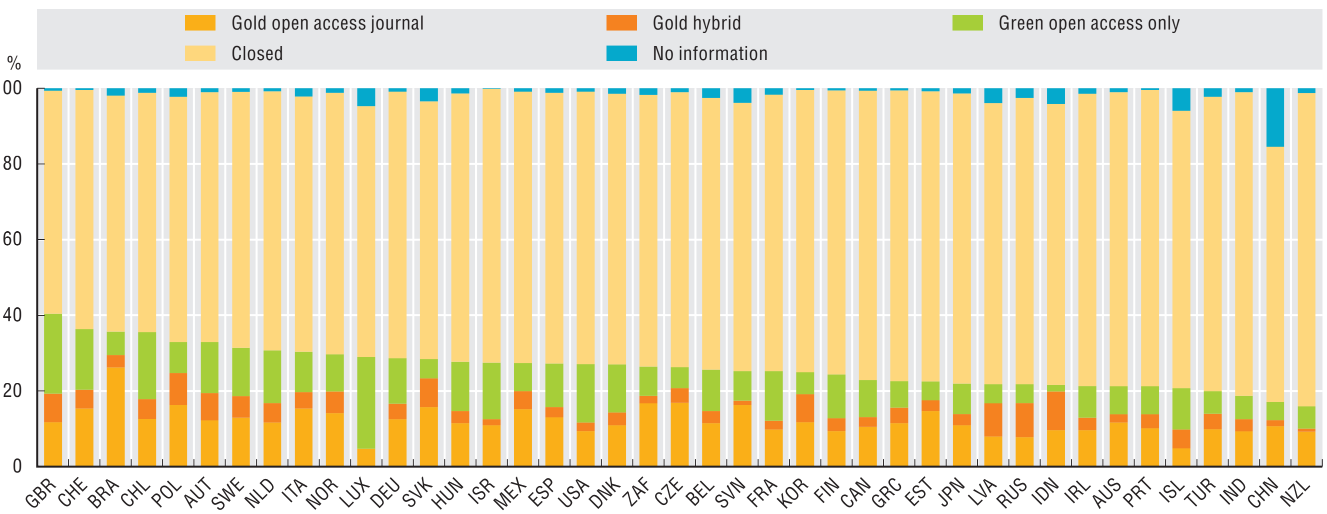
The disciplinary areas are based on Elsevier's classification approach whereby each journal in Scopus is assigned to one or more subjects using its "All Science and Journal Classification" (ASJC). This comprises 27 main fields and 334 more narrowly defined subjects. Results are presented for the main fields on a fractional basis. In the case of documents in general journals, each document is apportioned across substantive areas based on the distribution of citing and cited documents ASJC fields. Further work is necessary to understand the extent and nature of interdisciplinary in this area. For example, evidence of interdisciplinarity can be found in instances of highly cited documents on the use of graphene (a nanotechnology product) in the early detection of dementia in patients.

Opening access to science

Access to scientific research articles plays an important role in the diffusion of scientific knowledge. Today's digital opportunities facilitate the sharing of scientific knowledge to promote its use for further research and innovation. The promotion of open access (OA) to publications is relevant to open science (i.e. efforts to make the outputs of publicly funded research more widely accessible in digital format to the scientific community and to society more broadly). A new and experimental indicator, based on online queries for documents about one year after publication, reveals that 60% to 80% of content published in 2016 is only available one year after to readers via subscription or payment of a fee. Journal-based OA (gold) is particularly noticeable in Brazil, as well as in many other Latin American economies. Repository-based OA (green) is especially important for authors based in the United Kingdom. Nowadays, about 5% of authors appear to be paying a fee to make their papers publicly available within traditional subscription journals (gold hybrid).

66. Open access of scientific documents, 2017

As a percentage of a random sample of 100 000 documents published in 2016



Source: OECD calculations based on Scopus Custom Data, Elsevier, Version 4.2017; and roaDOI "wrapper" routine for the oaDOI API, *https://oaDOI.org*, July 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933618099

How to measure open access using online tools

The last edition of this publication measured open access to scientific publications using the results of an online survey of scientific authors worldwide carried out by OECD (*http://oe.cd/issa*). This edition derives the indicator from an automated online query on a random (non-stratified) sample of 100 000 citable documents (articles, reviews and conference proceedings) published in 2016 and contained in the Scopus database, with associated DOIs (over 90% of cases). Assessment of the OA status of the documents was conducted in June 2017 using the R-language based "wrapper" routine for the oaDOI application programme interface (API) produced by ImpactStory, an open-source website that works to help researchers explore and share the online impact of their research. The API returns information on the ability to secure legal copies of the relevant document for free and the different mechanisms:

Gold open access journal applies to documents associated to publishers included in the Dictionary of Open Access Journals that make their content openly available at no charge to readers.

Gold hybrid indicates that a document is accessible from a publisher that typically requires subscription for general access, but allows open access to the specific document, normally with the author or their sponsors paying article processing charges that provide for open access by third parties (as for most gold open access journals).

Green open access indicates that legal versions of the document exist in repositories or related outfits, and do not match either of the gold categories. This value may be underestimated if the oaDOI fails to identify all legally available copies or nearly identical versions.

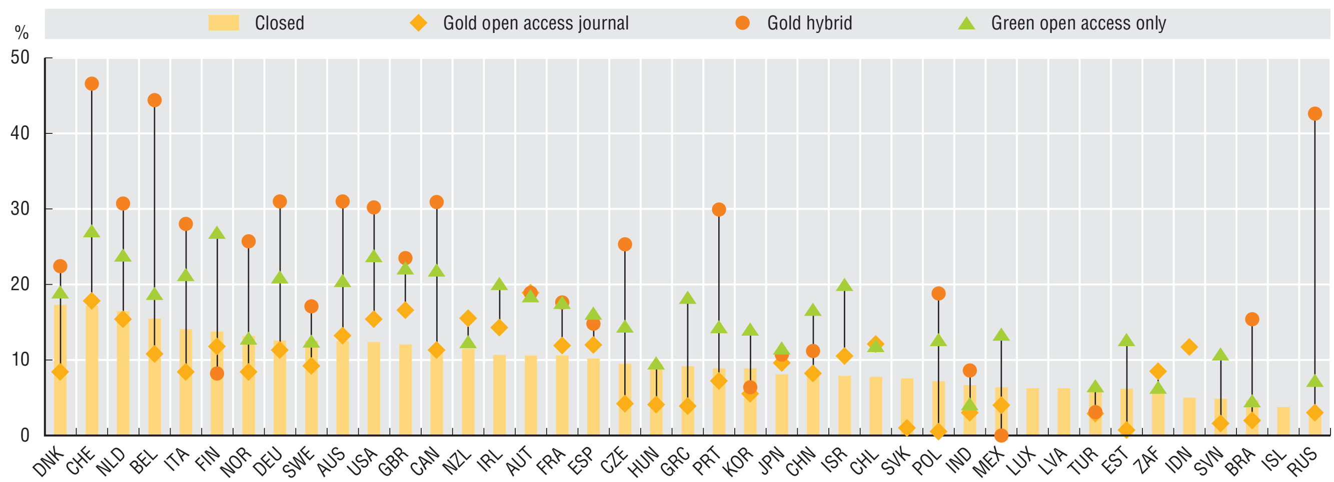
When the DOI cannot be resolved to any source of access information, the result is marked as "No information - status not available". This category is particularly high for China at more than 15%. When the DOI resolves and the return indicates that there are no legal open versions available, the document is marked as "Closed". This includes documents under embargo.

Opening access to science

Assessing the extent to which open access (OA) publications receive more citations than non-OA publications helps policy makers evaluate the social costs and benefits of alternative scientific publication funding mechanisms. This has led to efforts to measure the so-called "open access citation advantage". Bibliometric results using the latest wave of data available confirm previous survey results presenting a mixed picture (OECD, 2015c; Boselli and Galindo-Rueda, 2016), as not all forms of OA appear to confer an advantage. OA is associated overall with higher citation rates among documents covered by major indices, but this does not apply to documents published in OA journals, which on average tend to be more recent and present lower historical citation rates. Repository-based (green) OA systematically confers a citation advantage. In most cases, higher citation rates are found within countries among "gold hybrid" documents (i.e. those published in subscription journals whose authors pay publishers a fee to enable free online access on the part of potential readers).

67. Highly cited scientific documents, by open-access status, 2017

Percentage within the 10% most-cited published in 2016



Source: OECD calculations based on Scopus Custom Data, Elsevier, Version 4.2017; and roaDOI wrapper for the oaDOI API, *https://oaDOI.org*, July 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933618118

The impact of open access beyond citation by peers

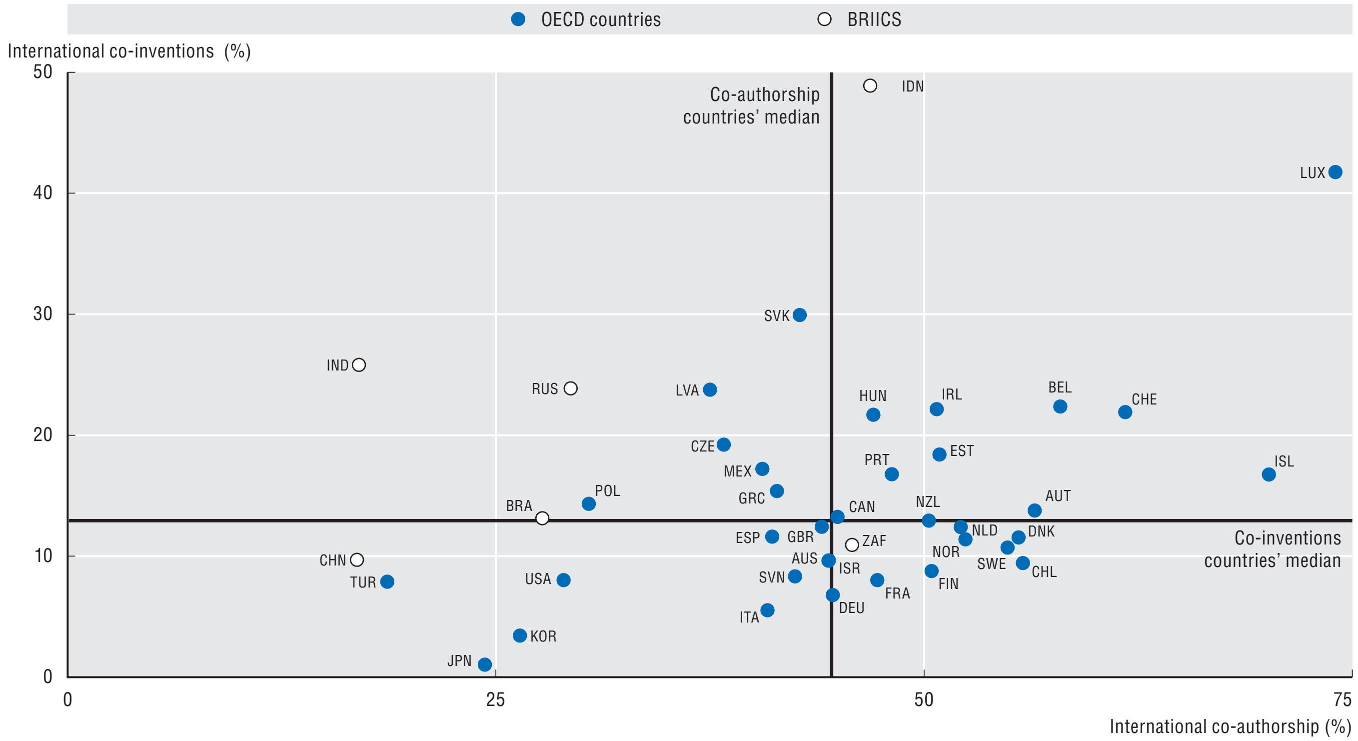
Citation rates are imperfect measures of scientific impact, even when normalised by field, cohort and type of document. A major concern is that they do not capture the relevance and usefulness of the research to a wider community of potential users of scientific knowledge, who are less likely to publish in peer-reviewed scholarly journals (e.g. general medical practitioners, inventors in business, government officials, etc.). Based on self-reported information by authors, the OECD ISSA1 study shows that open-access documents are more likely to have been cited in a broader set of use settings, such as government reports, patents, legal cases or practitioner protocols, as well as non-peer-reviewed working papers. Given the increasing digital fingerprint of many of those activities, Internet-based metrics are increasingly being used to provide information on broader types of impacts. However, one possible drawback is that these metrics may actually provide measures of "popularity" and in turn distort behaviours if used to conduct research assessment (*http://oe.cd/blue-sky*). Analysis of the link between different forms of open access to scientific documents and research impact appears to point to a potential decoupling of the quality assurance and access roles traditionally played by academic journals.

Promoting international collaboration and mobility

Collaboration within and across countries is a pervasive feature of research and innovation activities worldwide, and a key driver of knowledge exchange. International collaboration can be documented by tracking the affiliation(s) of co-authors of scientific publications and co-inventors of patented inventions. With the exception of India and Indonesia, all BRIICS (white circles) and OECD countries (blue circles) display higher rates of scientific collaboration than international co-invention. While exhibiting similar levels of engagement in international co-authorships, scientifically and technologically advanced economies such as Japan, Korea and the United States present different levels of co-inventorship, with Asian inventors being relatively less engaged in cross-country collaboration. Small, open economies tend to display higher collaboration rates. Factors such as scientific and technological specialisation, collaboration opportunities, and geographical and institutional proximity may help explain these patterns.

68. International collaboration in science and innovation, 2005-16

Co-authorship and co-invention as a percentage of scientific publications and IP5 patent families



Source: OECD calculations based on Scopus Custom Data, Elsevier, Version 4.2017 and OECD, STI Micro-data Lab: Intellectual Property Database, *http://oe.cd/ipstats*, July 2017. StatLink contains more data. See chapter notes.

StatLink *http://dx.doi.org/10.1787/888933618137*

Interpreting the indicators

International co-inventions are the share of inventions that include at least one foreign co-inventor in total patents invented domestically. Data refer to IP5 patent families (inventions patented in the five top IP offices) filed in 2005-15 according to the inventor's residence, by first filing date and according to the inventor's residence, using whole counts.

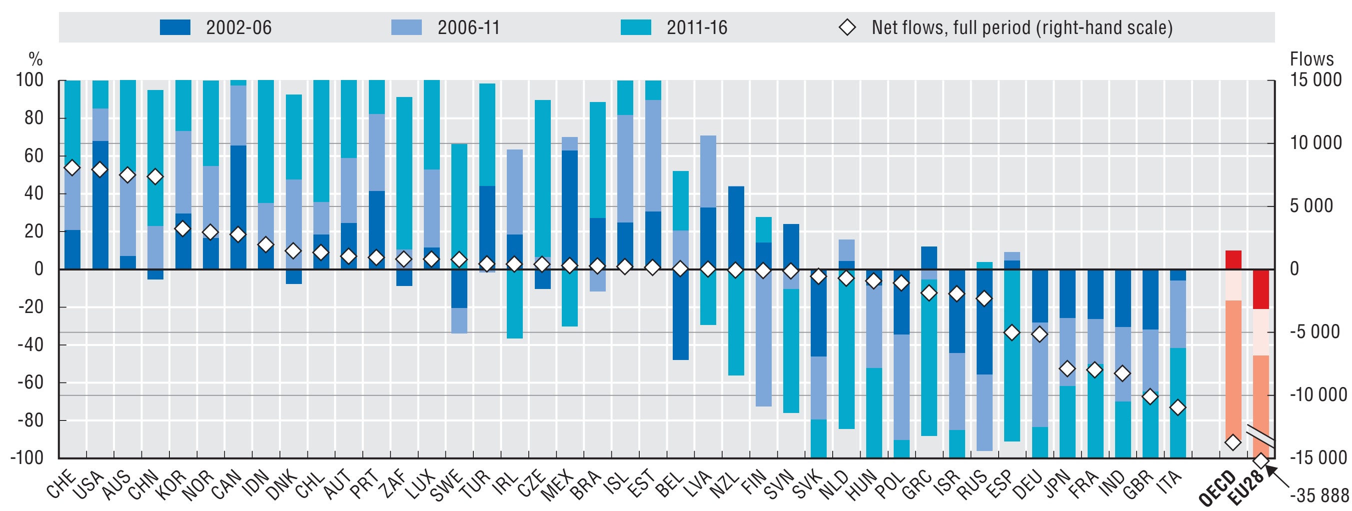
International co-authorship of scientific publications is measured in terms of the share of articles featuring authors affiliated with foreign institutions (from a different country or economy) in total articles produced by domestic institutions. For comparability with data on co-inventions, a whole counts approach is used in this case. This results in larger estimates than presented on a fractional basis in Chapter 3 of this publication.

Promoting international collaboration and mobility

Indicators of international scientist mobility, based on changes in authors' affiliations, reveal that mobility is mostly characterised by mutual "brain circulation", rather than one-directional flows ("brain gain/drain"). However, analysis of net entry and exit flows of scientific authors over time can be highly informative, especially with regard to a science system's response to events and policies adopted by countries linked to the funding of scientific research, support for scientific international mobility and policies designed to attract the highly qualified. Data on net flows since 2001 show that Switzerland, the United States and Australia attract the largest numbers of scientists, followed closely by China, which has gone from being a large net "donor" to becoming the largest net recipient among major economies. In the United States, the net entry of scientists has slowed in recent years. Japan and India have accumulated net losses, while the Russian Federation began to attract more publishing scientists since 2014. The EU28 area became a net attractor for a short period in 2008-09, but registered a very significant deficit after 2011. Over the last 15 years, almost 36 000 more scientific authors left the EU than entered. This is explained in part by the return mobility of individuals who arrived as students before becoming published scientists. There are significant variations across the largest EU28 countries, with the United Kingdom attracting scientists in 2014-16, while Spain joined Italy in becoming the largest relative net donors among economies with high levels of scientific output.

69. International net flows of scientific authors, selected economies, 2002-16

Difference between annual fractional inflows and outflows, as a percentage of total flows



Source: OECD calculations based on Scopus Custom Data, Elsevier, Version 4.2017, July 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933618156

How to read this figure

This figure decomposes the overall net flow of scientific authors across different years for OECD countries and BRIICS economies over the period 2001-16, expressed in relative terms. This helps to identify the timing and intensity of different phases of net entry and net exit from the perspective of a given country. For example, Germany and Spain experienced a similar cumulative net loss over the period (see the diamond value on the right-hand scale). In the case of Spain, this is the result of a phase of moderate gains in the 2000s, followed by a significant net outflow of scientific authors after the crisis. In contrast, Germany's pattern is relatively more stable and it has reduced its deficit in recent years.

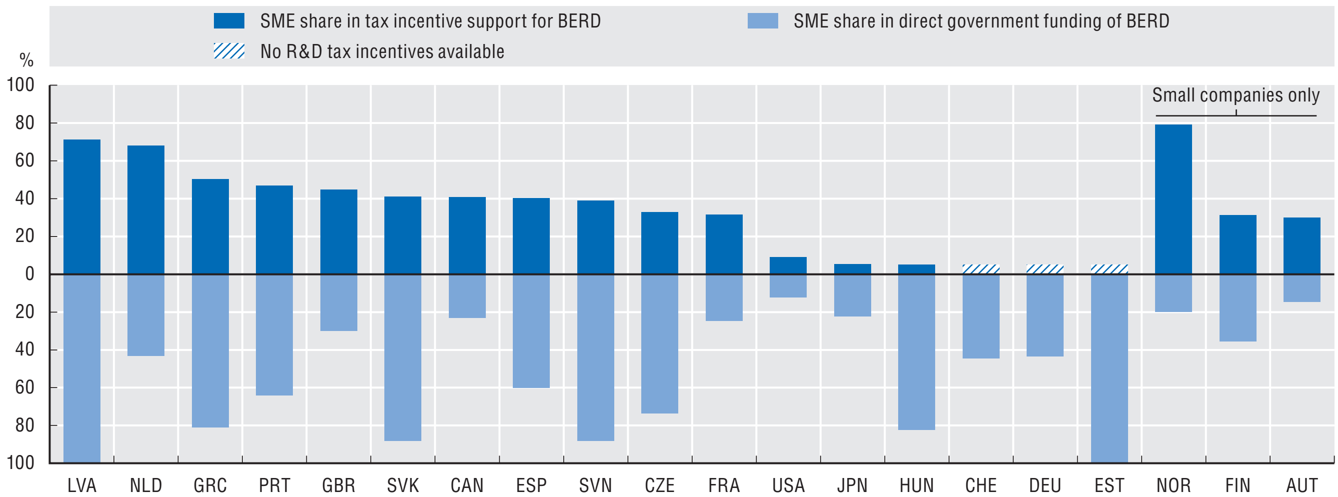
Monitoring changes in scientist affiliations in global repositories of publications provides a complementary source of detailed information. However, its scope is limited to authors who publish and do so regularly, as otherwise their affiliations cannot be detected and timed in a sufficiently accurate way. Mobility can only be computed among authors with at least two publications. These indicators are likely to understate flows involving countries and fields where there are moves to industry or organisations within which scholarly publication is not the norm. Furthermore, the measurement of mobility can be hard to disentangle from that of collaboration in the case of authors with multiple affiliations in different countries. A fractional mobility count approach has been used in this case.

Supporting business innovation

Government support for business R&D seeks to encourage firms to invest in knowledge that can result in innovations that transform markets and industries and result in benefits to society. Governments can adopt various instruments to incentivise R&D by business. In addition to direct support such as grants and buying R&D services, 30 out of the 35 OECD countries provided fiscal incentives in 2017, up from 16 OECD countries in 2000. As R&D is highly concentrated in large firms, the latter tend to be the main recipients of direct and tax support for business R&D (BERD). New OECD analysis sheds light on the distribution of support by business size for a number of countries. The SME share in R&D tax support ranges from 5% in Hungary to 71% in Latvia and 79% in Norway (small companies only). While direct support is by and large discretionary, the SME share in tax support tends to be more closely aligned with the SME share in BERD, confirming the notion that tax incentives are generally a demand-driven complement to direct government support for R&D. It is worth noting that the SME share in tax support exceeds the share of direct funding in Austria, Canada, France, the Netherlands, Norway and the United Kingdom. All these countries offer refundable R&D tax incentives that particularly target smaller R&D performers, allowing them to make use of earned tax credits even in the case of insufficient tax liability where any excess credits are paid in full or in part to the taxpayer.

70. Direct funding and tax incentive support for business R&D by SMEs, 2015

As a percentage of government support for BERD in each category



Source: OECD, R&D Tax Incentive Indicators, *http://oe.cd/rdtax*, July 2017. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933618175

How to measure R&D tax incentives

OECD estimates of the cost of R&D tax incentives are combined with data on direct R&D funding, as reported by firms through R&D surveys, to provide a more complete picture of government efforts to promote business R&D. These efforts can now be mapped over time. The OECD data collection on R&D tax incentives (now in its fifth edition) attempts to identify and address subtle differences in the tax treatment of R&D, the relevant tax benchmark and measurement approaches. National experts on science and technology indicators have collaborated with public finance and tax authorities to provide the most up-to-date and internationally comparable figures possible. The estimated cost of provisions for the treatment of R&D expenditures by firms is presented relative to a common benchmark (full deductibility of current R&D) whenever possible. Estimates reflect the sum of foregone tax revenues – on an accruals basis – and refunds where applicable. The latest edition of the OECD *Frascati Manual* incorporates a new chapter dedicated to the measurement of R&D tax incentives (OECD, 2015a): see *http://oe.cd/frascati*.

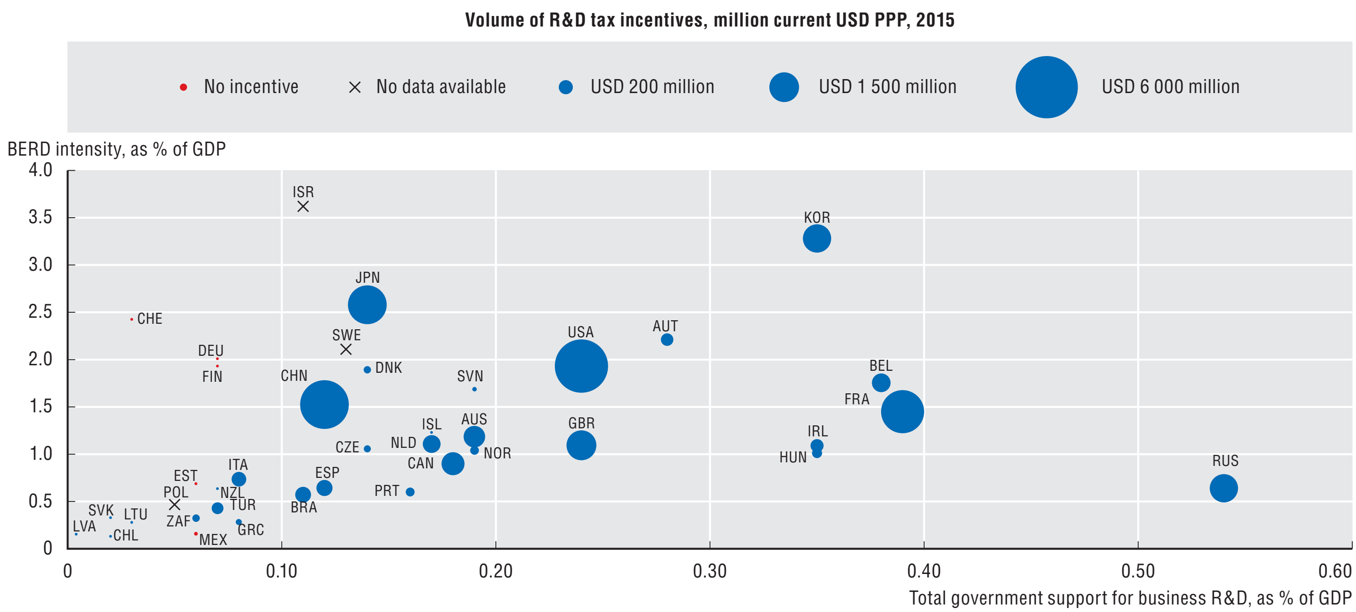
This specific indicator is presented on a experimental basis. International comparability may be limited (e.g. due to variations in SME definitions for business R&D versus R&D tax relief reporting purposes). For BERD and government-funded BERD, SME figures generally refer to enterprises with 1 to 249 employees (i.e. excluding firms with zero employees), unless otherwise specified. A number of countries adopt additional criteria to define SME status. For SME definitions, see *http://oe.cd/sb2017_notes_rdtax*.

Supporting business innovation

Across countries, R&D intensity in the business sector has a positive correlation (0.3) with the level of government support to business R&D, with some notable exceptions. Germany and Korea present relatively high business R&D intensities compared to their degree of measured government support, while France, Hungary and the Russian Federation have high rates of support relative to countries with similar business R&D-to-GDP ratios. A complementary indicator compares the evolution of government support for R&D and business R&D intensity. Over the 2006-15 period, countries with the largest increase in government support exhibited higher growth in R&D intensity. China and Korea's growth in R&D intensity is higher than predicted by their change in measured government support. Changes in government support appear to account for approximately 17% of the observed variation in business R&D intensity over the 2006-15 period. Additional analysis shows that almost two-thirds of this explained variation is accounted for by changes in direct support and the remainder by tax support.

71. Business R&D intensity and government support to business R&D, 2015

As a percentage of GDP

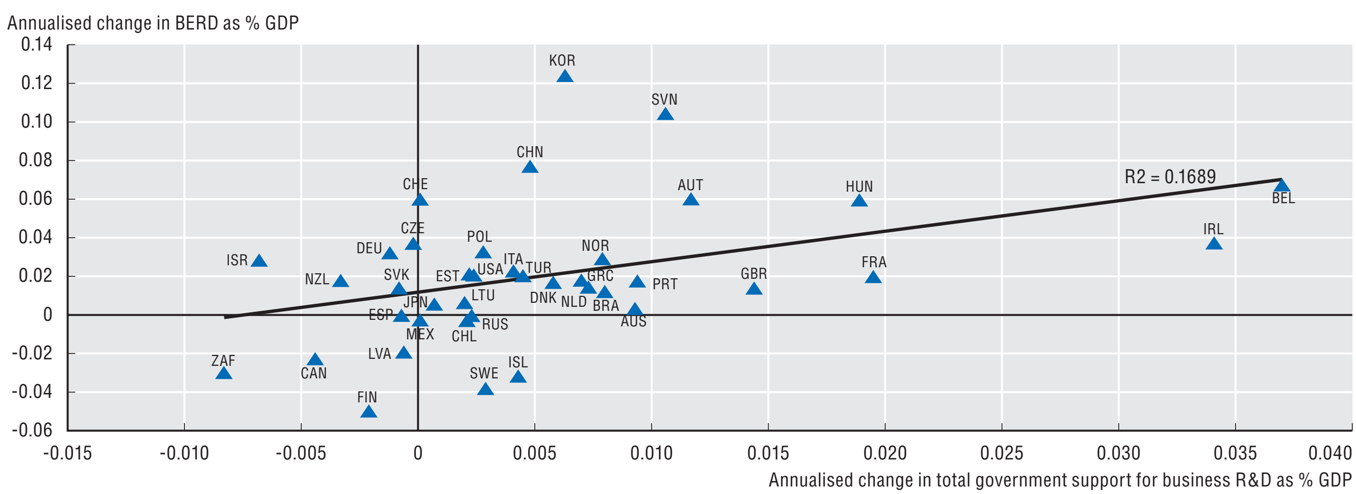


Source: OECD, R&D Tax Incentive Indicators, *http://oe.cd/rdtax*, July 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933618194

72. Changes in government support to business R&D and total business expenditures on R&D, 2006-15

Annualised absolute changes of figures as a percentage of GDP



Source: OECD, R&D Tax Incentive Indicators, *http://oe.cd/rdtax*, July 2017. StatLink contains more data. See chapter notes.

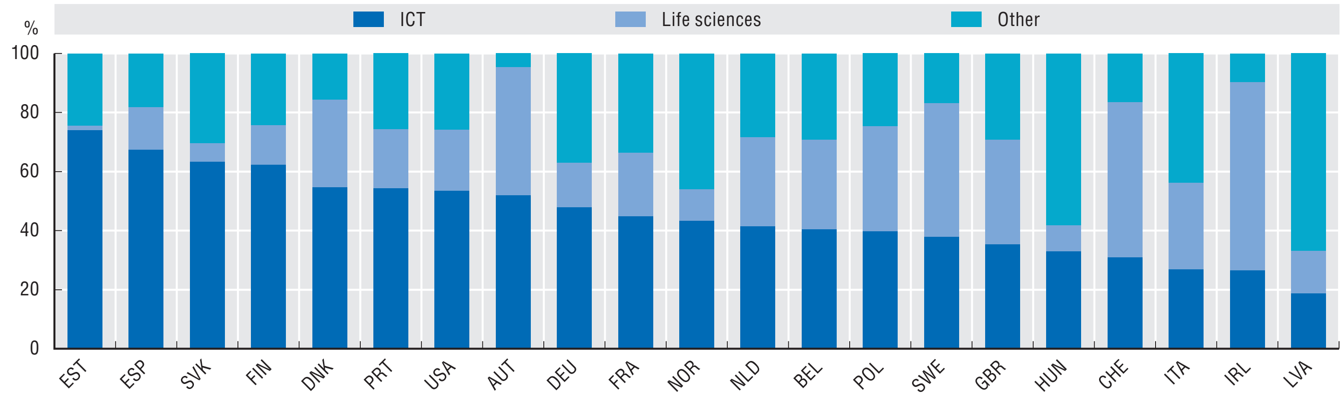
StatLink http://dx.doi.org/10.1787/888933618213

Financing entrepreneurship and innovation

Access to finance for new and innovative small firms involves both debt and equity finance. Venture capital (VC) and business angel investments are important sources of equity funding, especially for young technology-based firms. Available industry level data show that VC investments in 2016 were concentrated mostly in the ICT sector, especially in countries such as Estonia, Spain and the Slovak Republic. In Europe, data for 2015 show that more than one-third of business angel deals involved the ICT sector, while in the United States, data for 2016 show that 45% of all deals related to software, Internet and mobile phones.

73. Venture capital investment in selected countries, by sector, 2016

As a percentage of total venture capital investment

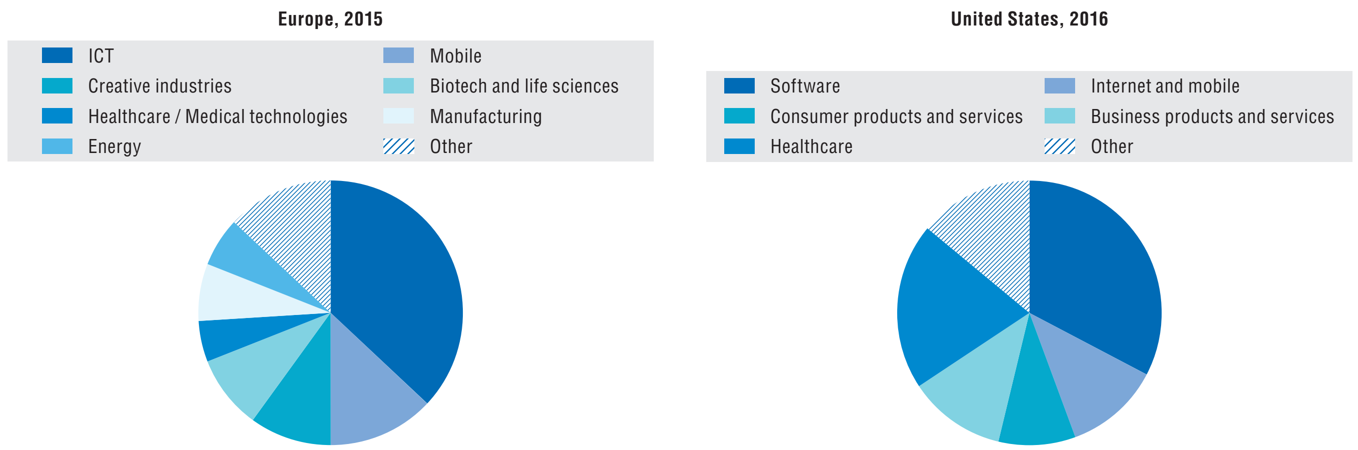


Source: OECD, based on OECD Entrepreneurship Financing Database, September 2017. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933618232

74. Business angel deals by sector, Europe, 2015 and the United States, 2016

As a percentage of total business angel deals



Source: OECD calculations based on ARI (Angel Resource Institute) and networks surveyed by EBAN (European Trade Association for Business Angels, Seed Funds and other Early Stage Market Players), September 2017. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933618251

Measuring venture capital and angel capital

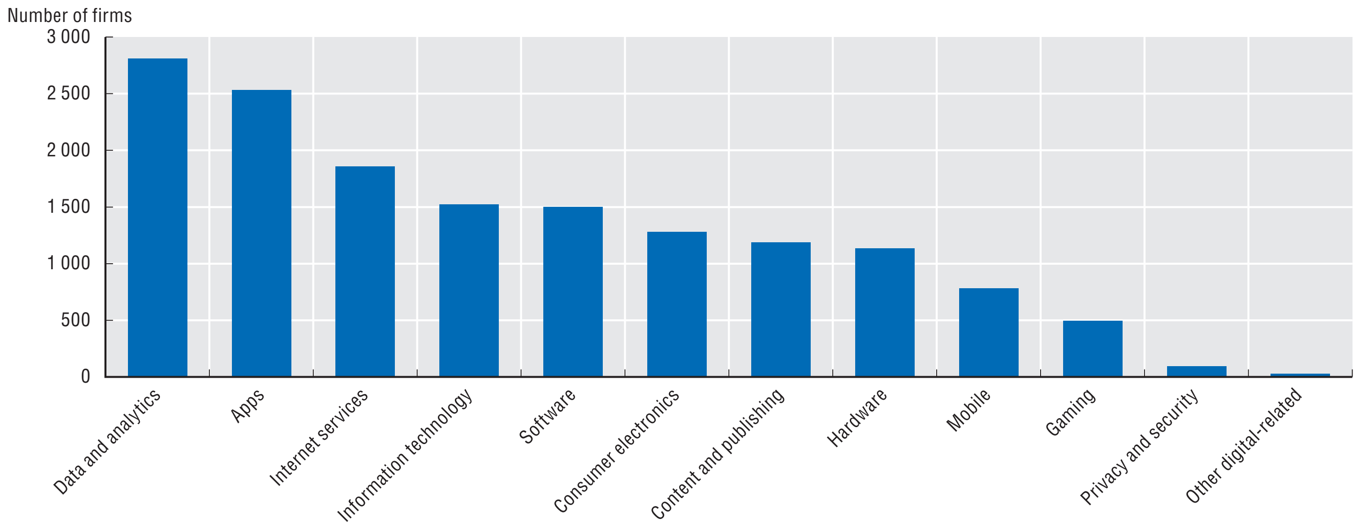
Data on VC are drawn from national or regional venture capital associations and commercial data providers. There is no standard international definition of VC or an available breakdown by stage of development and industry. The OECD Entrepreneurship Financing Database aggregates original data to fit the OECD classification of venture capital by stages and by aggregate industries. Increased co-operation among national/regional VC data providers is likely to improve data availability to provide internationally comparable information on VC investment in different sectors across countries. Angel capital data are collected from the angel networks and groups surveyed by business angel associations. Data on angel investment are difficult to assess due to the discrete nature of such financing (leading to an "invisible market") and differences in definitions across countries regarding what constitutes an angel investor. In addition, survey-based data typically suffer from inconsistencies regarding the year-on-year number of respondents, as well as from incomplete market coverage (OECD, forthcoming).

Financing entrepreneurship and innovation

Experimental indicators relying on detailed data from Crunchbase© reveal that the majority of equity funds flowing into digital-related start-ups is concentrated in the apps, data and analytics industries. From 2011 to 2016, equity funding in these two sectors accounted for 80% of all equity funding in the digital-related sectors in Estonia and Latvia, and 70% in China.

75. Start-ups in digital-related sectors that attracted equity funding in OECD and BRIICS, 2011-16

Firms aged five years old or less

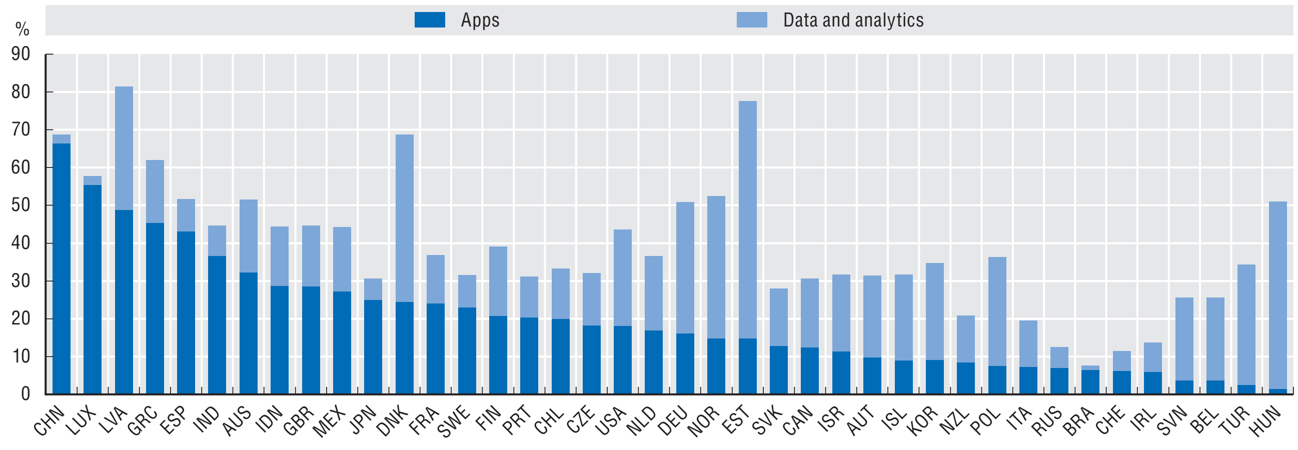


Source: Crunchbase© data, *www.crunchbase.com*, September 2017, as reported in Breschi, Lassebie and Menon (forthcoming). See chapter notes.

StatLink http://dx.doi.org/10.1787/888933618270

76. Top digital-related sectors that attracted equity funding, 2011-16

As a percentage of total equity funding in digital-related sectors



Source: Crunchbase© data, *www.crunchbase.com*, September 2017, as reported in Breschi, Lassebie and Menon (forthcoming), September 2017. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933618289

Insights from *Crunchbase*©

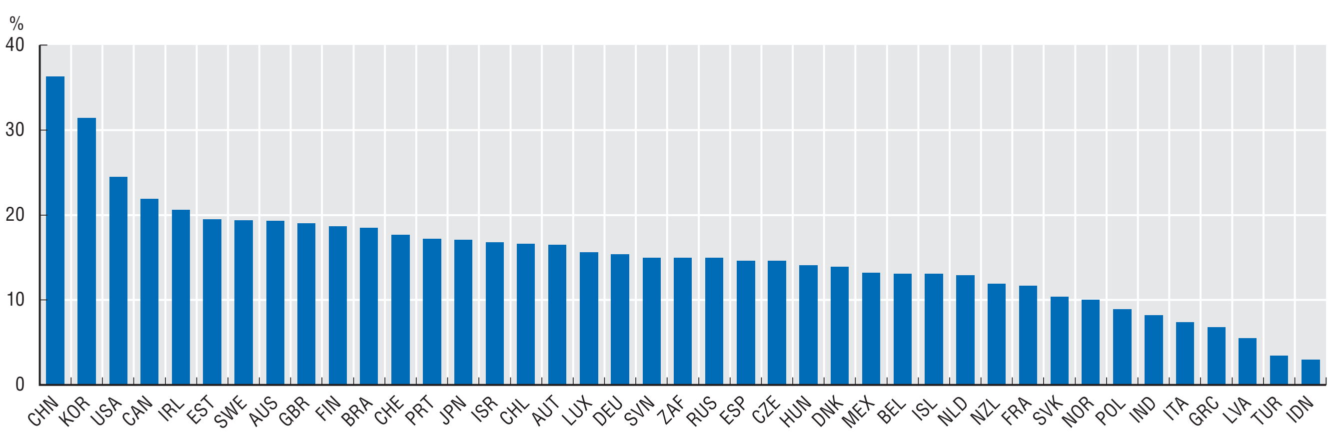
Crunchbase© provides information on start-up activity and financing within and across countries worldwide. Available variables include company size class, location (city and region), primary role (firms, group, investor or school), status (operational, acquired, IPO or closed), founding date and the dates on which the record was created and updated, respectively. For more information, see Dalle, Denbesten and Menon (forthcoming). In the figures presented here, the sample is restricted to firms founded after 2010 (i.e. five years old or less in 2016) that attracted equity funding over the 2011-16 period. Equity funding includes venture capital and other risk finance such as business angel investments or debt financing. Digital-related sectors are identified on the basis of correspondence between the sectors available in the database with the ISIC Rev.4 industry list. Results reported here should be considered as an initial exploration of Crunchbase© data for the purposes of statistical and economic analysis.

Promoting scientific excellence

How effective are different mechanisms for funding scientific research? A new and experimental indicator explores the extent to which publishing scientists secure direct funding for their research based on whether authors acknowledge funders in their publications. This provides an approximate, bottom-up view of the extent of activity-specific (and likely competitive) funding, from the viewpoint of researchers, that is linked to scientific outputs. Authors who do not cite specific funders are more likely to rely on institutional resources for research, including their own salaries. Authors based in China, Korea and the United States – where project-based funding is most common – are the most likely to acknowledge sources of funding in their papers. In contrast, authors based in Italy and France presents some of the lowest funding acknowledgement rates, reflecting the relatively higher importance of institutional funding in those countries. A comparison of citation patterns within countries reveals that funding acknowledgement is associated with a significantly higher excellence rate, measured by the proportion of each class that features among the world's 10% most-cited documents in their field and cohort. This result may be indicative of selection by funders of the most "impactful" activities or a reflection of the benefits of securing additional funding. Assessing the relative efficiency of alternative resource allocation mechanisms requires additional information on funding amounts and selection mechanisms as applied at the micro level. This calls for a more fine-grained data infrastructure to complement the top-down view provided by government R&D budget statistics.

77. Scientific documents acknowledging direct sources of funding, 2016

As a percentage of all citable documents

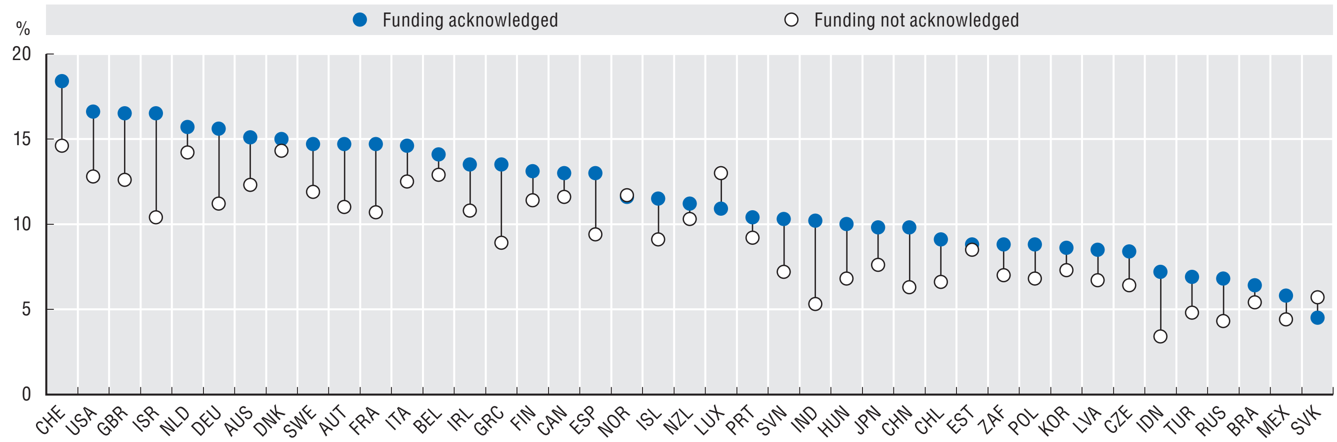


Source: OECD calculations based on Scopus Custom Data, Elsevier, Version 4.2017, July 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933618308

78. Funding acknowledgement in scientific publications and their citation impact, 2016

As a percentage of top 10% ranked documents within each category



Source: OECD calculations based on Scopus Custom Data, Elsevier, Version 4.2017; and 2015 Scimago Journal Rank from the Scopus journal title list (accessed June 2017), July 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933618327

Notes and references

Cyprus

The following note is included at the request of Turkey:

"The information in this document with reference to 'Cyprus' relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognizes the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Turkey shall preserve its position concerning the 'Cyprus issue'."

The following note is included at the request of all of the European Union Member States of the OECD and the European Union:

"The Republic of Cyprus is recognized by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus."

Israel

"The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities or third party. 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.

"It should be noted that statistical data on Israeli patents and trademarks are supplied by the patent and trademark offices of the relevant countries."

2. Mobile broadband penetration, OECD, G20 and BRIICS, 2016

For Argentina, Brazil, China, India, Indonesia, the Russian Federation, Saudi Arabia and South Africa, the data source is ITU World Telecommunication/ICT Indicators Database, July 2017.

For Israel, the data source is GSMA Intelligence.

For Switzerland and the United States, data are estimates.

3. M2M SIM card penetration, OECD, World and G20 countries, June 2017

Data for 2017, refer to the second quarter.

To ensure comparable data using the same methodology, data for all economies including OECD countries are sourced from GSMA Intelligence (www.gsmaintelligence.com, extracted September 2017). GSMA uses the following definition for measuring M2M connections: "A unique SIM card registered on the mobile network at the end of the period, enabling mobile data transmission between two or more machines. It excludes computing devices in consumer electronics such as e-readers, smartphones, dongles and tablets."

4. Top M2M SIM card connections, June 2017

Data refer to the second quarter of 2017.

To ensure comparable data using the same methodology, data for all economies including OECD countries are sourced from GSMA Intelligence (www.gsmaintelligence.com, extracted September 2017). GSMA uses the following definition for measuring M2M connections: "A unique SIM card registered on the mobile network at the end of the period, enabling mobile data transmission between two or more machines. It excludes computing devices in consumer electronics such as e-readers, smartphones, dongles and tablets."

5. Top players in emerging ICT technologies, 2012-15

Data refer to IP5 families, by filing date and the applicant's residence, using fractional counts. Patent "bursts" correspond to periods characterised by a sudden and persistent increase in the number of patents filed by International Patent Classification (IPC) classes. Top patent bursts are identified by comparing the filing patterns of all 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 from 2010 are included. Data for 2014 and 2015 are incomplete.

Descriptions of IPC groups are available at: *http://web2.wipo.int/classifications/ipc/ipcpub*.

6. Intensity and development speed in ICT-related technologies, 2000-14

Patent "bursts" correspond to periods characterised by a sudden and persistent increase in the number of patents filed in ICT-related technologies. Top patent bursts are identified by comparing the filing patterns of all other technologies. The intensity of a patent burst refers to the relative strength of the observed increase in filing patterns. Data refer to IP5 patent families, by filing date, using fractional counts. Patents in ICT are identified using the list of IPC codes in Inaba and Squicciarini (2017). Only the top 25 ICT-related patent classes featuring a positive burst intensity from 2000 are included.

Descriptions of IPC groups are available at: *http://web2.wipo.int/classifications/ipc/ipcpub*.

7. Patents in artificial intelligence technologies, 2000-15

Data refer to the number of IP5 patent families in artificial intelligence (AI), by filing date and inventor's country, using fractional counts. AI refers to the "Human interface" and "Cognition and meaning understanding" categories in the ICT patent taxonomy as described in Inaba and Squicciarini (2017). 2014 and 2015 figures are estimated based on available data for those years.

8. Patents for top technologies that embed artificial intelligence, 2000-05 and 2010-15

Data refer to the number of IP5 patent families in artificial intelligence (AI), by filing date and International Patent Classification (IPC) codes listed in patent documents that are not related to AI, using fractional counts. AI refers to the "Human interface" and "Cognition and meaning understanding" categories in the ICT patent taxonomy as described in Inaba and Squicciarini (2017). Data for 2014 and 2015 are incomplete.

9. Top 10 medical technologies combined with artificial intelligence, 2000-05 and 2010-15

Data refer to the number of IP5 patent families in medical technologies and in artificial intelligence (AI), by filing date and International Patent Classification (IPC) codes listed in patent documents that are not related to AI, using fractional counts. Patents are allocated to medical technologies on the basis of the IPC codes, following the concordance provided by WIPO (2013). AI refers to the "Human interface" and "Cognition and meaning understanding" categories in the ICT patent taxonomy as described in Inaba and Squicciarini (2017). Data for 2014 and 2015 are incomplete.

10. R&D in OECD and key partner countries, 2015

Owing to methodological differences, data for some OECD partner economies may not be fully comparable with figures for other countries.

Researchers' data are in full-time units.

For Brazil, India and Indonesia, data are provided by the UNESCO Institute for Statistics.

For Canada and Mexico, data refer to 2015, 2013 and 2015.

For Australia, data refer to 2013, 2010 and 2013.

For Brazil, data refer to 2014, 2010 and 2014.

For France, data refer to 2015, 2014 and 2015.

For Indonesia, data refer to 2013, 2009 and 2013.

For Ireland, data refer to 2014, 2015 and 2014.

For Israel, data refer to 2015, 2012 and 2015 and defence R&D is partly excluded from available estimates.

For South Africa, data refer to 2013.

For the United States, data for researchers have been estimated based on contemporaneous data on business researchers and past data for other sectors.

11. Economies with the largest volume of top-cited scientific publications, 2005 and 2016

"Top-cited publications" are the 10% most-cited papers normalised by scientific field and type of document (articles, reviews and conference proceedings). The Scimago Journal Rank indicator is used to rank documents with identifical numbers of citations within each class. This measure is a proxy indicator of research excellence. Estimates are based on fractional counts of documents by authors affiliated to institutions in each economy.

12. Recent trends in scientific excellence, selected countries, 2005-16

"Top-cited publications" are the 10% most-cited papers normalised by scientific field and type of document (articles, reviews and conference proceedings). The Scimago Journal Rank indicator is used to rank documents with identifical numbers of citations within each class. This measure is a proxy indicator of research excellence. Estimates are based on fractional counts of documents by authors affiliated to institutions in each economy.

13. R&D expenditures by performing sector, OECD area, 1995-2015

These statistics are based on the OECD Main Science and Technology Indicators Database (*http://oe.cd/msti*). For more information on these data, including on data issues such as breaks in series, please see this source.

14. Trends in total R&D performance, OECD and selected economies, 1995-2015

For the United States, except for GOVERD, which includes capital expenditure used for R&D, reported figures refer to current expenditures but include a depreciation component, which may differ from the actual level of capital expenditure.

OECD estimates for the EU28 zone may differ slightly from those published by EUROSTAT. In this publication, national estimates are aggregated using USD Purchasing Power Parity indices (PPPs) instead of EUR exchange rates applied by EUROSTAT. For example, the EU28 measure of GERD to GDP intensity is an average of EU countries' GERD intensities, weighted by the share of countries' GDP to EU GDP in USD PPPs, as opposed to EUR-based GDP shares.

These statistics are based on the OECD Main Science and Technology Indicators Database (*http://oe.cd/msti*). For more information on these data, including on data issues such as breaks in series, please see this source.

15. R&D expenditures over the business cycle by source of financing, OECD area, 1995-2016

Business and government-financed R&D expenditures are subcomponents of Gross Domestic Expenditure on R&D (GERD) (i.e. intramural R&D expenditures on R&D performed in the national territory). Funding sources are typically identified by the R&D-performing units.

Government budget data tend to be more timely, but may not coincide with R&D performer-reported funding by government, owing to factors such as differences between budgetary plans and actual disbursements.

These statistics are based on the OECD Main Science and Technology Indicators Database (*http://oe.cd/msti*). For more information on these data, including on data issues such as breaks in series, please see this source.

16. Trends in basic and applied research and experimental development in the OECD area, 1985-2015

Due to the presence of missing breakdowns of GERD by type of R&D (basic, applied and experimental development), as well as breaks in series, long-term trends have been estimated by chain-linking year-on-year growth rates. These are calculated each year on a variable pool of countries for which balanced data are available in consecutive years without intervening breaks. The trend series is an index of the volume of expenditures on basic and applied research and experimental development, based on GERD data in USD PPP 2010 constant prices. Some OECD countries are completely missing from the calculations due to the unavailability of detailed breakdowns by type of R&D. Further details on the calculations are available on request.

China's share of GERD by type of R&D has been estimated based on the sum of current and capital expenditures. For the OECD, a GERD-weighted estimate has been computed on the pool of 14 countries for which data by type of R&D were available in 2015. Data used for each country refer to the sum of current and capital expenditures, except for Chile, Norway and the United States, for which only current costs are included in estimates reported to the OECD.

17. Concentration of business R&D: top 50 and top 100 performers, 2014

This is an experimental indicator. International comparability may be limited. For more information on the OECD microBeRD project, see *http://oe.cd/microberd*.

Figures may differ or appear to differ from official R&D statistics owing to different methodologies adopted for the purpose of micro-data analysis. The estimates presented should be taken as experimental and are not intended as substitutes for existing official statistics.

For Austria, Belgium, Germany, France and Italy, figures refer to 2013. For Portugal, figures refer to 2012.

Figures refer to the enterprise as the statistical unit of analysis, except for Israel where figures are at establishment level.

The analysis covers enterprises with 10 or more employees except for Japan, where it covers enterprises with 50 or more employees.

The analysis covers industry sectors (ISIC Rev.4, two-digit level) 5-72, excluding 45, 47, 55-56 and 68-69, except for Canada and the United States.

Figures for Canada and the United States were calculated by the countries using their own procedures.

18. Business R&D performance by size and age, 2014

This is an experimental indicator. International comparability may be limited. For more information on the OECD microBeRD project, see *http://oe.cd/microberd*.

Figures may differ or appear to differ from official R&D statistics owing to different methodologies adopted for the purpose of micro-data analysis. The estimates presented should be taken as experimental and are not intended as substitutes for existing official statistics.

For Belgium and Italy, figures refer to 2013. For Portugal, figures refer to 2012.

Figures refer to the enterprise as the statistical unit of analysis, except for Israel where figures are at establishment level.

The analysis covers enterprises with 10 or more employees. Small firms have 10-49 employees, medium firms 50-249 employees and large firms 250 or more employees. Firms are classified as old if they are more than five years old.

The analysis covers industry sectors (ISIC Rev.4, two-digit level) 5-72, excluding 45, 47, 55-56 and 68-69.

19. External sources of R&D funding by firm size and age, 2014

This is an experimental indicator. International comparability may be limited. For more information on the OECD microBeRD project, see *http://oe.cd/microberd*.

Figures may differ or appear to differ from official R&D statistics owing to different methodologies adopted for the purpose of micro-data analysis. The estimates presented should be taken as experimental and are not intended as substitutes for existing official statistics.

For Belgium, figures refer to 2011. For Portugal, figures refer to 2012.

Figures refer to the enterprise as the statistical unit of analysis, except for Israel where figures are at establishment level.

The analysis covers enterprises with 10 or more employees. Small firms have 10-49 employees, medium firms 50-249 employees and large firms 250 or more employees. Firms are classified as old if they are more than five years old.

The analysis covers industry sectors (ISIC Rev.4, two-digit level) 5-72, excluding 45, 47, 55-56 and 68-69.

20. R&D expenditures and the IP bundle of the top R&D companies, 2014

Data relate to companies in the top 2 000 corporate R&D sample, ranked by R&D expenditures.

The IP bundle refers to the number of patents, trademarks and designs filed in 2012-14, and owned by the top R&D companies, using fractional counts. Data covers: IP5 patent families; trademark applications filed at the EUIPO, the JPO and the USPTO; design applications filed at the EUIPO and the JPO, and design patents filed at the USPTO.

21. Patent portfolio of top R&D companies, by industry, 2012-14

Data refer to IP5 families, by filing date, owned by top R&D companies, using fractional counts. Patents in ICT are identified using the list of IPC codes in Inaba and Squicciarini (2017). Data for 2014 are partial.

22. Top corporate R&D with IP, 2012-14

Data relate to the share of the patent (design) portfolio of companies in total patents (designs) filed by the top 2 000 corporate R&D sample in 2012-14.

Patent data refer to IP5 patent families; design data include applications filed at the EUIPO and the JPO, and design patents filed at the USPTO.

Industries are defined according to ISIC Rev.4. The ICT sector covers ICT manufacturing industries (classes 2610, 2620, 2630, 2640 and 2680), ICT trade industries (4651 and 4652), ICT services industries (5820), Telecommunications (61), Computer programming (62), Data processing (631), and Repair of computers and communication equipment (951).

23. Top 20 emerging technologies developed by top R&D companies, 2012-14

Data refer to the share of IP5 patent families owned by the top 2 000 corporate R&D investors sample in all IP5 patent families, by filing date and International Patent Classification (IPC) classes. The top 20 emerging technologies correspond to the IPC classes featuring a positive "burst" intensity within the patent portfolio of top R&D companies from 2010. A patent burst corresponds to periods characterised by a sudden and persistent increase in the number of patents by IPC classes. Top patent bursts are identified by comparing the filing patterns of all IPC classes within the portfolio of top R&D companies. The intensity of a patent burst refers to the relative strength of the observed increase in filing patterns. Data for 2014 are partial.

Technologies are displayed following the WIPO IPC-Technology concordance (2013) and the ICT taxonomy.

Descriptions of IPC groups are available at: http://web2.wipo.int/classifications/ipc/ipcpub.

24. Artificial intelligence patents by top 2 000 R&D companies, by sector, 2012-14

Data refer to IP5 patent families related to artificial intelligence (AI) owned by companies in the top 2 000 corporate R&D investors sample, filed in 2012-14. Artificial intelligence patents refer to IP5 patent families that belong to the "Human interface" and "Cognition and meaning understanding" categories in the ICT patent taxonomy as described in Inaba and Squicciarini (2017). Data for 2014 are partial.

Industries are defined according to ISIC Rev.4.

25. Artificial intelligence patents by top R&D companies, by headquarters' location, 2012-14

Data refer to IP5 patent families related to artificial intelligence (AI) owned by companies in the top 2 000 corporate R&D investors sample, filed in 2012-14, by location of the companies' headquarters. Artificial intelligence patents refer to IP5 patent families that belong to the "Human interface" and "Cognition and meaning understanding" categories in the ICT patent taxonomy as described in Inaba and Squicciarini (2017). Data for 2014 are partial.

26. Trends in scientific publications related to machine learning, 2003-16

This is an experimental indicator.

Estimates are based on fractional counts of documents by authors affiliated to institutions in each economy.

These estimates are based on a search for the text item "*machine learn*" in the abstracts, titles and keywords of documents published between 2003 and 2016 and indexed in the Scopus database.

27. Top-cited scientific publications related to machine learning, 2006 and 2016

This is an experimental indicator.

This figure provides a count of each country or economy's top-cited publications related to machine learning (ML). These are the 10% most-cited papers normalised by scientific field and type of document (articles, reviews and conference proceedings). The Scimago Journal Rank indicator is used to rank documents with identical numbers of citations within each class. This measure is an indicator of research excellence. Estimates are based on fractional counts of documents by authors affiliated to institutions in each economy.

These estimates are based on a search for the text item "*machine learn*" in the abstracts, titles and keywords of documents published between 2006 and 2016 and indexed in the Scopus database.

28. Top robot-intensive countries and BRICS, 2005 and 2015

Robot use collected by the International Federation of Robotics (IFR) is measured as the number of robots purchased by a given country/industry. Robot stock is constructed by taking the initial IFR stock starting value, then adding to it the purchases of robots from subsequent years with a 10% annual depreciation rate. The graph covers all manufacturing, mining and utilities sectors. Data for the following countries is extrapolated for the years 2014 and 2015 due to the lack of data: Australia, Chile, Estonia, Finland, Greece, Iceland, Ireland, Latvia, Lithuania, New Zealand, Norway and Slovenia. Due to lack of available data, the OECD average excludes Canada, Israel, Luxembourg and Mexico. The EU28 average excludes Cyprus and Luxembourg.

29. Robot intensity and ICT task intensity of manufacturing jobs, 2012 or 2015

Robot use data collected by the International Federation of Robotics (IFR) is measured as the number of robots purchased by a given country/industry. Robot stock is constructed by taking the initial IFR stock starting value, then adding to it the purchases of robots from subsequent years with a 10% annual depreciation rate. The sample covers the manufacturing and utilities sectors only. The indicator of the ICT task intensity of jobs relies on exploratory state-of-the-art factor analysis. It captures the use of ICT tasks on the job and relies on 11 items from the OECD Programme for International Assessment of Adult Competencies (PIAAC) ranging from simple use of the Internet to the use of Word or Excel software or a programming language. The detailed methodology can be found in Grundke et al. (2017).

Data for the following 23 countries from the first round of PIAAC refer to the year 2012: Australia, Austria, Belgium (Flanders), Canada, the Czech Republic, Germany, Denmark, Estonia, Finland, France, Ireland, Italy, Japan, Korea, the Netherlands, Norway, Poland, the Russian Federation (excluding Moscow), the Slovak Republic, Spain, Sweden, the United Kingdom

(England and Northern Ireland) and the United States. Data for the remaining countries refer to 2015 and are sourced from the second round of the first wave of the PIAAC survey as far as ICT task intensity is concerned.

30. Dispersion of sectors in each considered dimension of digitalisation, 2013-15

All underlying indicators are expressed as sectoral intensities. For each indicator, the sectoral values are averages across countries and years. These values are then standardised relative to the mean, such that the resulting series by indicator have mean zero and standard deviation 1.

The taxonomy is based on information for the following countries: Australia, Austria, Denmark, Finland, France, Italy, Japan, the Netherlands, Norway, Sweden, the United Kingdom and the United States, for which values for all indicators in all considered sectors and years are non-missing, with the exception of robot use and online sales, where some sectors are not sampled.

"Software investment" is the ratio of volumes of GFCF in software over volumes of total GFCF. The same applies to "ICT tangible investment". For these indicators, data are sourced from the OECD Annual National Accounts and Intan-Invest. Volumes are obtained from current price series, which are deflated using country-specific deflators derived from Intan-Invest (software) and national accounts (ICT tangible).

Intermediate ICT goods is the ratio of purchases of intermediate materials by the sector from the ICT goods-producing sector ("Computer, electronic and optical equipment", or ISIC Rev.3 sectors 30, 32, 33) over the output of the purchasing sector, both sourced from the OECD Inter-Country Input-Output Database and national input-output tables. The same applies to Purchases of ICT services but for a sector's purchases from the ICT service-producing sector ("Computer and related activities", or ISIC Rev.3 sector 72). Purchases of ICT goods or services are deflated by the price of output in the ICT goods or service-producing sectors in a given country, while the sectoral output is deflated by the sector's output price in the country. Deflators are sourced from the OECD Structural Analysis (STAN) database or the OECD National Accounts database. Purchases of ICT goods by machinery-producing sectors (ISIC Rev. 3 sectors 29 to 35) are replaced with missing values by design.

Data on purchases of robots is collected by the International Federation of Robotics (IFR) in terms of the number of robots purchased by a given country/industry. Robot use here is the ratio between the stock of robots purchased by the sector and the sector's employment. The stock is constructed by taking the initial IFR stock starting value, then adding to it purchases of robots from subsequent years with a 10% annual depreciation rate. The dataset covers agriculture, mining, manufacturing, constructions and utilities (and the R&D-producing sector, which is excluded from this analysis).

Revenues from online sales measure the proportion of the sector's turnover coming from online sales, as collected by the Eurostat Digital Economy and Society Statistics database. The data refer to European countries only and exclude the following ISIC Rev.4 sectors by sampling design: sectors 1 to 9 (Agriculture, Mining), 64 to 66 (Finance and insurance), and 84 and above (Public services, Social and personal services).

"ICT specialists" is measured as the number of individuals employed in an ICT specialist occupation in the sector, over total sectoral employment. The choice of which occupations are considered ICT specialists in this exercise is explained in Calvino et al. (forthcoming). These occupations are ISCO2008 occupation 251 (Software and applications developers and analysts), 252 (Database and network professionals), 133 (Information and communications technology service managers) and 351 (Information and communications technology operations and user support). Data on employment by occupation and sector is sourced from Australian, Canadian, European and Japanese Labour Force Surveys, the U.S. Current Population Survey, the Japanese Employment Census, and the Korean Labour and Income Panel Study.

For additional information on the assumptions applied in calculating the indicators, as well as any cleaning or interpolation/extrapolation the series may have undergone, refer to Calvino et al. (forthcoming): "A Taxonomy of Digital Sectors".

31. Taxonomy of sectors by quartile of digital intensity, 2013-15

All underlying indicators are expressed as sectoral intensities. For each indicator, the sectoral values are averages across countries and years. These values are then standardised relative to the mean, such that the resulting series by indicator have mean zero and standard deviation 1. The colour of the cells in the table correspond to the quartile of the sectoral distribution in which the sector is ranked. Values for the construction of the quartiles by indicator are reported at the bottom of the table.

The taxonomy is based on information for the following countries: Australia, Austria, Denmark, Finland, France, Italy, Japan, the Netherlands, Norway, Sweden, the United Kingdom and the United States, for which values for all indicators in all considered sectors and years are non-missing, with the exception of robot use and online sales, where some sectors are not sampled.

"Software investment" is the ratio of volumes of GFCF in software over volumes of total GFCF. The same applies to "ICT tangible investment". For these indicators, data are sourced from the OECD Annual National Accounts and Intan-Invest. Volumes are obtained from current price series, which are deflated using country-specific deflators derived from Intan-Invest (software) and national accounts (ICT tangible).

Intermediate ICT goods is the ratio of purchases of intermediate materials by the sector from the ICT goods-producing sector ("Computer, electronic and optical equipment", or ISIC Rev.3 sectors 30, 32, 33) over the output of the purchasing sector, both sourced from the OECD Inter-Country Input-Output Database and national input-output tables. The same applies to Purchases of ICT services but for a sector's purchases from the ICT service-producing sector ("Computer and related activities", or ISIC Rev.3 sector 72). Purchases of ICT goods or services are deflated by the price of output in the ICT goods or service-producing sectors in a given country, while the sectoral output is deflated by the sector's output price in the country. Deflators are sourced from the OECD Structural Analysis (STAN) database or the OECD National Accounts database. Purchases of ICT goods by machinery-producing sectors (ISIC Rev. 3 sectors 29 to 35) are replaced with missing values by design.

Data on purchases of robots is collected by the International Federation of Robotics (IFR) in terms of the number of robots purchased by a given country/industry. Robot use here is the ratio between the stock of robots purchased by the sector and the sector's employment. The stock is constructed by taking the initial IFR stock starting value, then adding to it purchases of robots from subsequent years with a 10% annual depreciation rate. The dataset covers agriculture, mining, manufacturing, constructions and utilities (and the R&D-producing sector, which is excluded from this analysis).

Revenues from online sales measure the proportion of the sector's turnover coming from online sales, as collected by the Eurostat Digital Economy and Society Statistics database. The data refer to European countries only and exclude the following ISIC Rev.4 sectors by sampling design: sectors 1 to 9 (Agriculture, Mining), 64 to 66 (Finance and insurance), and 84 and above (Public services, social and personal services).

"ICT specialists" is measured as the number of individuals employed in an ICT specialist occupation in the sector, over total sectoral employment. The choice of which occupations are considered ICT specialists in this exercise is explained in Calvino et al. (forthcoming). These occupations are ISCO2008 occupation 251 (Software and applications developers and analysts), 252 (Database and network professionals), 133 (Information and communications technology service managers) and 351 (Information and communications technology operations and user support). Data on employment by occupation and sector is sourced from Australian, Canadian, European and Japanese Labour Force Surveys, the U.S. Current Population Survey, the Japanese Employment Census, and the Korean Labour and Income Panel Study.

For additional information on the assumptions applied in calculating the indicators, as well as any cleaning or interpolation/extrapolation the series may have undergone, refer to Calvino et al. (forthcoming): "A Taxonomy of Digital Sectors".

32. Skill levels in digital and less-digital industries, 2012 or 2015

All differences in skill means between digital and non-digital industries are significant at the 5% level.

The individual-level skill indicators are based on data from the OECD Programme for International Assessment of Adult Competencies (PIAAC). Literacy, numeracy and problem solving in technology-rich environments are cognitive skills that are measured through assessment tests. The other skill indicators are constructed using data on the frequency of tasks workers carry out on the job and by applying a state-of-the-art factor analysis. The detailed methodology can be found in Grundke et al. (2017). All skill indiciators are rescaled to the interval 0-100. Averages are calculated for digital and non-digital industries across all 31 PIAAC countries with the same weight given to each country.

A taxonomy of digital-intensive sectors is proposed in Calvino et al. (forthcoming), which accounts for the multidimensionality of the digital transformation by considering sector intensities in: ICT tangible and intangible investment, purchases of ICT goods and services, robot use, revenues from online sales and ICT specialists. The sectors ranking above the median sector by the joint distribution of these indicators are defined as digital-intensive.

The pooled sample of countries includes 31 countries (round 1 and 2 of PIAAC). The data for the following 23 countries from the first round of PIAAC refer to the year 2012: Australia, Austria, Belgium (Flanders), Canada, the Czech Republic, Germany, Denmark, Estonia, Finland, France, Ireland, Italy, Japan, Korea, the Netherlands, Norway, Poland, the Russian Federation (excluding Moscow), the Slovak Republic, Spain, Sweden, the United Kingdom (England and Northern Ireland) and the United States. Data for the following eight countries refer to 2015 and are sourced from the second round of the first wave of the PIAAC survey: Chile, Greece, Israel, Lithuania, New Zealand, Singapore, Slovenia and Turkey.

33. Additional labour market returns to skills in digital-intensive industries, 2012 or 2015

Shaded bars indicate that the coeffcient is insignificant at the 5% level.

The individual-level skill indicators are based on data from the OECD Programme for International Assessment of Adult Competencies (PIAAC). Literacy, numeracy and problem solving in technology-rich environments are cognitive skills that are measured through assessment tests. The remaining skill indicators are constructed using data on the frequency of tasks workers carry out on the job and by applying a state-of-the-art factor analysis. The detailed methodology can be found in Grundke et al. (2017).

Labour market returns to skills are based on OLS wage regressions (Mincer equations) using data from the OECD Programme for International Assessment of Adult Competencies (PIAAC). Estimates rely on the log of hourly wages as a dependent variable and include a number of individual-related control variables (including age, years of education, gender and the cognitive skills literacy and numeracy) as well as country, industry and occupation dummy variables. The coefficients are obtained by estimating the specification for the pooled sample of 31 countries.

A taxonomy of digital-intensive sectors is proposed in Calvino et al. (forthcoming), which accounts for the multidimensionality of the digital transformation by considering sector intensities in: ICT tangible and intangible investment, purchases of ICT goods and services, robot use, revenues from online sales and ICT specialists. The sectors ranking above the median sector by the joint distribution of these indicators are defined as digital intensive.

The pooled sample of countries includes 31 countries (round 1 and 2 of PIAAC). The data for the following 23 countries from the first round of PIAAC refer to the year 2012: Australia, Austria, Belgium (Flanders), Canada, the Czech Republic, Germany, Denmark, Estonia, Finland, France, Ireland, Italy, Japan, Korea, the Netherlands, Norway, Poland, the Russian Federation (excluding Moscow), the Slovak Republic, Spain, Sweden, the United Kingdom (England and Northern Ireland) and the United States. The data for the following eight countries refer to 2015 and are sourced from the second round of the first wave of the PIAAC survey: Chile, Greece, Israel, Lithuania, New Zealand, Singapore, Slovenia and Turkey.

34. Where people gained and lost jobs, 2010-16

Data refer to 2010-15 for Israel, Japan, Korea, Mexico, New Zealand and the OECD area aggregate.

Changes in levels of employment by economic activity can be "normalised" to highlight their relative contributions, in each country, to the total change in employment between two periods. This is achieved, for each country, by expressing sectoral changes as a percentage of the sum of absolute changes. The aggregate activity groups are defined according to ISIC Rev.4 classes.

Aggregate industrial activities are defined according to ISIC Rev.4: Agriculture, forestry and fishing (Divisions 01-03); Mining and utilities (05-09 and 35-39); Manufacturing (10-33); Construction (41-43); Wholesale, retail trade, hotels, food services, transportation (45-56); Information and communication (58-63); Finance and insurance (64-68); Professional, scientific and technical and other business services (69-82); and Public administration, education, health and other services (84-99).

The gains and losses are expressed in thousands and represent the sum of those aggregate sectors with positive changes and the sum of those aggregate sectors with negative changes, respectively. A finer activity breakdown (e.g. 2-digit ISIC Rev.4) would produce different estimates for total gains and losses.

The employment data are drawn mostly from National Accounts (SNA) sources and are measured in terms of persons, except for Canada, Japan and Mexico where they are measured in terms of jobs.

35. Employment growth in information industries, OECD, 1997-2015

Information industries are defined according to ISIC Rev.4 and cover ICT manufacturing: Division 26 (Computer, electronic and optical products) and, Information services: ISIC Rev.4 Divisions 58 to 60 (Publishing, audio-visual and broadcasting activities), 61 (Telecommunications) and 62 to 63 (IT and other information services).

Business sector corresponds to ISIC Rev.4 Divisions 05 to 66 and 69 to 82 (i.e. Total economy excluding Agriculture, forestry and fishing (Divisions 01 to 03), Real estate activities (68), Public administration (84), Education (85), Human health and social work activities (86 to 88) and Arts, entertainment, repair of household goods and other personal services (90 to 99)).

36. Origin of demand sustaining business sector jobs in the OECD, 1995-2014

The business sector corresponds to ISIC Rev.3 Divisions 10 to 74 (i.e. Total economy excluding Agriculture, forestry and fishing (Divisions 01-05), Public administration (75), Education (80), Health (85) and Other community, social and personal services (90-95)).

EU28 refers to the 28 members of the European Union; Southeast Asia (excluding Indonesia) comprises Brunei Darussalam, Cambodia, Malaysia, Philippines, Singapore, Thailand and Viet Nam; East Asia covers Japan, Korea, Hong Kong-China and Chinese Taipei; NAFTA includes Canada, the United States and Mexico; and BRIICS (excluding China) consists of Brazil, the Russian Federation, India, Indonesia and South Africa.

37. Origin of demand sustaining jobs in OECD information industries, 1995-2014

Information industries correspond to ISIC Rev.3 Divisions 30, 32, 33, 64 and 72.

EU28 refers to the 28 members of the European Union; Southeast Asia (excluing Indonesia) comprises Brunei Darussalam, Cambodia, Malaysia, Philippines, Singapore, Thailand and Viet Nam; East Asia covers Japan, Korea, Hong Kong-China and Chinese Taipei; NAFTA includes Canada, the United States and Mexico; and BRIICS (excluding China) consists of Brazil, the Russian Federation, India, Indonesia and South Africa.

39. Share of non-routine employment and ICT task intensity, 2012 or 2015

The index of the ICT task intensity of jobs relies on exploratory state-of-the-art factor analysis and captures the use of ICT on the job. It relies on 11 items of the OECD Programme for International Assessment of Adult Competencies (PIAAC) ranging from simple use of the Internet, to the use of Word or Excel software or a programming language. The detailed methodology can be found in Grundke et al. (2017). Intensities have been rescaled from the 0-1 to the 0-100 interval.

The share of non-routine employment represents the proportion of the industry's total employment accounted for by the 3-digit occupations found to be intensive in non-routine tasks. Occupations are ranked in terms of their intensity in routine tasks following the methodology detailed in Marcolin et al. (2015). Routine-intensive occupations are those ranking above the median in terms of the routine intensity of the tasks performed on the job; non-routine occupations score below the median.

The differences observed in the trend lines of macro industries should be considered with caution, as the Wald test fails to reject the hypothesis of equality between the correlations in the market service and manufacturing industries.

Dots represent simple averages of industry values in the manufacturing vs. market service sectors. Manufacturing covers mining; food and beverages; textiles, apparel and leather; wood, paper and publishing; basic and fabricated metals; chemicals, rubber, plastics and other non-metallic mineral products; machinery and equipment n.e.c; electronic, optical, and computing equipment; transportation equipment; manufacturing n.e.c. Market services include utilities, construction, trade, repairers, hotels and accomodation; transportation and telecommunication services; finance; and business services.

The data for the following 22 countries from the first round of PIAAC refer to the year 2012: Australia, Austria, Belgium (Flanders), Canada, the Czech Republic, Germany, Denmark, Estonia, Finland, France, Ireland, Italy, Japan, Korea, the Netherlands, Norway, Poland, the Slovak Republic, Spain, Sweden, the United Kingdom (England and Northern Ireland) and the United States. Data for the remaining countries refer to 2015 and are sourced from the second round of the first wave of the PIAAC survey.

40. Workers receiving firm-based training, by skill level, 2012 or 2015

The percentages of trained people are calculated as the ratio of total employed persons displaying a given skill level and receiving training at least once in the year, over total employment in the economy. Training refers to formal, on-the-job, or both types as defined in Squicciarini et al. (2015). Low-skilled individuals refers to persons who have not completed any formal education or have attained 1997 ISCED classification level 1 to 3C degrees (if 3C is lower than two years). Medium-skilled individuals have attained a 3C (longer than two years) to 4 level degree. High-skilled individuals have attained a higher than ISCED1997 category 4 degree. Values are reweighted to be representative of the countries' populations.

The data for the following 23 countries from the first round of PIAAC refer to the year 2012: Australia, Austria, Belgium (Flanders), Canada, the Czech Republic, Germany, Denmark, Estonia, Finland, France, Ireland, Italy, Japan, Korea, the Netherlands, Norway, Poland, the Russian Federation (excluding Moscow), the Slovak Republic, Spain, Sweden, the United Kingdom (England and Northern Ireland) and the United States. Data for the remaining countries refer to 2015 and are sourced from the second round of the first wave of the PIAAC survey.

41. Gender wage gap by country, 2012 or 2015

The estimates for the gender wage gap are based on OLS wage regressions (Mincer equations) using data from the OECD Programme for International Assessment of Adult Competencies (PIAAC). Estimates rely on the log of hourly wages as the dependent variable and include a number of individuals-related control variables (including age, years of education, gender and various skill measures detailed in Grundke et al., 2017) as well as industry dummy variables.

The data for the following 23 countries from the first round of PIAAC refer to the year 2012: Australia, Austria, Belgium (Flanders), Canada, the Czech Republic, Germany, Denmark, Estonia, Finland, France, Ireland, Italy, Japan, Korea, the Netherlands, Norway, Poland, the Russian Federation (excluding Moscow), the Slovak Republic, Spain, Sweden, the United Kingdom (England and Northern Ireland) and the United States. Data for the remaining countries refer to 2015 and are sourced from the second round of the first wave of the PIAAC survey.

42. Labour market returns to ICT tasks by gender, 2012 or 2015

The index of the ICT task intensity of jobs relies on exploratory state-of-the-art factor analysis. It captures the use of ICT tasks on the job and relies on 11 items of the OECD Programme for International Assessment of Adult Competencies (PIAAC) ranging from simple use of the Internet, to the use of Word or Excel software or a programming language. The detailed methodology can be found in Grundke et al. (2017).

Labour market returns to task intensities are based on OLS wage regressions (Mincer equations) using data from the OECD Programme for International Assessment of Adult Competencies (PIAAC). Estimates rely on the log of hourly wages as the dependent variable and include a number of individual-related control variables (including age, years of education, gender and the other skill measures detailed in Grundke et al., 2017) as well as industry dummy variables. The coefficients for male and female workers are obtained by estimating the specification for each sub-sample, respectively. The country mean of ICT task intensity that is used to compute the percentage changes in wages for a 10% change in ICT task intensity refers to the country mean for male and female workers, respectively.

The data for the following 23 countries from the first round of PIAAC refer to the year 2012: Australia, Austria, Belgium (Flanders), Canada, the Czech Republic, Germany, Denmark, Estonia, Finland, France, Ireland, Italy, Japan, Korea, the Netherlands, Norway, Poland, the Russian Federation (excluding Moscow), the Slovak Republic, Spain, Sweden, the United Kingdom (England and Northern Ireland) and the United States. Data for the remaining countries refer to 2015 and are sourced from the second round of the first wave of the PIAAC survey.

43. Employees participating in on-the-job training by gender, 2012 or 2015

The proportion of women and men engaged in on-the-job training excludes individuals who did not provide information on whether the activity was carried out during or outside working hours (around 4% of the cross-country sample). The number of women and men engaged in on-the-job training during working hours is computed as the number of employees that confirmed attending the learning activity "only" or "mostly" during working hours. The proportions are computed over the total number of employees of the given gender in the economy.

The data for the following 23 countries from the first round of PIAAC refer to the year 2012: Australia, Austria, Belgium (Flanders), Canada, the Czech Republic, Germany, Denmark, Estonia, Finland, France, Ireland, Italy, Japan, Korea, the Netherlands, Norway, Poland, the Russian Federation (excluding Moscow), the Slovak Republic, Spain, Sweden, the United Kingdom (England and Northern Ireland) and the United States. Data for the remaining countries refer to 2015 and are sourced from the second round of the first wave of the PIAAC survey.

44. Decomposition of labour productivity growth by industry, 2001-07 and 2009-15

The latest period for Ireland and New Zealand is 2009-14. For Switzerland, the latest period is 2010-15, and Manufacturing includes Mining and utilities.

Labour productivity growth is defined as the annual change in gross value added (in volume terms) per hour worked.

The aggregate industrial activities are defined according to ISIC Rev.4: Mining and utilities (Divisions: 05 to 09 and 35 to 39); Manufacturing (10 to 33); Construction (41 to 43); Wholesale, retail, hotels, food services, transportation (45 to 56); Information and communications (58 to 63); Finance and insurance (64 to 66); and Professional, scientific, technical and other business services (69 to 82). Total non-agriculture business sector covers ISIC Rev.4 Divisions 05 to 66 and 69 to 82. Real estate activities (68) are excluded as the value added of this sector includes an imputation made for dwelling services provided and consumed by home-owners.

45. Labour productivity levels in the information industries, 2015

Labour productivity is defined as current price value added per hour worked and per person employed.

Information industries are defined according to ISIC Rev.4: Computer, electronic and optical products (Division 26), Publishing, audio-visual and broadcasting (58 to 60), Telecommunications (61) and IT and other information services (62, 63).

Total non-agriculture business sector covers ISIC Rev.4 Divisions 05 to 66 and 69 to 82. Real estate activities (68) are excluded as the value added of this sector includes an imputation made for dwelling services provided and consumed by home-owners.

Estimates for Israel, Korea, Latvia and Luxembourg do not include Computer, electronic and optical products (Division 26).

Estimates for Germany, Ireland, Poland, Portugal, New Zealand, Spain, Sweden and Switzerland refer to 2014; estimates for Canada and Korea refer to 2013; estimates for Australia and New Zealand refer to fiscal year 2014-15.

The OECD average is an unweighted average of value added per person employed for the countries shown.

46. Multifactor productivity growth 1995-2015

Estimates for Ireland, Portugal and Spain refer to 1995-2014.

47. Extended ICT domestic value added footprint, 2011

In this analysis, information and communication technology (ICT) industries are defined according to ISIC Rev.3 and consist of Computer, electronic and optical products (Divisions 30, 32 and 33), Post and telecommunications services (Division 64), and Computer and related activities (Division 72). The underlying ICIO database is constructed from contemporaneous SNA93 National Accounts statistics and, hence, the figures for ICT value added presented here may not match the latest equivalent SNA08, ISIC Rev.4, ICT value added statistics.

48. ICT-related domestic value added, 2011

Information and communication technology (ICT) industries are defined according to ISIC Rev.3 and consist of Computer, electronic and optical products (Divisions 30, 32 and 33), Post and telecommunications services (Division 64), and Computer and related activities (Division 72).

Value added of domestic ICT industries is embodied in a wide range of final goods and services meeting final demand both at home and abroad. Similarly, domestic value added (DVA) from other industries ("non-ICT") can be embodied in final ICT goods and services consumed globally.

49. ICT-related foreign value added content of domestic final demand, 2011

Information and communication technology (ICT) industries are defined according to ISIC Rev.3 and consist of Computer, electronic and optical products (Divisions 30, 32 and 33), Post and telecommunications services (Division 64), and Computer and related activities (Division 72).

Value added of foreign ICT industries can be embodied in a wide range of final goods and services meeting domestic demand. Similarly, value added from other foreign industries ("non-ICT") can be embodied in final ICT goods and services consumed domestically.

50. Contribution of ICT equipment and knowledge capital assets to KBC-augmented labour productivity growth, 2000-14

The graph shows the contribution of KBC and tangible ICT capital to labour productivity growth as a percentage of labour productivity growth itself over 2000-14. Contributions are calculated using a standard non-parametric growth accounting method for the overall period, assuming constant returns to scale and full competitive markets, where production technology takes a log linear form and output elasticities are equal to factor shares. KBC capital includes software, R&D and organisational capital (from Le Mouel et al., 2016). Software, R&D and ICT equipment investment data are sourced from the OECD System of National Accounts (SNA) Database, except for the United States, whose investment in R&D is sourced from the U.S. Bureau of Economic Analysis Satellite Accounts.

All underlying data are expressed in real terms. Capital stocks estimations rely on applying the Perpetual Inventory Method on investment data with 1993 as the initial year. Some data points are interpolated or extrapolated, where necessary.

The sample covers the market sectors only (i.e. ISIC Rev.4 Divisions 01 to 82 excluding 68 and 90 to 96).

51. Contribution of KBC and MFP to KBC-augmented labour productivity growth, 2000-14

The graph shows the contribution of KBC and MFP to labour productivity growth as a percentage of labour productivity growth itself over 2000-14. Contributions are calculated using a standard non-parametric growth accounting method for the overall period, assuming constant returns to scale and full competitive markets, where production technology takes a log linear form and output elasticities are equal to factor shares. KBC capital includes software, R&D and organisational capital (from Le Mouel et al., 2016). Software and R&D investment data are sourced from the OECD System of National Accounts (SNA) Database, except for the United States, whose investment in R&D is sourced from the U.S. Bureau of Economic Analysis Satellite Accounts.

All underlying data are expressed in real terms. Capital stocks estimations rely on applying the Perpetual Inventory Method on investment data with 1993 as the initial year. Some data points are interpolated or extrapolated, where necessary.

The sample covers the market sectors only (i.e. ISIC Rev.4 Divisions 01 to 82 excluding 68, and 90 to 96).

52. KBC intensity for the market and non-market sectors, 2015

The market sector covers ISIC Rev.4 Divisions 01 to 82 excluding 68, and 90 to 96. The non-market sector follows the definition proposed by SPINTAN and covers both public and non-profit entities in the ISIC Rev.4 Divisions 72 and 84 to 88.

Intensities are defined as investment over Gross Value Added as sourced from the OECD System of National Accounts (SNA) Database. For the non-market sector, KBC investment data are sourced from SPINTAN and are extrapolated, where necessary, using the past cross-country average growth rate of non-market investment in SPINTAN. Data on investment in other non-SNA KBC assets are sourced from INTAN-Invest and extrapolated, where necessary, using the growth rate of Intellectual Property Gross Fixed Capital Formation from the OECD System of National Accounts (SNA) Database. Investment and value added data are in current prices.

53. Change in the centrality of IT manufacturing across economies, 1995-2011

IT manufacturing is defined as ISIC Rev.3 sectors 30, 32 and 33: Computer, electrical and optical products.

Economies are placed according to their location. The size of the nodes reflects the magnitude of the change (in levels) of total foreign centrality over the period 1995-2011. These changes are graphed using a log scale for readability. Blue coloured nodes reflect increasing centrality and red denotes falling centrality.

Centrality indicators are derived from OECD's (2015) Inter-Country-Input-Output Database, which provides data on input flows for 61 countries and 34 industries from 1995 to 2011. Centrality is calculated for each country-industry as a baseline centrality, plus a weighted sum of centralities of their trade partners, where the weights are input shares. Total centrality is the average of centrality calculated using forwards linkages (exports of inputs) and backwards linkages (imports of inputs). Centrality is decomposed into foreign and domestic origins. Foreign centrality represents the centrality due to (direct and indirect) linkages to foreign sectors, and domestic centrality represents the component due to (direct and indirect) linkages to domestic sectors.

54. Change in the centrality of IT services across economies, 1995-2011

IT services consist of ISIC Rev.3 sector 72: Computer and related activities.

Economies are placed according to their location. The size of the nodes reflects the magnitude of the change (in levels) of total foreign centrality over the period 1995-2011. These changes are graphed using a log scale for readability. Blue coloured nodes reflect increasing centrality and red denotes falling centrality.

Centrality indicators are derived from OECD's (2015) Inter-Country-Input-Output Database, which provides data on input flows for 61 countries and 34 industries from 1995 to 2011. Centrality is calculated for each country-industry as a baseline centrality, plus a weighted sum of centralities of their trade partners, where the weights are input shares. Total centrality is the average of centrality calculated using forwards linkages (exports of inputs) and backwards linkages (imports of inputs). Centrality is decomposed into foreign and domestic origins. Foreign centrality represents the centrality due to (direct and indirect) linkages to foreign sectors, and domestic centrality represents the component due to (direct and indirect) linkages to domestic sectors.

55. Largest changes in foreign and domestic centrality: IT manufacturing and services, 1995-2011

IT manufacturing is defined as ISIC Rev.3 sectors 30, 32 and 33: Computer, electrical and optical products.

IT services consist of ISIC Rev.3 sector 72: Computer and related activities.

Centrality indicators are derived from OECD's (2015) Inter-Country-Input-Output Database, which provides data on input flows for 61 countries and 34 industries from 1995 to 2011. Centrality is calculated for each country-industry as a baseline centrality, plus a weighted sum of centralities of their trade partners, where the weights are input shares. Total centrality is the average of centrality calculated using forwards linkages (exports of inputs) and backwards linkages (imports of inputs). Centrality is decomposed into foreign and domestic origins. Foreign centrality represents the centrality due to (direct and indirect) linkages to foreign sectors, and domestic centrality represents the component due to (direct and indirect) linkages to domestic sectors.

56. Top 10 most central IT hubs, 1995 and 2011

Centrality indicators are derived from OECD's (2015) Inter-Country-Input-Output Database, which provides data on input flows for 61 countries and 34 industries from 1995 to 2011. Centrality is calculated for each country-industry as a baseline centrality, plus a weighted sum of centralities of their trade partners, where the weights are input shares. Total centrality is the average of centrality calculated using forwards linkages (exports of inputs) and backwards linkages (imports of inputs). Centrality is decomposed into foreign and domestic origins. Foreign centrality represents the centrality due to (direct and indirect) linkages to foreign sectors, and domestic centrality represents the component due to (direct and indirect) linkages to domestic sectors.

57. Internet usage trends, 2005-16

Notes for Panel A:

Data are based on OECD estimations.

Notes for Panel B:

Unless otherwise stated, Internet users are defined for a recall period of 3 months. For Australia, Canada and Japan, the recall period is 12 months. For the United States, the recall period is 6 months for 2015, and no time period is specified in 2006. For Korea and New Zealand, the recall period is 12 months in 2006. For Chile in 2009, China, India, Indonesia, the Russian Federation and South Africa, no time period is specified.

For Australia, data refer to the fiscal years 2006/07 ending on 30 June and 2014/15.

For Brazil, data refer to 2008 and 2015.

For Canada, data refer to 2007 and 2012. In 2007, data refer to individuals aged 16 and over instead of 16-74.

For Chile, data refer to 2009 and 2015.

For China, India, Indonesia, the Russian Federation and South Africa, data originate from ITU, ITU World Telecommunication/ICT Indicators Database, and refer to 2015 instead of 2016.

For Iceland and Switzerland, data refer to 2014 instead of 2016.

For Indonesia, data relates to individuals aged 5 or more.

For Israel, data refer to 2015 instead of 2016 and to individuals aged 20 and more instead of 16-74.

For Japan, data refer to 2015 instead of 2016 and to individuals aged 15-69.

For Korea, data refer to 2015 instead of 2016.

For New Zealand, data refer to 2012 instead of 2016.

For Turkey, data refer to 2007 instead of 2006.

For the United States, data refer to 2007 and 2015.

58. Internet usage trends, by age, 2005-16

Notes for Panel A:

Data are based on OECD estimations.

Notes for Panel B:

Unless otherwise stated, Internet users are defined for a recall period of 12 months, and data for all individuals refer to individuals aged 16-74. For the United States, no time period is specified.

For Australia, data refer to the fiscal year 2014/15 and the recall period is 3 months.

For Brazil, Chile, Colombia, Israel, Japan, Korea and the United States, data refer to 2015.

For Canada, data refer to 2012 and to individuals aged 65 or more instead of 55-64.

For Iceland and Switzerland, data refer to 2014.

For Israel, data refer to individuals aged 20 or more instead of 16-74 and to individuals aged 20-24 instead of 16-24.

For Japan, data refer to individuals aged 15-69 instead of 16-74 and 60-69 instead of 55-74. Data for individuals aged 60-69 originate from the Consumer Usage Trend Survey 2015, Ministry of Internal Affairs and Communications.

For New Zealand, data refer to 2012.

59. Women tertiary graduates in natural sciences, engineering and ICTs (NSE & ICT), 2015

Tertiary education comprises Levels 5 to 8 of the ISCED-2011 classification.

The Information and communication technologies field of study refers to the ISCED-F 2013 Fields of education classification.

The OECD aggregate is an unweighted average of countries with available data.

60. Women in science, 2015

This is an experimental indicator based on a stratified random sample of scientific authors.

Samples are drawn from documents published in 2011 and indexed in the Scopus database. Fields covered include Arts and Humanities, Business, Chemical Engineering, Immunology & Microbiology, Materials Science, Neuroscience and Physics & Astronomy.

Weighted estimates take into account sampling design and non-response patterns by field, country and journal status.

61. Patenting activity by women inventors, 2012-15

The share of patents invented by women refers to the number of patents with women inventors located in a given country divided by the total number of patents invented in the country. Data refer to IP5 families, by filing date, according to the inventors' residence and gender, using fractional counts. Inventors' gender were identified using a gender-name dictionary (first names by country), following the methodology described in Lax Martínez, Raffo and Saito (2016). Patents are allocated to technology fields on the basis of their International Patent Classification (IPC) codes, following the concordance provided by WIPO (2013). Only countries with more than 100 patent families in total and 25 patent families in each depicted technology for 2012-15, and with more than 80% of inventor's names allocated to gender, are included. Figures for 2014 and 2015 are estimated based on available data for those years.

62. Government R&D budgets, selected economies, 2008-16

These statistics are based upon OECD R&D databases including the R&D Statistics (*http://oe.cd/rds*) and Main Science and Technology Indicators Databases (*http://oe.cd/msti*). For more information on these data, including on data issues such as breaks in series, please see those sources.

For Australia, Canada, Japan, Korea and the United States, only Central or Federal government budget allocations for R&D are included.

63. Government R&D budgets, by socio-economic objective, 2016

These statistics are based upon OECD R&D databases including the R&D Statistics (http://oe.cd/rds) and Main Science and Technology Indicators Databases (http://oe.cd/msti). For more information on these data, including on data issues such as breaks in series, please see those sources.

For Australia, Austria, Canada, Iceland, Japan, Korea and the United States, only Central or Federal government budget allocations for R&D are included.

64. Scientific research on dementia and neurodegenerative diseases, selected countries, 1996-2016

This is an experimental indicator.

These estimates are based on a search for the text items "neurodegenerat", "dementia" and "Alzheimer" in the abstracts of articles published between 1996 and 2016 contained in the Scopus database.

Country-level counts are on a fractional basis.

65. Disciplinary areas contributing to the scientific output on dementia and neurodegenerative diseases, 1996-2016

This is an experimental indicator.

These estimates are based on a search for the text items "neurodegenerat", "dementia" and "Alzheimer" in the abstracts of articles published between 1996 and 2016 contained in the Scopus database.

Subject-level counts are on a fractional basis.

66. Open access of scientific documents, 2017

This is an experimental indicator.

This indicator is based on an automated query on a random (non-stratified) sample of 100 000 citable documents (articles, reviews and conference proceedings) published in 2016 and indexed in the Scopus database, with valid DOIs associated to them (more than 90% of cases). The open access status of the documents has been assessed using the R wrapper for the oaDOI API produced by ImpactStory, an open-source website that aims to help researchers explore and share the online impact of their research. The API returns information on the possibility of securing legal copies of the relevant document and the different mechanisms.

"Gold open access" applies to documents associated to publishers included in the Dictionary of Open Access Journals that make their content openly available at no charge to readers. "Gold hybrid" indicates that a document is accessible from a publisher that typically requires a subscription for general access, but allows open access to the specific document, normally with the author or their sponsors paying article-processing charges that provide for open access by third parties (as for most "gold open access" journals). "Green open access" denotes the existence of legal versions of the document in repositories or related outfits, which do not match either of the gold categories. When the DOI can not be resolved to any source of access information, the result is marked as "status not available". When the DOI resolves and the return indicates that there are no legal open versions available, the document is marked as "closed".

Effective open access may be underestimated as a result of imperfect resolution of DOIs in tracing legal open versions as well as the existence of versions non-compliant with copyrights. This indicator reflects the access status of documents within six months to one year and a half after publication. Documents under temporary embargo will fall under the "closed" category but would be categorised as open at a later stage.

67. Highly cited scientific documents, by open-access status, 2017

This is an experimental indicator.

This indicator is based on an automated query on a random (non-stratified) sample of 100 000 citable documents (articles, reviews and conference proceedings) published in 2016 and indexed in the Scopus database, with valid DOIs associated to them (more than 90% of cases). The open access status of the documents has been assessed using the R wrapper for the oaDOI API produced by ImpactStory, an open-source website that aims to help researchers explore and share the online impact of their research. The API returns information on the possibility of securing legal copies of the relevant document and the different mechanisms.

"Gold open access" applies to documents associated to publishers included in the Dictionary of Open Access Journals that make their content openly available at no charge to readers. "Gold hybrid" indicates that a document is accessible from a publisher that typically requires a subscription for general access, but allows open access to the specific document, normally with the author or their sponsors paying article-processing charges that provide for open access by third parties (as for most "gold open access" journals). "Green open access" denotes the existence of legal versions of the document in repositories or related outfits, which do not match either of the gold categories. When the DOI can not be resolved to any source of access information, the result is marked as "status not available". When the DOI resolves and the return indicates that there are no legal open versions available, the document is marked as "closed".

Effective open access may be underestimated as a result of imperfect resolution of DOIs in tracing legal open versions as well as the existence of versions non-compliant with copyrights. This indicator reflects the access status of documents within six months to one year and a half after publication. Documents under temporary embargo will fall under the "closed" category but would be categorised as open at a later stage.

Highly cited documents are the 10% most-cited papers normalised by scientific field and type of document (articles, reviews and conference proceedings). The Scimago Journal Rank indicator is used to rank documents with identifical numbers of citatations within each class. This measure is an indicator of research excellence. Estimates are based on fractional counts of documents by authors affiliated to institutions in each economy.

68. Intenational collaboration in science and innovation, 2005-16

International co-inventions are measured as the share of IP5 patent families featuring inventors located in at least two economies, out of the total number of IP5 patent families having inventors located in the economy considered. Data refer to IP5 patent families filed in 2005-15 according to the inventor's residence. Only economies with more than 100 patents families in 200515 are included. A whole-counts approach has been used.

International co-authorship of scientific publications is defined at the institutional level. A scientific document is deemed to involve an international collaboration if institutions from different countries or economies are present in the list of affiliations reported by single or multiple authors. For comparability with data on co-inventions, a whole-counts approach is used in this case. This results in larger estimates than presented on a fractional basis in Chapter 3 of this publication.

69. International net flows of scientific authors, selected economies, 2002-16

This is an experimental indicator.

Estimates are based on differences between implied inflows and outflows of scientific authors for the reference economy, as indicated by a change in the main affiliation of a given author with a Scopus ID over the author's indexed publication span. This chart decomposes net flows recorded over the period on a year-by-year basis for selected economies. An inflow is computed for year t and economy c if an author who was previously affiliated to another economy is first seen to be affiliated to an institution in that economy and year. Likewise, an outflow is recorded when an author who was affiliated to c in a previous period is first observed to be affiliated in a different economy in year t. In the case of affiliations in more than one economy, a fractional counts approach is used. In the case of multiple publications per author in a given year, the last publication in any given year is used as reference, while others are ignored.

The actual mobility date is undetermined as the span between publications may be more than one year. As a result, the timing implied by this figure may be subject to a lag with respect to the point at which mobility flows took place. The timing will be more accurate for more prolific authors. Estimates for early years are not reported because mobility flows can only be computed once a second publication by an author is captured in the database. Likewise, incomplete indexing of all authors over 2000-03 may result in understating total flows and as a consequence estimated net flows, albeit to a lesser extent.

70. Direct funding and tax incentive support for business R&D by SMEs, 2015

This is an experimental indicator. International comparability may be limited (e.g. due to variations in SME definitions for business R&D vs. R&D tax relief reporting purposes).

For BERD and government-funded BERD, SME figures generally refer to enterprises with 1-249 employees (i.e. excluding firms with zero employees), unless specified otherwise. A number of countries adopt additional criteria to define SME status. Independence is one relevant criterion currently adopted by a few countries (e.g. Canada, the United Kingdom) in reporting government-funded BERD and R&D tax support by firm size. This further limits international comparability. For SME definitions, see country-specific notes.

For more information on R&D tax incentives, see *http://oe.cd/rdtax*, and for general notes and country-specific notes for this R&D tax incentive indicator, see *http://oe.cd/sb2017_notes_rdtax*.

71. Business R&D intensity and government support to business R&D, 2015

For more information on R&D tax incentives, see http://oe.cd/rdtax, and for general notes and country-specific notes for this R&D tax incentive indicator, see *http://oe.cd/sb2017_notes_rdtax*.

72. Changes in government support to business R&D and total business expenditures on R&D, 2006-15

For more information on R&D tax incentives, see http://oe.cd/rdtax, and for general notes and country-specific notes for this R&D tax incentive indicator, see *http://oe.cd/sb2017_notes_rdtax*.

73. Venture capital investment in selected countries, by sector, 2016

For the United States, data also include venture capital investments by other investors alongside venture capital firms, but exclude investment deals 100% financed by corporations and/or business angels.

Data providers are Invest Europe for European countries and NVCA for the United States.

"ICT" refers to "Communications" and "Computer and consumer electronics" for European countries and "Information technology" for the United States.

"Other" includes Agriculture, Business products and services, Chemicals and materials, Construction, Consumer goods and services, Energy and environment, Financial and insurance activities, Real estate and Transportation sectors for European countries and Energy, Materials and resources, B2C (Business to consumer), B2B (Business to business) and Financial services industries for the United States.

74. Business angel deals by sector, Europe, 2015 and the United States, 2016

A business angel is a private investor who generally provides finance and business expertise to a company in return for an equity share in the firm. Some business angels form syndicates or networks in order to take on larger deals and share the risk.

Business angel groups are formed by individual angels who join forces to evaluate and invest in entrepreneurial ventures. The groups are able to pool their capital to make larger investments.

A business angel network is an organisation designed to facilitate the matching of entrepreneurs with business angels.

Data refer to networks and groups surveyed by the business angel associations.

Europe includes: Andorra, Austria, Belgium, Bosnia-Herzegovina, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Kosovo, Latvia, Lithuania, Luxembourg, Macedonia, Malta, the Netherlands, Norway, Poland, Portugal, the Russian Federation, Serbia, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine and the United Kingdom.

For the United States, data refer to the simple average of the following regions: Northwest, California, Southwest Texas, Great Plains, Great Lakes, Southeast, Mid-Atlantic, New York and Northeast.

75. Start-ups in digital-related sectors that attracted equity funding in OECD and BRIICS, 2011-16

The sample is restricted to firms founded after 2010 (i.e. five years old or less in 2016) that attracted equity funding over the 2011-16 period.

Equity funding includes venture capital and other forms of risk finance such as business angel investments or debt financing.

Digital-related sectors are identified by the OECD on the basis of the correspondence between the sectors available in the database with the ISIC Rev.4 industry list.

"Other digital related" includes Navigation and mapping, Payments, Messaging and telecommunications and Platforms.

76. Top digital-related sectors that attracted equity funding, 2011-16

The sample is restricted to firms founded after 2010 (i.e. five years old or less in 2016) that attracted equity funding over the 2011-16 period.

Equity funding includes venture capital and other forms of risk finance such as business angel investments or debt financing.

Digital-related sectors are identified by the OECD on the basis of the correspondence between the sectors available in the database with the ISIC Rev.4 industry list.

77. Scientific documents acknowledging direct sources of funding, 2016

This is an experimental indicator.

This indicator is constructed for citable scholarly documents (articles, reviews or conference proceedings) published in 2016 and indexed in the Scopus database according to whether a record exists of the author(s) acknowledging funding by any given organisation(s). It provides a proxy measure of the extent to which scientists have to secure direct funding for their research activities on the basis that support needs to be acknowledged within relevant outputs.

78. Funding acknowledgment in scientific publications and their citation impact, 2016

This is an experimental indicator.

This indicator is constructed for citable scholarly documents (articles, reviews or conference proceedings) indexed in the Scopus database according to whether a record exists of the author(s) acknowledging funding by any given organisation(s).

The proportion of top-ranked indicators for each country and document type according to funding acknowledgement is computed based on a field and document-type normalised impact indicators that rank documents within each group by actual citations and, on parity of citations, according to the prestige of the journal according to the Scimago Journal Rank indicator for 2015. Documents are assigned to the top 10% of their class and aggregated using fractional counts by field and country. Given the short citation window (one year after publication), the results are heavily influenced by the journal ranking.

References

Boselli, B. and F. Galindo-Rueda (2016), "Drivers and Implications of Scientific Open Access Publishing: Findings from a Pilot OECD International Survey of Scientific Authors", *OECD Science, Technology and Industry Policy Papers*, No. 33, OECD Publishing, Paris, *http://dx.doi.org/10.1787/5jlr2z70k0bx-en*.

Breschi, S., J. Lassebie, and C. Menon (forthcoming), "A micro-data analysis of innovative start-ups and venture-capital investments across countries".

Calvino et al. (forthcoming), "A Taxonomy of Digital Sectors".

Corrado, C., C. Hulten and D. Sichel (2009), "Intangible capital and US economic growth", *Review of Income and Wealth*, Vol. 55/3, pp. 661-685.

Criscuolo, C. and J. Timmis (forthcoming), "GVCs and centrality: Mapping key hubs, spokes and the periphery", *OECD Productivity Working Papers*.

Daiko, T. et al. (2017), *World Corporate Top R&D Investors: Industrial Property Strategies in the Digital Economy*, a JRC and OECD common report, Publications Office of the European Union, Luxembourg.

Dalle, J.M., M. Denbesten and C. Menon (forthcoming), "Using Crunchbase for academic and managerial research".

Dernis, H. et al. (2015), *World Corporate Top R&D Investors: Innovation and IP Bundles*, a JRC and OECD common report, Publications Office of the European Union, Luxembourg.

Dernis, H., Squicciarini M. and R. de Pinho (2016), "Detecting the emergence of technologies and the evolution and co-development trajectories in science (DETECTS): A 'burst' analysis-based approach", *Journal of Technology Transfer*, Vol. 41/5, pp. 930–960.

Grundke, R. et al. (forthcoming), "Which skills for the digital era? A returns to skills analysis".

Grundke, R. et al. (2017), "Skills and global value chains: A characterisation", *OECD Science, Technology and Industry Working Papers*, No. 2017/05, OECD Publishing, Paris, *http://dx.doi.org/10.1787/cdb5de9b-en*.

Haines, W., L. Marcolin, and M. Squicciarini (forthcoming), "Intangibles and productivity growth: a new assessment".

Inaba, T. and M. Squicciarini (2017), "ICT: A new taxonomy based on the international patent classification", *OECD Science, Technology and Industry Working Papers*, No. 2017/01, OECD Publishing, Paris, *http://dx.doi.org/10.1787/ab16c396-en*.

International Federation of Robotics (2016), *World Robotics: Industrial Robots*, Frankfurt am Main, Germany.

Kalantari, A. et al. (2017), "A bibliometric approach to tracking big data research trends", *Journal of Big Data*, Vol. 4/30, pp. 1-18, *https://doi.org/10.1186/s40537-017-0088-1*.

Le Mouel, M., L. Marcolin, and M. Squicciarini (2016), "Investment in organisational capital: Methodology and panel estimates", *SPINTAN Working Papers*, No. 21, European Commission, Brussels.

Lax Martínez G., Raffo J. and K. Saito (2016), "Identifying the gender of PCT inventors", *Economic Research Working Paper No. 33*, World Intellectual Property Organization (WIPO), Geneva, *www.wipo.int/publications/en/details.jsp?id=4125*.

Marcolin, L., S. Miroudot, and M. Squicciarini (2016), "The routine content of occupations: New cross-country measures based on PIAAC", No. 188, *OECD Trade Policy Papers*, OECD Publishing, Paris.

OECD (forthcoming), *Financing SMEs and Entrepreneurs 2018: An OECD Scoreboard*.

OECD (2017a), *OECD Compendium of Productivity Indicators 2017*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/pdtvy-2017-en*.

OECD (2017b), *Government at a Glance 2017*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/gov_glance-2017-en*.

OECD (2015a), *Frascati Manual 2015: Guidelines for Collecting and Reporting Data on Research and Experimental Development, The Measurement of Scientific, Technological and Innovation Activities*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/9789264239012-en*.

OECD (2015b), *Addressing Dementia: The OECD Response*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/9789264231726-en*.

OECD (2015c), "Making Open Science a Reality", *OECD Science, Technology and Industry Policy Papers*, No. 25, OECD Publishing, Paris, *http://dx.doi.org/10.1787/5jrs2f963zs1-en*.

OECD (2011), *OECD Guide to Measuring the Information Society 2011*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/9789264113541-en*.

Squicciarini, M., L. Marcolin and P. Horvát (2015), "Estimating cross-country investment in training: An experimental methodology using PIAAC data", *OECD Science, Technology and Industry Working Papers*, No. 2015/09, OECD Publishing, Paris, *http://dx.doi.org/10.1787/5jrs3sftp8nw-en*.

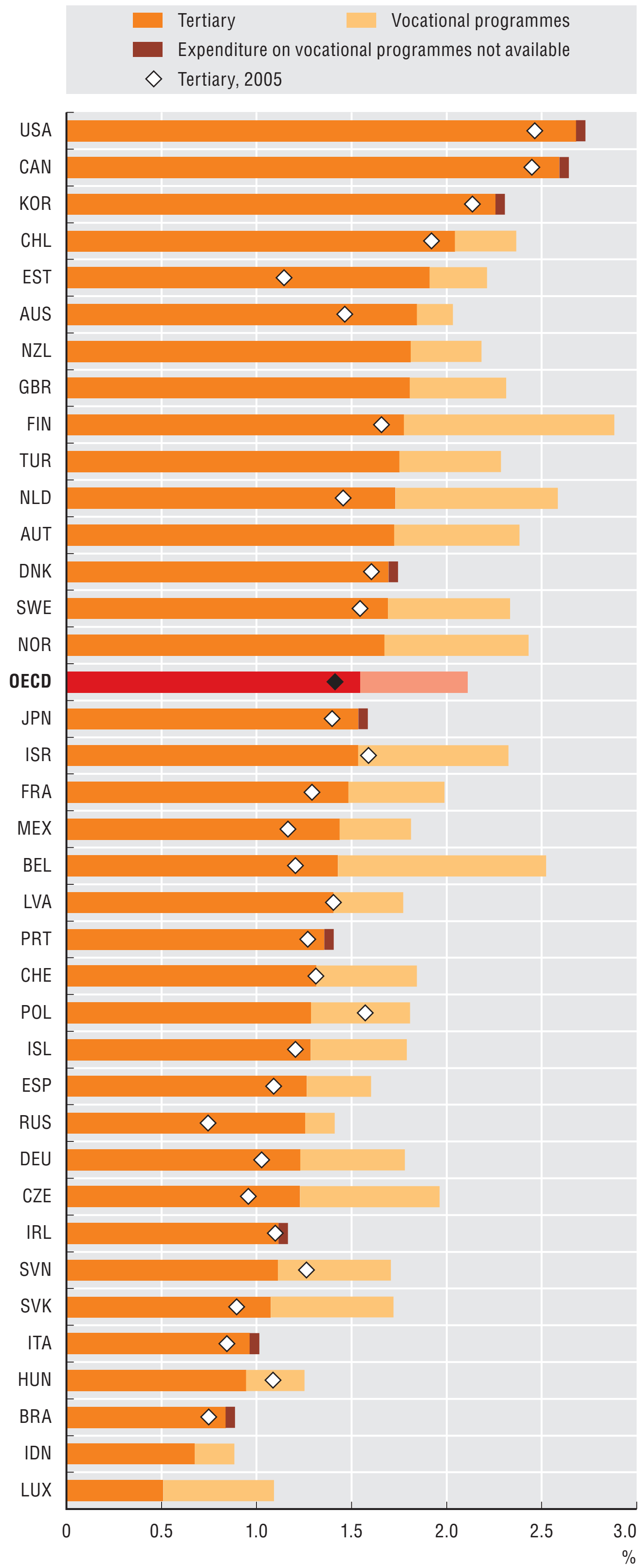
WIPO (2013), "IPC Concordance Table", WIPO, Geneva, *www.wipo.int/ipstats/en/statistics/technology_concordance.html* (accessed 1 June 2017).

2. KNOWLEDGE, TALENT AND SKILLS

1. Investment in knowledge

Expenditure on tertiary education and vocational programmes, 2014

As a percentage of GDP



Source: OECD based on OECD (2017), *Education at a Glance 2017: OECD Indicators*, OECD Publishing, Paris. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933618346

Did you know?

Over the last decade, OECD countries increased expenditure on tertiary education by about 9% and expenditure on R&D by 11%.

Investment in human capital is key for innovation, technological development and long-term growth. Such investment can take the form of expenditure on education – notably tertiary and vocational training, expenditure on research and development (R&D), and investment in enabling technologies such as information and communication technologies (ICT).

Over a decade, almost all OECD countries increased their investment in tertiary education, reaching an average of 1.5% of GDP in 2014. Expenditure on vocational training increases the average spending in post-secondary education by one-third. Spending on tertiary education grew most in Estonia (67%), followed by six other OECD countries, including the Czech Republic, Australia, Mexico (by about 20% or more).

R&D expenditure also increased in almost all countries, with the Slovak Republic experiencing the most growth (140%) between 2005-15. In 2015, the R&D-to-GDP ratio ranged between 4.25% in Israel and 0.38% in Chile. There is also substantial heterogeneity in the share of "research" compared to "experimental development": in 2015, research comprised less than a quarter of total R&D expenditure in Israel, but over 70% in a number of countries including Latvia and the Netherlands.

From 2005 to 2015, OECD investment in ICT assets remained unchanged at 2.3% of GDP, on average. This might be explained in part by the substitution between capital investment and purchases of ICT services including increased penetration of cloud-based services, and the rapid decline in prices for ICT equipment. Interestingly, in 2015 the proportion of ICT investment accounted for by computer software and databases ranged from about 40% in Estonia, Latvia and Norway to 80% or more in France and the Netherlands.

Definitions

Expenditure on education measures spending on educational institutions by governments, enterprises and private individuals.

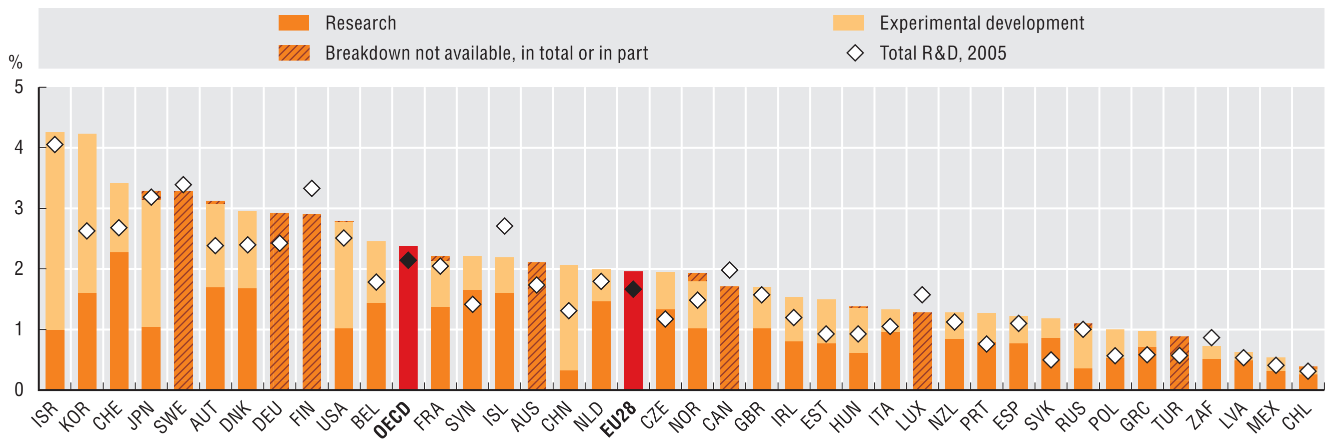
Vocational training refers to upper secondary education level programmes granting labour-market relevant vocational qualifications to participants for direct entry into specific occupations.

Gross domestic expenditure on R&D (GERD), totals all expenditure on inputs used in performing R&D. *Research* is original investigation undertaken to acquire new knowledge; *Experimental development* builds upon research to produce new or improved products or processes.

ICT investment refers to gross fixed capital formation (GFCF) of "information and communication equipment" and "computer software and databases", as defined by the System of National Accounts 2008 (SNA08).

Gross domestic expenditure on R&D, by type of R&D, 2015

As a percentage of GDP

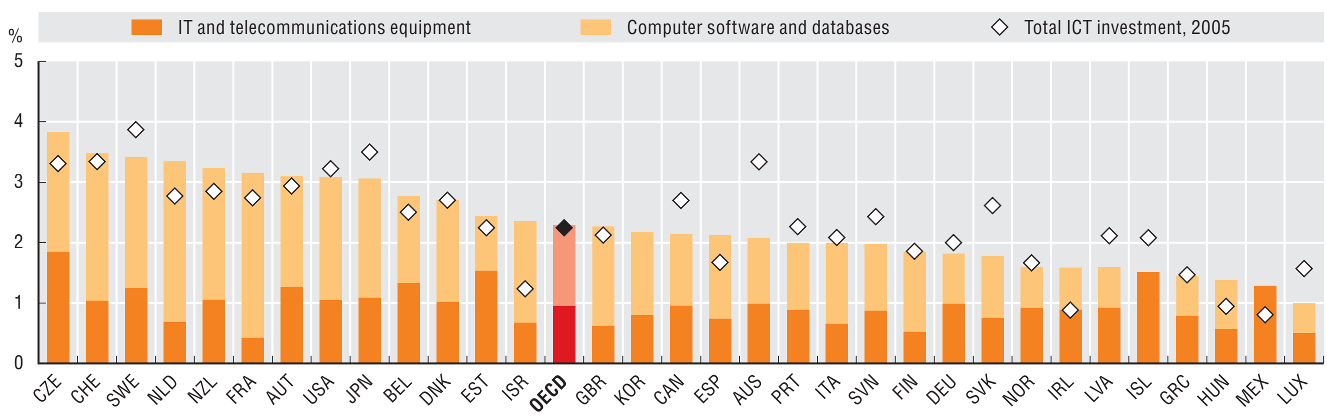


Source: OECD, Main Science and Technology Indicators Database, *http://oe.cd/msti*, July 2017, and Research and Development Statistics Database, *http://oe.cd/rds*, June 2017. StatLink contains more data. See chapter notes.

StatLink *http://dx.doi.org/10.1787/888933618365*

ICT investment, by asset, 2015

As a percentage of GDP



Source: OECD, Annual National Accounts Database, *http://www.oecd.org/std/na*, Eurostat and national sources, July 2017. StatLink contains more data. See chapter notes.

StatLink *http://dx.doi.org/10.1787/888933618384*

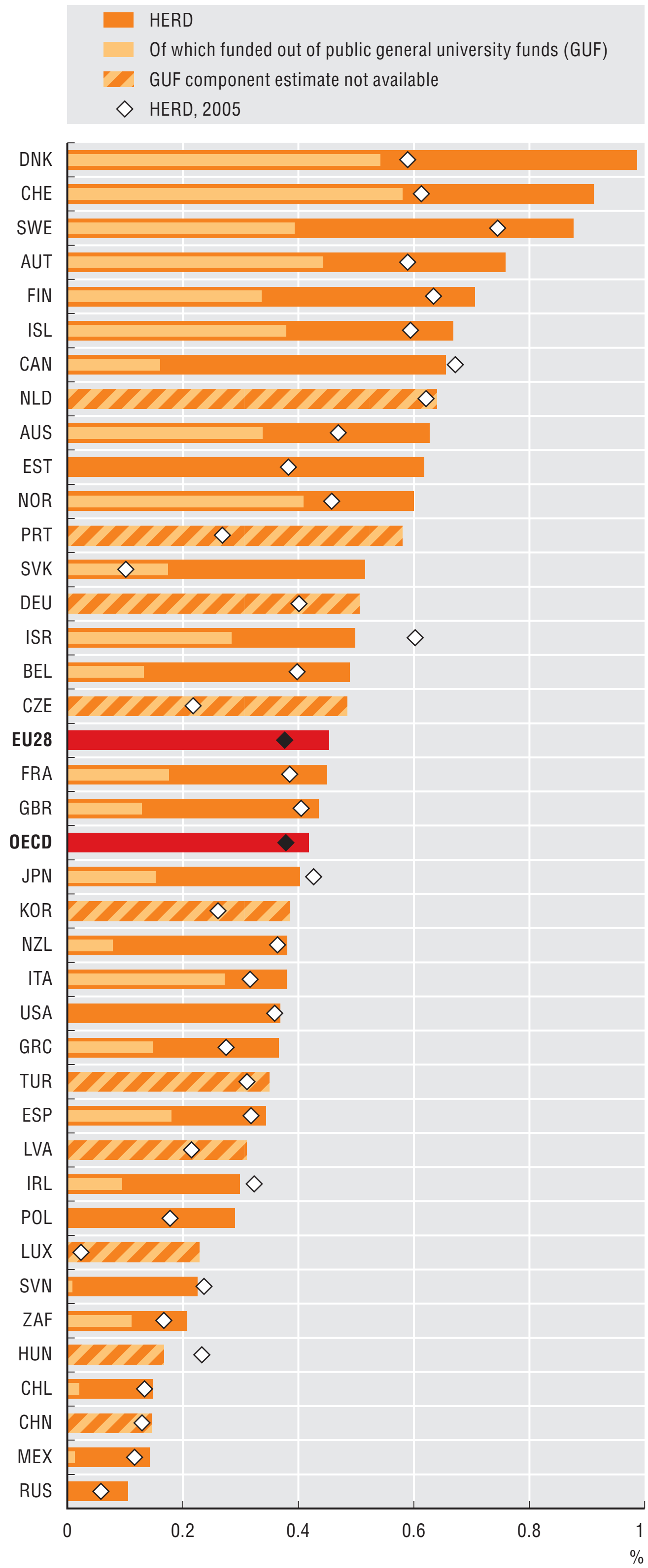
Measurability

Spending on education is shaped by factors such as age structure of the population, enrolment rates, and nature of demand for skills and teachers' salaries. Data on R&D expenditure are primarily collected through surveys of R&D performing organisations. Expenditure is identified as relating to (basic or applied) research or experimental development; this can be challenging in some cases – particularly for expenditure on capital inputs to R&D or certain sectors (notably higher education) – and can cause the breakdown to be unavailable in part or in full. While the measurement of physical investment (in current prices) in ICT assets such as information technology and telecommunication equipment is relatively well established, measuring software and databases is considerably more challenging. Evidence highlights significant differences in measurement approaches in the case of software (particularly own-account software). In the case of databases, the SNA08 recommends including only the costs of physical maintenance and construction of databases as produced capital, rather than the earnings potential of the data embedded in the database itself (see Ahmad and Schreyer, 2016).

2. Higher education and basic research

Higher education expenditure on R&D, 2015

As a percentage of GDP



Source: OECD, Main Science and Technology Indicators Database, *http://oe.cd/msti*, July 2017. StatLink contains more data. See chapter notes.

StatLink *http://dx.doi.org/10.1787/888933618403*

Did you know?

On average, one-third of R&D carried out by the higher education sector in OECD countries is funded through multi-purpose general university funds from government.

OECD countries spent 0.4% of GDP on higher education R&D (HERD) in 2015. However, expenditure in Denmark, Switzerland, and Sweden reached more than twice this amount. Between 2005 and 2015, this share increased in most countries but decreased markedly in Hungary and Israel.

Higher education institutions (HEIs) and government research organisations are responsible for over three-quarters of basic research on average. However, the share is lower in Korea at 43%, with businesses accounting for 56%. Most basic research is typically performed by HEIs, though government leads in the Czech Republic (53%), Hungary (44%), the Russian Federation (76%) and Mexico (52%), and is responsible for over 40% of basic research in China.

Government funds 70% of HERD on average, often through general university funds, which HEIs have discretion to use for R&D or other activities. HEIs may also use their own funds (e.g. from tuition revenues) or receive transfers from collaborating HEIs to pay for R&D; this is notable in Turkey (46% of HERD) and Japan (44%). In the Slovak Republic, 56% of HERD is funded from abroad, mainly by the EU.

Business funding of R&D performed by HEIs provides one indication of R&D collaboration between these two sectors. The share is greatest in China and the Russian Federation, where businesses (including state-owned enterprises) fund around 30% of HERD. In contrast, the OECD average is 6%. Businesses may also support HERD indirectly by paying to use HEI R&D facilities, buying R&D results or investing in spinoff companies.

Definitions

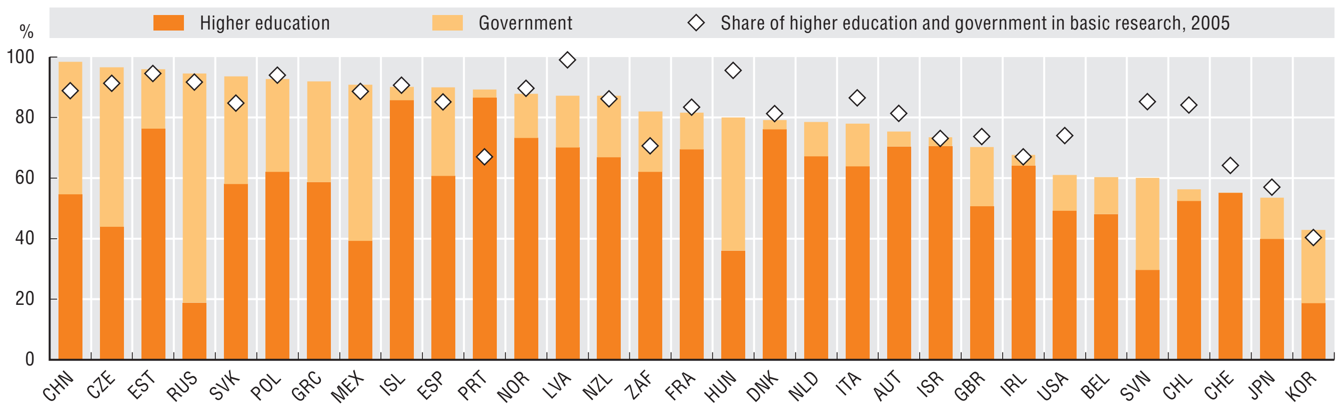
The *higher education sector* comprises all universities, colleges of technology and other institutions providing formal tertiary education programmes, whatever their source of finance or legal status, and all research institutes, centres, experimental stations and clinics whose R&D activities fall under the direct control of tertiary education institutions.

Public *general university funds* (GUF) refer to the R&D funding share from the general grant that universities receive from the central (federal) ministry of education or corresponding provincial (state) or local (municipal) authorities in support of their overall research/teaching activities.

Basic research is the component of R&D – alongside applied research and experimental development – comprising experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, without any particular application or use in view.

Basic research performed in the higher education and government sectors, 2015

As a percentage of domestic expenditures on basic research

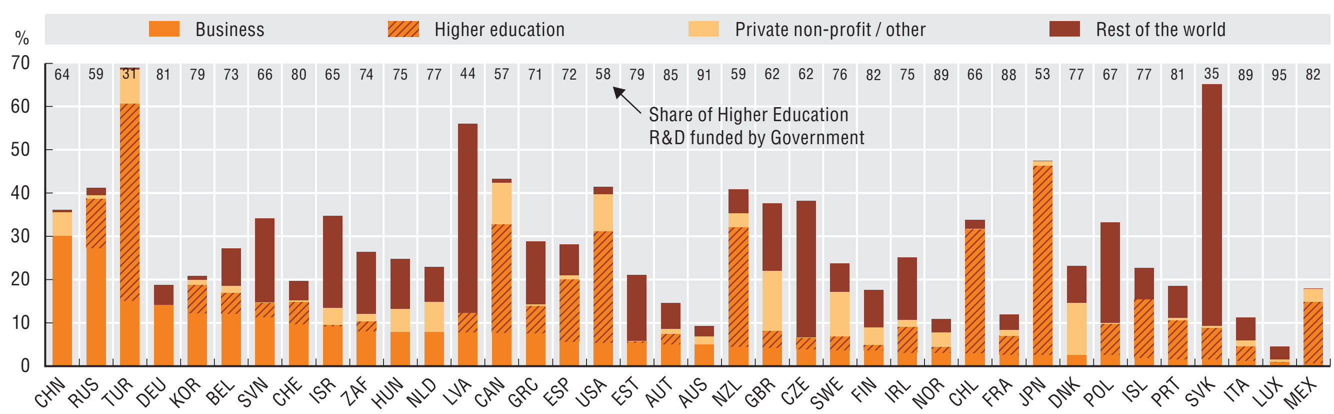


Source: OECD, Research and Development Statistics Database, *http://oe.cd/rds*, June 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933618422

Funding of R&D in higher education, 2015

As a percentage of Higher Education R&D expenditure



Source: OECD, Research and Development Statistics Database, *http://oe.cd/rds*, June 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933618441

Measurability

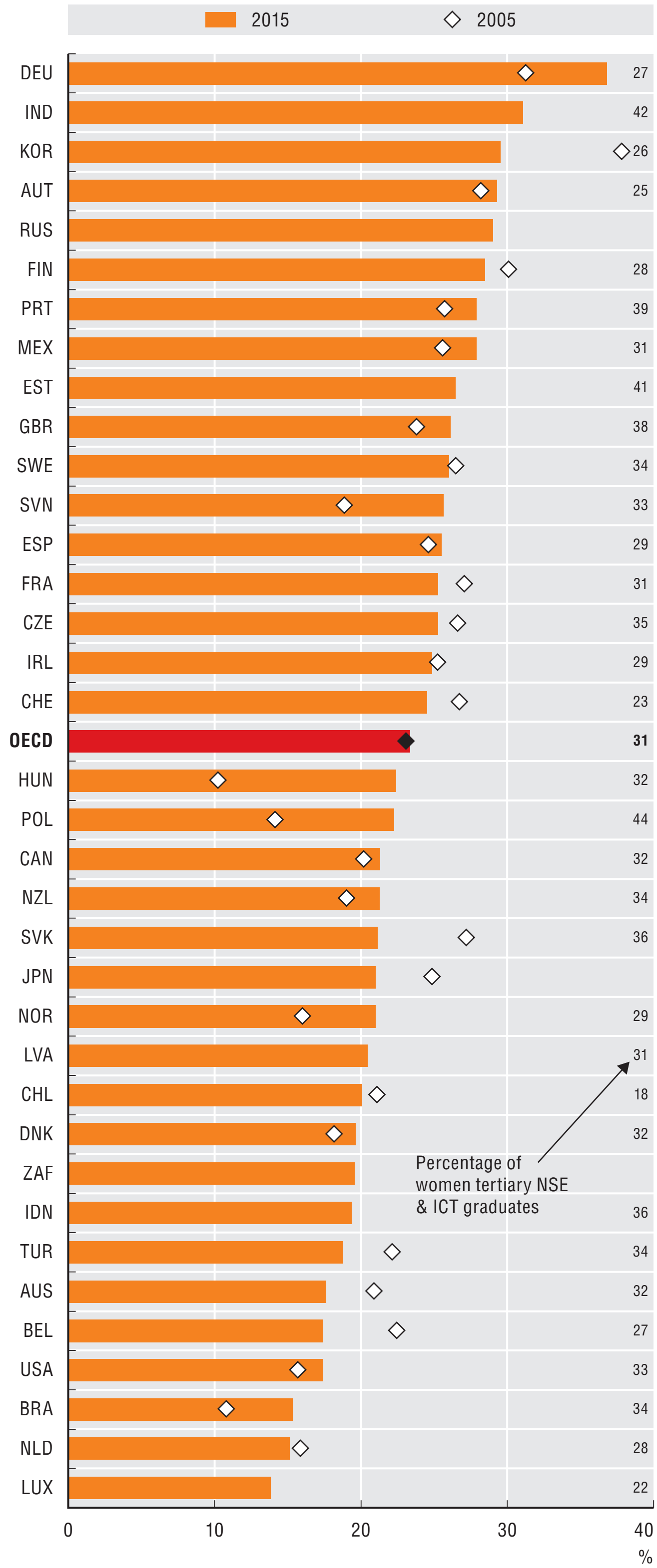
The *higher education sector* is identified separately in R&D statistics because of the important role played by universities and related institutions in performing R&D and training researchers through doctoral and other research degrees. Measurements of HERD rely on dedicated institutional surveys in most OECD countries, often complemented by administrative data sources.

There can be challenges in deriving comparable measures of sources of funding for higher education due to the wide diversity of R&D funding arrangements across countries that shape the type of data HEIs can draw upon for reporting on their R&D activities. Public general university funds are presented as government support for R&D, although they could also be perceived as internal university resources, since universities have a degree of discretion over whether to use such funds for R&D.

3. The science and engineering workforce

Tertiary graduates in the natural sciences, engineering and ICTs (NSE & ICT), 2005 and 2015

As a percentage of all tertiary graduates



Source: OECD, based on OECD (2017), *Education at a Glance 2017: OECD Indicators* and OECD (2007), *Education at a Glance 2007: OECD Indicators*, OECD Publishing, Paris. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933618460

Did you know?

India has almost 600 000 tertiary ICT graduates, about five times as many as the United States.

Tertiary education has expanded worldwide to support the supply of highly educated individuals and meet rising demand for cognitive skills. Policy makers are particularly interested in the supply of scientists, engineers and ICT experts because of their direct involvement in technical change and the ongoing digital transformation. In 2015, 23% of students graduating at tertiary level within the OECD did so with a degree in the natural sciences, engineering, and information and communication technologies (NSE & ICTs). In spite of perceived shortages in this area, this share has remained fairly constant over the past decade across the OECD. However, women account for only 31% of all NSE & ICT graduates in 2015, with shares ranging from 18% in Chile to 44% in Poland. India and Indonesia had the largest shares of ICT graduates in their tertiary graduate population. India contributed the largest number of ICT graduates at nearly 585 000 and is also the country closest to gender parity in this field.

Research skills also have high policy relevance and their acquisition through doctorate programmes is often subsidised by governments. There are marked differences among countries with respect to the share of the population with doctorate degrees. Switzerland has the greatest share of doctorates among the working-age population, due in part to a relatively large proportion of foreign doctoral graduates. In 2016, in more than one-third of countries for which data are available, doctoral holders represented over 1% of the working age population, a rate that has been increasing progressively over time. The share of female doctorate holders was 40% on average.

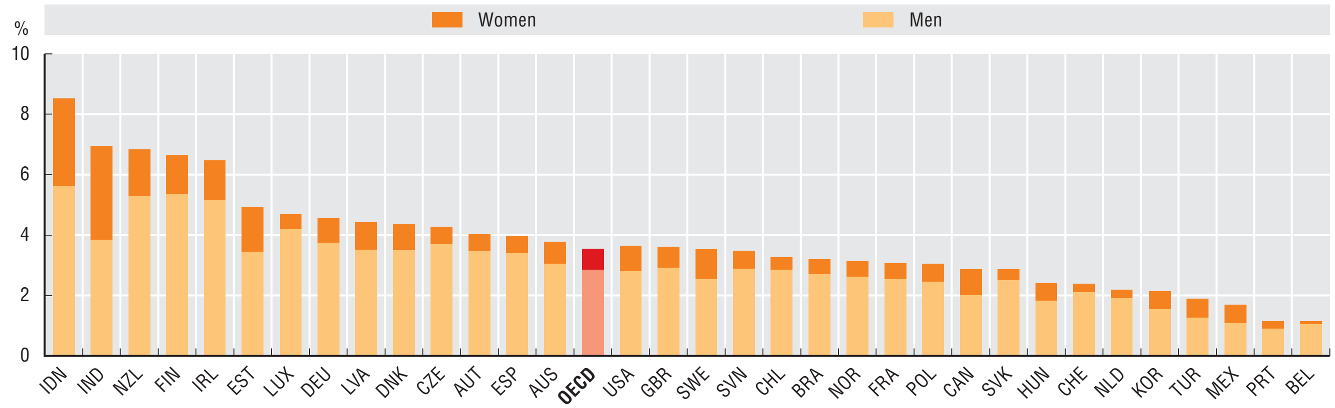
Definitions

The *natural sciences, engineering and ICT fields* correspond to the following fields in the ISCED-2013 classification: 05 Natural sciences, mathematics and statistics; 06 Information and Communication Technologies; and 07 Engineering, manufacturing and construction.

Graduates at the tertiary level are individuals that have obtained a degree at ISCED-2011 Levels 5 to 8. The doctorate level corresponds to individuals who have obtained a degree at ISCED-2011 Level 8, namely advanced research qualifications, usually concluding with the submission and defence of a substantive dissertation of publishable quality based on original research.

Tertiary graduates in Information and communication technologies, by gender, 2015

As a percentage of all tertiary graduates

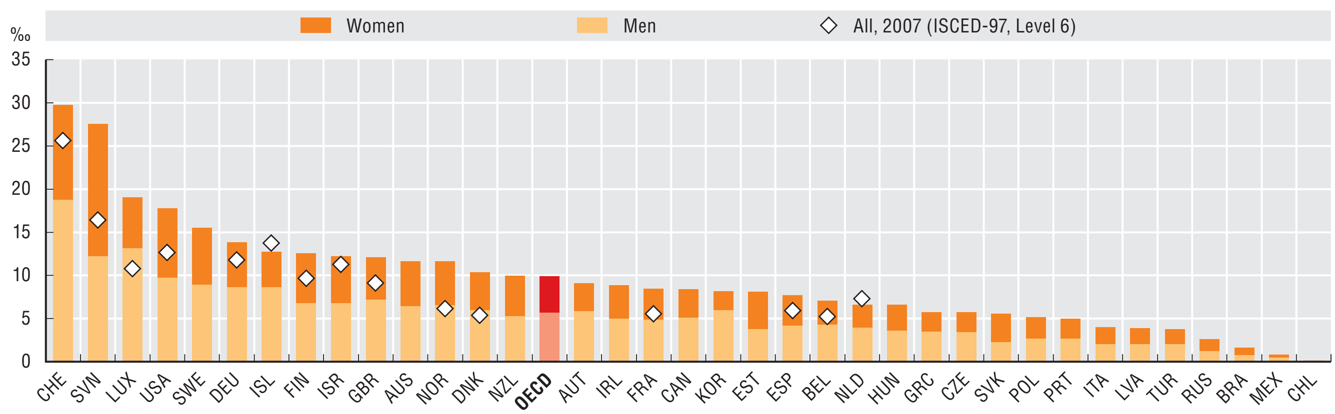


Source: OECD calculations based on OECD Education Database, September 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933618479

Doctorate holders in the working age population, 2016

Per thousand population aged 25-64



Source: OECD calculations based on OECD data collection on Careers of Doctorate Holders 2017, *http://oe.cd/cdh*, OECD (2017), *Education at a Glance 2017: OECD Indicators* and OECD (2009), *Education at a Glance 2009: OECD Indicators*, OECD Publishing, Paris. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933618498

Measurability

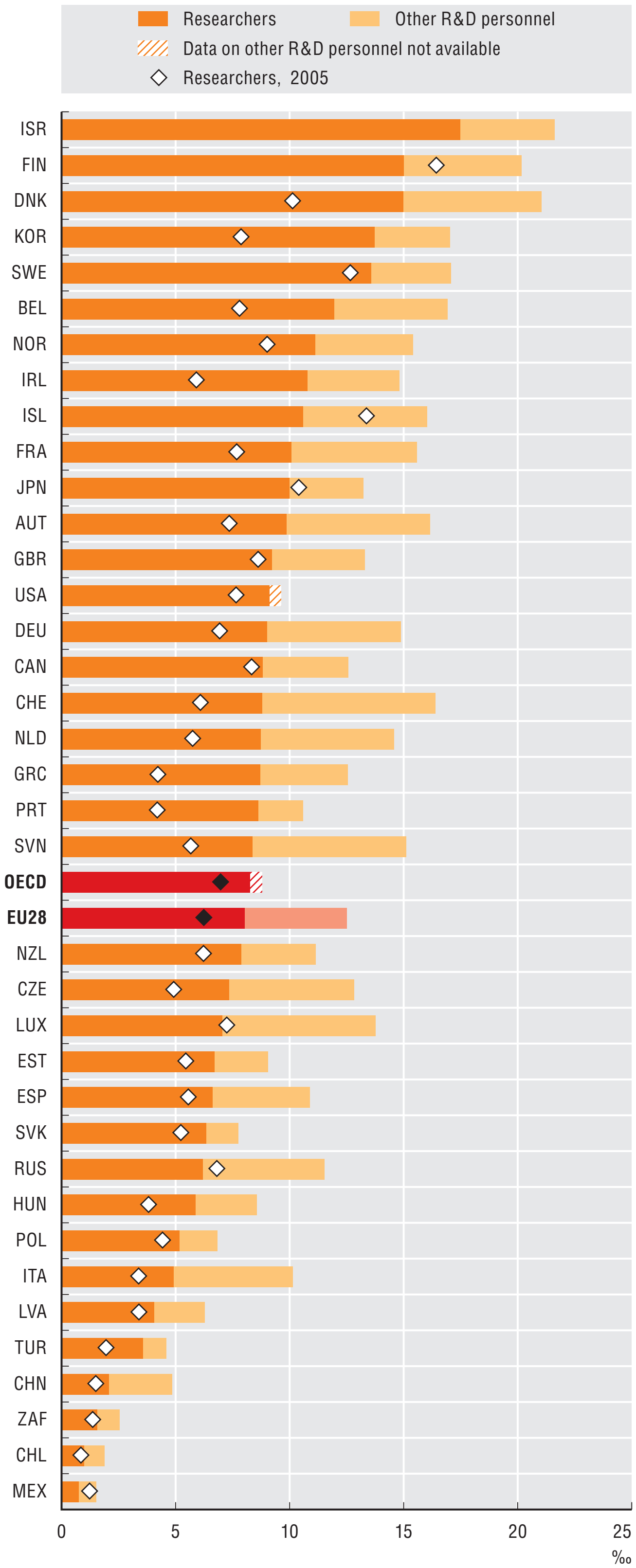
Indicators on graduates by field of education are computed on the basis of annual data jointly collected by UNESCO-UIS/OECD/Eurostat. This data collection process aims to provide internationally comparable information on key aspects of education systems in more than 60 countries worldwide (*http://www.oecd.org/education/database.htm*). The implementation in this data collection of the 2011 revision of the International Standard Classification of Education (ISCED-11) and the ISCED 2013 Fields classification impacts the comparability with data obtained in earlier collections. This presents a minor problem at the chosen level of aggregation, for which there is a clearer equivalence.

Obtaining statistically representative data on the role of doctorate holders in the population is challenging due to the relatively small size of this population. There is an ongoing horizontal effort at OECD to promote the regular and systematic reporting by countries of key features of this fast-growing and internationally mobile group with unique research competences that can be valuable beyond academia (*http://oe.cd/cdh*).

4. Researchers

R&D personnel, 2015

Per thousand employment



Source: OECD, Main Science and Technology Indicators Database, *http://oe.cd/msti*, July 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933618517

Did you know?

Latvia achieves gender parity in the number of researchers, while in Sweden women perform more research in companies than men.

Researchers and other R&D personnel constitute a vital input to R&D performance. Measured on a full-time equivalent (FTE) basis, over 2% of persons employed in Denmark, Finland, and Israel work in R&D – almost double the average of other countries (1.1%). Norway and Ireland rank highly even though their R&D spending is below the OECD average. The number and share of researchers has risen between 2005 and 2015 in most countries, though the share of researchers in total R&D personnel varies widely: from over 80% in Israel, Korea, the Slovak Republic, Sweden, and Portugal to 49% in Italy and 43% in China.

The business enterprise and higher education sectors are the main employers of researchers. Business represents the greatest share - over 70% of researchers in Israel, Japan, Korea, and the United States. The share of researchers working in the business sector has increased markedly between 2005 and 2015 in Hungary, Poland, and Turkey, but fallen in Greece, Luxembourg, Mexico, and South Africa.

Over 40% of researchers in Estonia, Latvia, Portugal, the Slovak Republic, and South Africa are women, while fewer than 25% are women in Austria, the Czech Republic, and Germany. Higher education institutions often employ the greatest share of women researchers. In Luxembourg, the creation of the country's first and only public research university in 2003 helped to produce a 10 percentage point increase in women researchers up to 2015.

Definitions

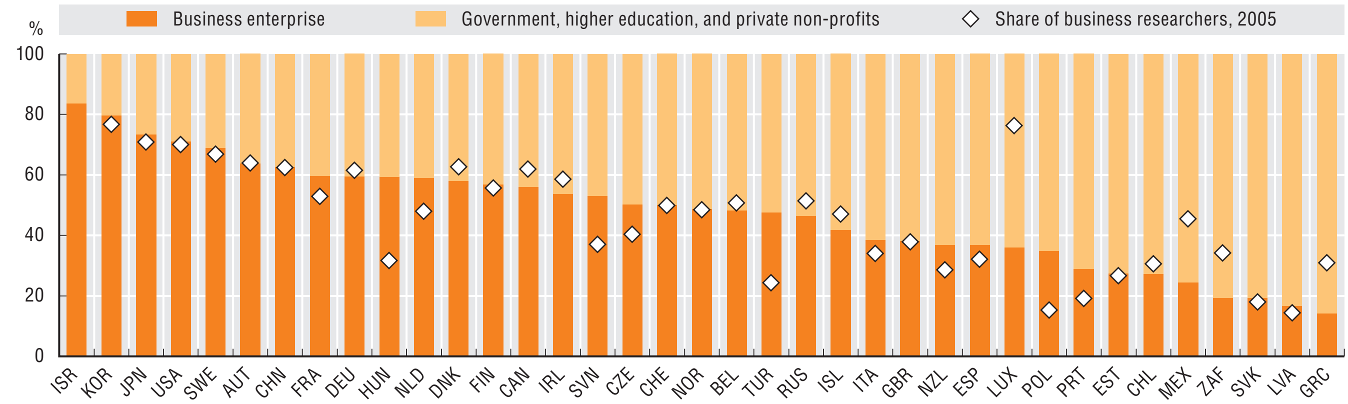
Research and development personnel include all persons employed directly in R&D activities, and comprises technicians and support staff as well as researchers.

Researchers are defined as professionals engaged in the conception or creation of new knowledge. They conduct research and improve or develop concepts, theories, models, techniques, instrumentation, software, or operational methods and are typically directly involved in the management of R&D projects.

R&D personnel are represented in *full-time equivalent* units defined as the ratio of working hours actually spent on R&D during a specific reference period (usually a calendar year) divided by the total number of hours conventionally worked in the same period by an individual or a group. A person working half-time on R&D is thus considered 0.5 of a person-year in R&D FTEs. This yields a more accurate measure of the volume of human resources devoted to R&D in a country than headcounts or jobs. For international comparisons, R&D personnel figures are normalised by total employment, as reported in OECD National Accounts statistics.

Researchers, by sector of employment, 2015

As a percentage of total researchers, full-time equivalents

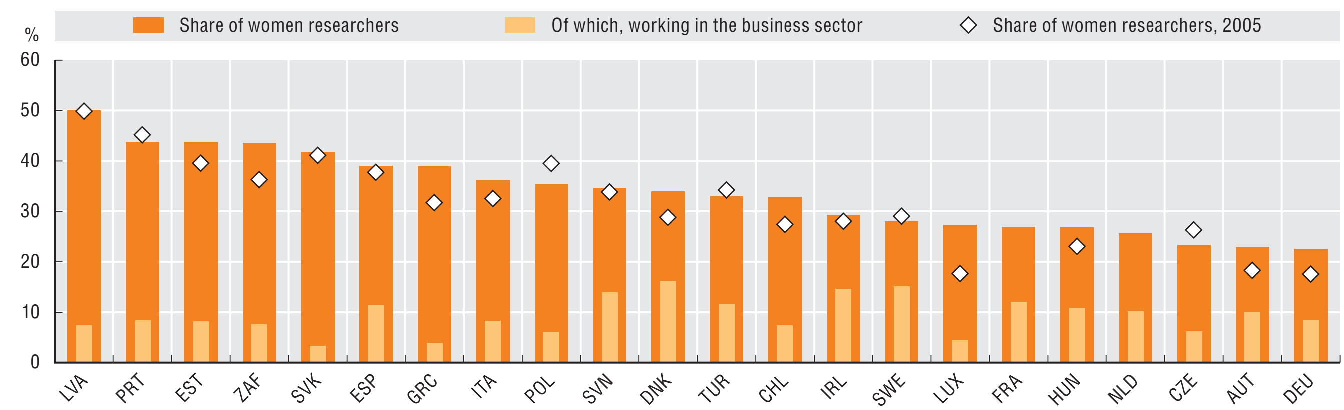


Source: OECD, Research and Development Statistics Database, *http://oe.cd/rds*, June 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933618536

Women researchers, 2015

As a percentage of total researchers, full-time equivalents



Source: OECD, Research and Development Statistics Database, *http://oe.cd/rds*, June 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933618555

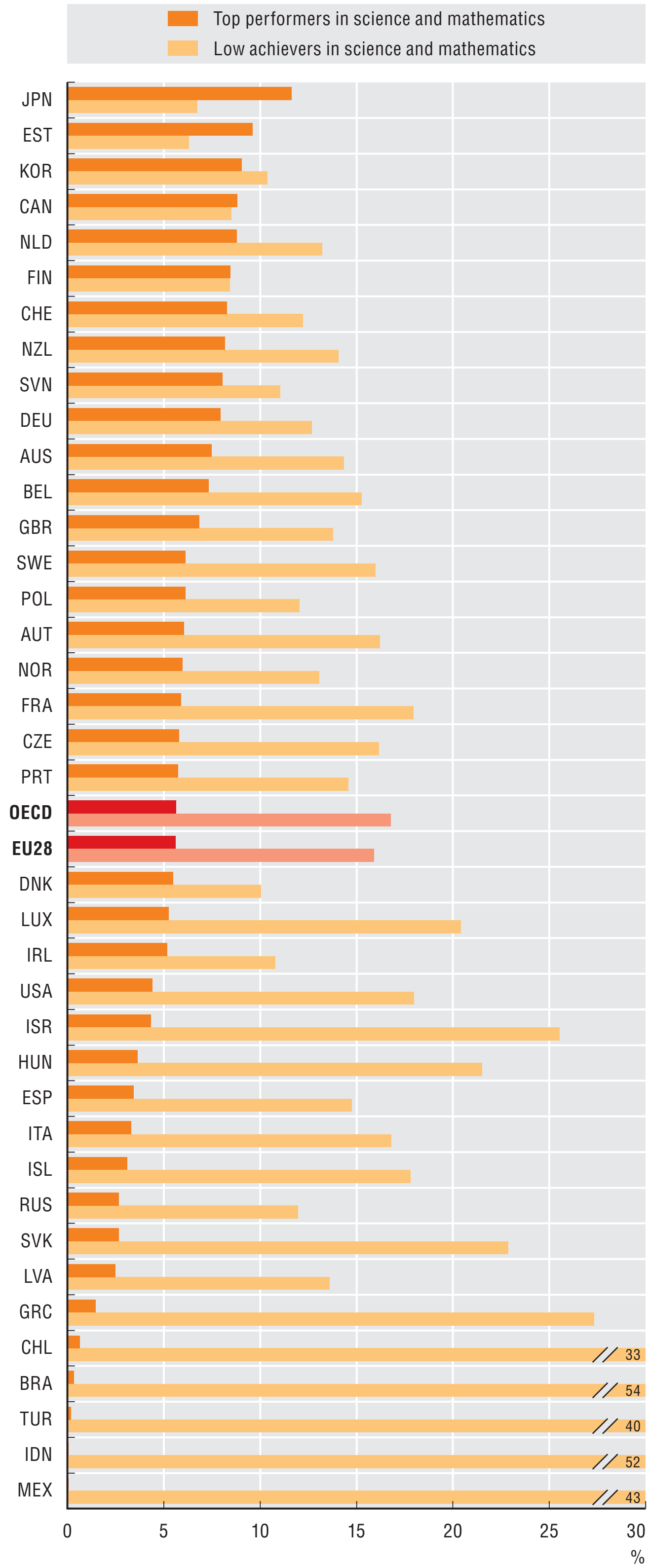
Measurability

Gathering detailed information (e.g. gender, age-band, qualifications, geographic origin, etc.) on people performing R&D can prove challenging. The Frascati Manual 2015 (*http://oe.cd/frascati*) prescribes breakdowns for R&D *employees*, because R&D performers are more likely to be in a position to provide such details for people they employ directly. However, some countries also include *external* persons, such as on-site consultants or unpaid volunteers, in their R&D personnel figures. In recent years, a number of countries have extended coverage of certain groups – such as funded PhD students or all permanent university academic staff – as researchers. Estimation methods also vary; for example, methods used to calculate FTEs may vary not only from country to country but also across sectors within countries, owing to differences in the data sources used to estimate R&D in each sector. Estimating FTEs is particularly challenging in higher education, as many researchers typically engage in other activities, such as teaching or administrative tasks – some at the boundary of R&D. Such variations between countries impact international comparability.

5. Skills in the digital era

Top and low PISA performers in science and mathematics, 2015

As a percentage of 15 year-old students



Source: OECD calculations based on OECD PISA 2015 Database, July 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933618574

Did you know?

In technology-rich environments, the share of young working men and women with good problem-solving skills is three and four times, respectively, that of the oldest generation.

Solid cognitive skills coupled with the ability to solve problems and learn and think creatively are key to adapting to the scale, speed and scope of digital transformations.

On average, 6% of OECD 15 year-olds are top performers in science and mathematics, according to the results of the 2015 OECD Programme for International Student Assessment (PISA). Two-thirds of them are also endowed with top reading skills. Conversely, about 17% of students perform poorly in at least two out of these three fields. Canada, Estonia, Finland and Japan are the only countries in which the share of top performers is higher or on par with that of low achievers (between 8.5% and 11.6% in the case of top achievers, and 6.3% to 8.5% for those at the bottom of the achievement scale).

Education and skills endowment at an early stage in life generally translate into better job performance. The differences observed in countries surveyed by the Programme for International Assessment of Adult Competencies (PIAAC) between workers aged 25-34 and those aged 55-65 point to the positive effect of education on skills. Across all countries, younger workers exhibit better problem-solving skills than older workers. Intergenerational differences are often higher for women than men. Young women are key to raising the average population score in countries where 30% or less workers have a medium or high ability to solve problems in technology-rich environments. This is the case, for example, in Slovenia, Greece and Turkey, where the share of young women with good abilities is 47%, 30% and 24%, respectively, versus 34%, 19% and 15%, respectively, for young men.

With regard to readiness to learn and creative thinking, age and gender-related differences are more significant across countries than within countries. This underlines the role of factors such as culture and societal norms in shaping personality traits.

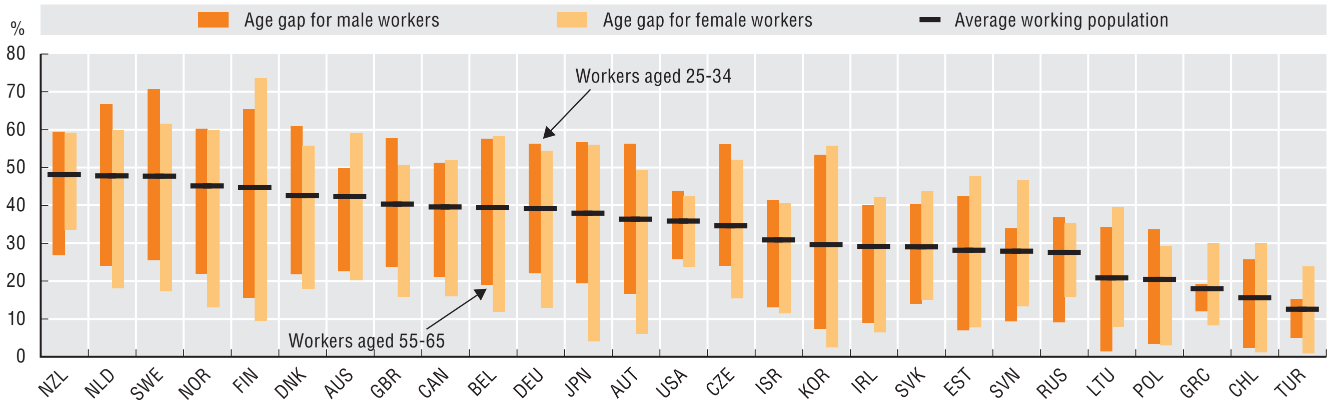
Definitions

Top performers are students aged 15-16 who achieved the highest level of proficiency (i.e. Levels 5 and 6) and *low achievers* performed below Level 2 at the PISA 2015 assessment.

Problem solving in technology-rich environments relate to tests conducted on workers aged 25-34 and 55-65 who exhibited medium and high performance (i.e. individuals reaching Level 2 or 3 in the test in PIAAC) in solving problems encountered when using information and communication technologies. The indicator on *readiness to learn and creative thinking* reflects personality traits and is based on six PIAAC questions.

Problem solving in technology-rich environments, 2012 or 2015

Percentage of workers with medium and high performance, by gender, for workers aged 25-34 and 55-65



Source: OECD calculations based on the OECD Programme for International Assessment of Adult Competencies (PIAAC) Database, June 2017. See chapter notes.

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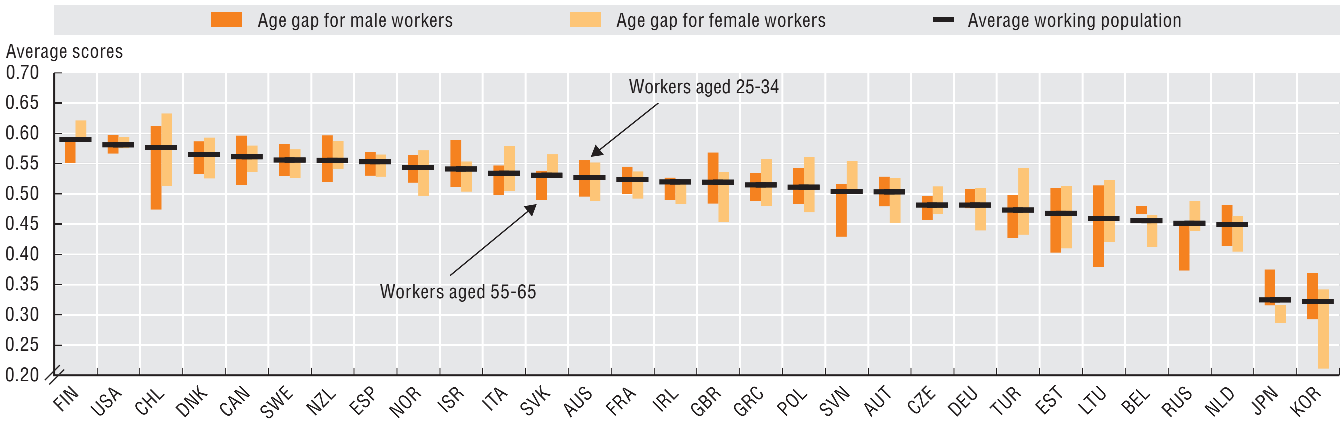
Readiness to learn and creative thinking, 2012 or 2015

Average scores by gender for workers aged 25-34 and 55-65



Source: OECD calculations based on the OECD Programme for International Assessment of Adult Competencies (PIAAC) Database, June 2017. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933618612

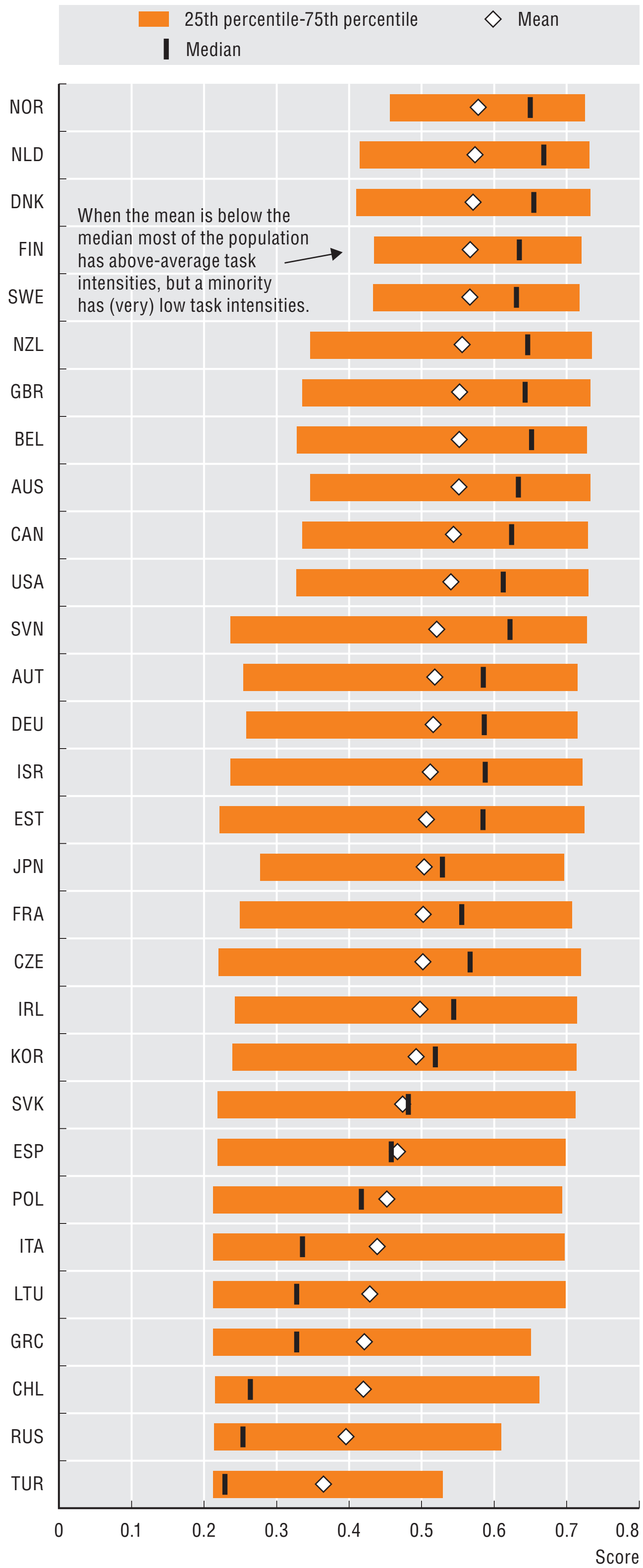
Measurability

Students assessed by the Programme for International Student Assessment (PISA) undertaken by the OECD are between the ages of 15 years, 3 months and 16 years, 2 months. They must be enrolled in school and have completed at least six years of formal schooling, regardless of the type of institution, programme followed or whether the education is full-time or part-time. The most recent, available PISA data were collected during the 2015 school year: over half a million students, representing 28 million 15-year-olds in 72 countries and economies took the internationally agreed 2-hour test. Figures related to problem solving in technology-rich environments are based on a subset of PIAAC countries, as France, Italy and Spain did not participate in the assessment tests. The indicator of readiness to learn and creative thinking was developed using exploratory state-of-the-art factor analysis. It relies on six items related to openness to new experiences and creative thinking, such as "Relate new ideas into real life" or "Like learning new things". The detailed methodology can be found in Grundke et al. (2017).

6. Returns to ICT skills

ICT task intensity of jobs, 2012 or 2015

Interquartile range, median and mean values



Source: OECD calculations based on the OECD Programme for International Assessment of Adult Competencies (PIAAC) Database, June 2017. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933618631

Did you know?

Workers in jobs that are 10% more ICT-intensive than the average job may earn hourly wages that are up to 4% higher.

Digital transformation is changing the ways in which people live and transforming workplaces and the nature of jobs. Workers increasingly need to perform tasks that require information and communication technology (ICT) skills. Wages reflect workers' overall skill endowment including but not limited to ICT skills, as these lead to better performance on the job and increased firm performance.

A new indicator using information on the tasks workers perform on the job shows that the ICT task intensity of any type of job varies substantially across countries. On average, workers in Nordic countries and the Netherlands perform jobs that have a higher ICT-related task content than jobs in other countries.

ICT skills are in high demand and – all things being equal (including education and other workers' skills) – the higher the ICT task intensity of jobs, the higher the hourly wage earned. Estimates suggest that the pay-off for working in ICT task-intensive jobs varies widely across countries. In Korea and the United States, workers in jobs requiring 10% higher ICT task intensity than the country average earn hourly wages that are more than 3.5% higher. Conversely, workers in Israel and Turkey enjoy relatively lower returns on ICT task-intensive jobs (i.e. only about 1%). Returns on ICT task-intensive jobs depend on many factors including a country's supply of and demand for ICT skills, and its wage structure.

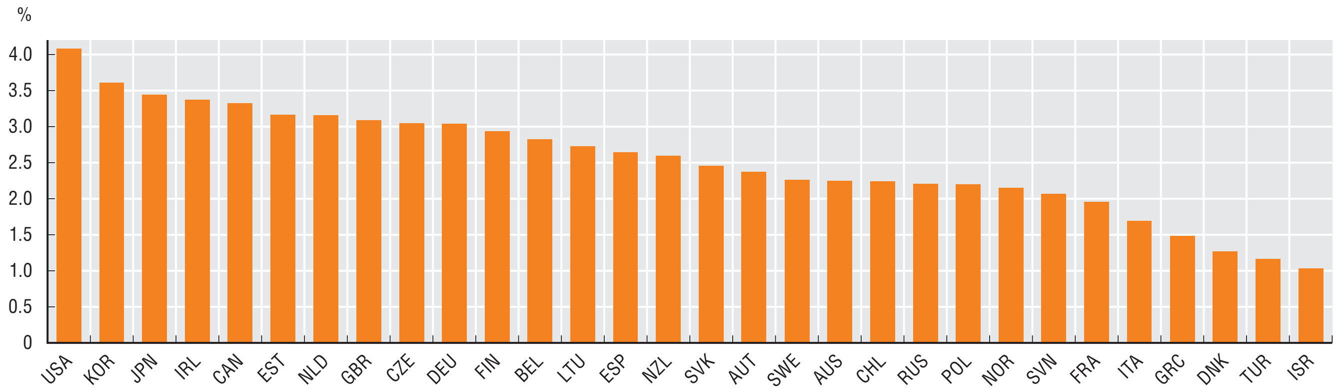
However, ICT skills alone are insufficient to thrive in the digital economy. Analysis suggests that workers need other competences, in particular management and communication (M&C) skills, and that ICT and M&C skills are highly complementary. This is confirmed by the extra rewards workers enjoy when ICT and M&C tasks are performed together as part of the same job. For example, a 10% increase in the M&C task content of jobs at the country mean translates into hourly wages that are 0.6% (Belgium) to 2.1% (Germany) higher, and adds another 0.3%, on average, to hourly wages in jobs that are ICT task-intensive. In the United Kingdom, this extra 1.4% ICT-bonus doubles the labour market returns on M&C tasks. The Russian Federation seems to be the only exception in the sample, as M&C skills do not provide an extra wage bonus when coupled with ICT skills.

Definitions

ICT task-intensive jobs are jobs that have a 10% higher ICT task intensity than the average job in the country. Average returns on M&C tasks are calculated at the country mean, keeping all other variables (including education and skills-related ones) constant.

Labour market returns to ICT tasks, 2012 or 2015

Percentage change in hourly wages for an increase in ICT task intensity by 10% (at the country mean)

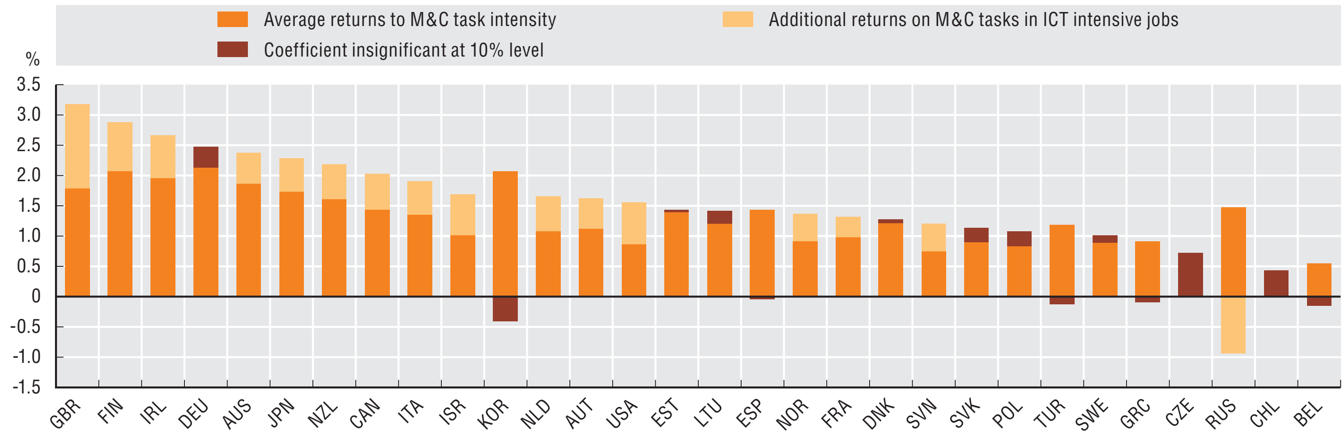


Source: OECD calculations based on the OECD Programme for International Assessment of Adult Competencies (PIAAC) Database, June 2017. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933618650

Returns to management and communication task intensity of jobs: the ICT bonus, 2012 or 2015

Percentage change in hourly wages for 10% increase in M&C task intensity of jobs (at the country mean)



Source: OECD calculations based on the OECD Programme for International Assessment of Adult Competencies (PIAAC) Database, June 2017. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933618669

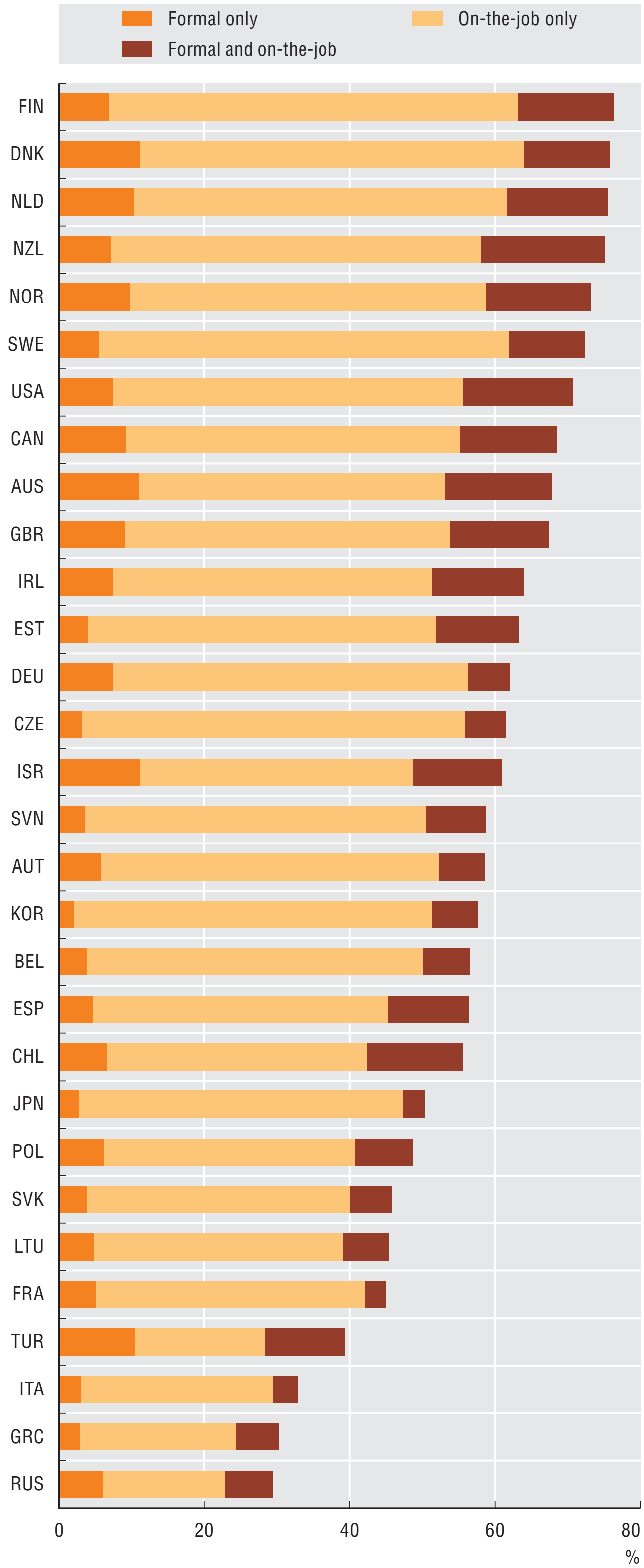
Measurability

Indicators of ICT task intensity and the Management and Communication (M&C) task intensity of jobs rely on exploratory state-of-the-art factor analysis and reflect the extent to which workers perform those tasks on the job. The ICT indicator relies on responses to 11 items on the OECD Programme for International Assessment of Adult Competencies (PIAAC) ranging from simple use of the Internet, to the use of Word or Excel software, or use of a programming language. The M&C indicator relies on five items ranging from negotiation tasks to planning the tasks of other workers, as well as advising and instructing others. The detailed methodology can be found in Grundke et al. (2017). Labour market returns on task intensities are based on OLS wage regressions (Mincer equations) using data from PIAAC. Estimates rely on the log of hourly wages as dependent variable and on a number of individual-related control variables including age, years of education, gender and the other skill measurements, as well as industry dummy variables as regressors. See Grundke et al. (forthcoming) for details.

7. Knowledge capital

Workers receiving training, by type of training, 2012 or 2015

As a percentage of total employed persons



Source: OECD calculations based on the OECD Programme for International Assessment of Adult Competencies (PIAAC) Database, June 2017. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933618688

Did you know?

In many OECD countries businesses invest more in intangibles assets than in machinery and equipment – more than twice as much in Ireland and Norway.

Knowledge-based capital (KBC) refers to assets that are non-physical ("intangible") in nature. They mostly relate to investment in human capital and pertain to the way knowledge is generated, codified and used. Forms of KBC include organisational capital (OC), research and innovation, software and databases. Some of these assets, including R&D and software, are now included in the System of National Accounts (SNA, 2008 revision), and are on average equivalent to over one-third of total business investment in machinery and equipment.

In 2015, on average across the countries considered, total business sector KBC investment – including estimates of investment in OC and training where available – was as important as investment in tangible assets and accounted for 15% of gross value added (GVA). France, Ireland, Sweden and the United States displayed the highest intensities (above 20%).

Investment in KBC in the non-market sector, which complements business sector investment, also varied greatly: between 2% (Spain) and 11% (Ireland) of the sector's GVA. Investment was highest in Ireland, Sweden, the United States and the United Kingdom. In comparison, market sector KBC intensity, remained 1.5 to 5 times higher and grew faster than the non-market one KBC (40% vs. 11%, on average, since 2000).

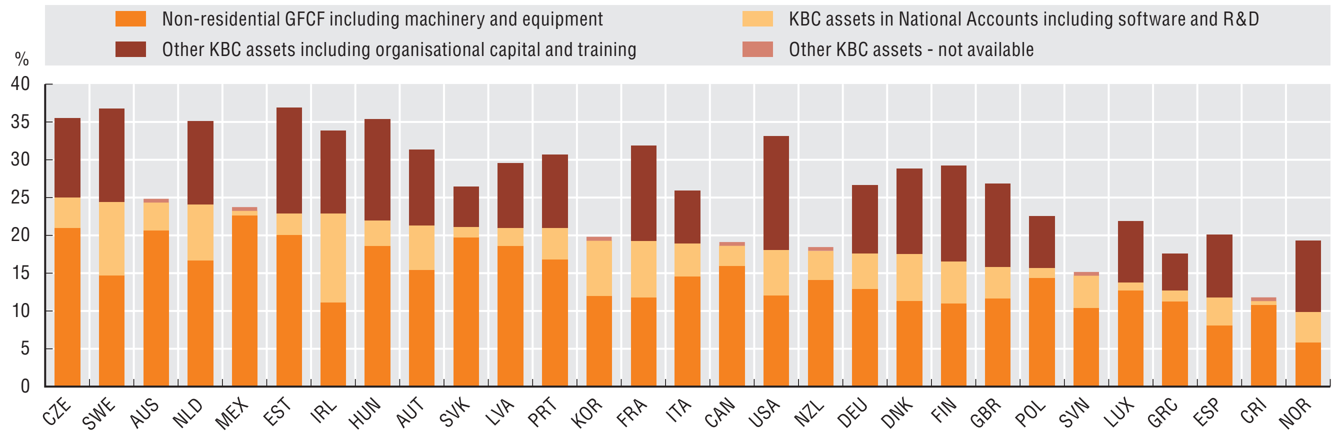
Investment in training endows workers with the skills needed to perform on the job and to transition between jobs, especially in an era of fast technological change. OECD estimates suggest that, while on average, about 60% of workers receive either formal or on-the-job training, the likelihood of receiving training ranges widely, from around 30% (Russian Federation) to over 75% (Finland). Training is mostly provided on the job (72%, on average), likely to ensure a better fit with firms' needs.

Definitions

Formal training refers to organised training undertaken outside of the work environment and results in the attainment of a degree. *On-the-job training* may take place both inside and outside a firm but it does not typically lead to attaining a formal degree. *KBC assets included in the SNA* include R&D, software, mineral explorations and artistic originals. Investment in *Other KBC* assets is estimated on the basis of INTAN-Invest data and covers brands, design, new financial products, organisational capital and firm-based training. Gross value added corresponds to output less the value of intermediate consumption. Non-residential gross fixed formation (GFCF) includes investment in tangible assets excluding dwellings.

Business investment in fixed and knowledge-based capital, 2015

As a percentage of business sector gross value added

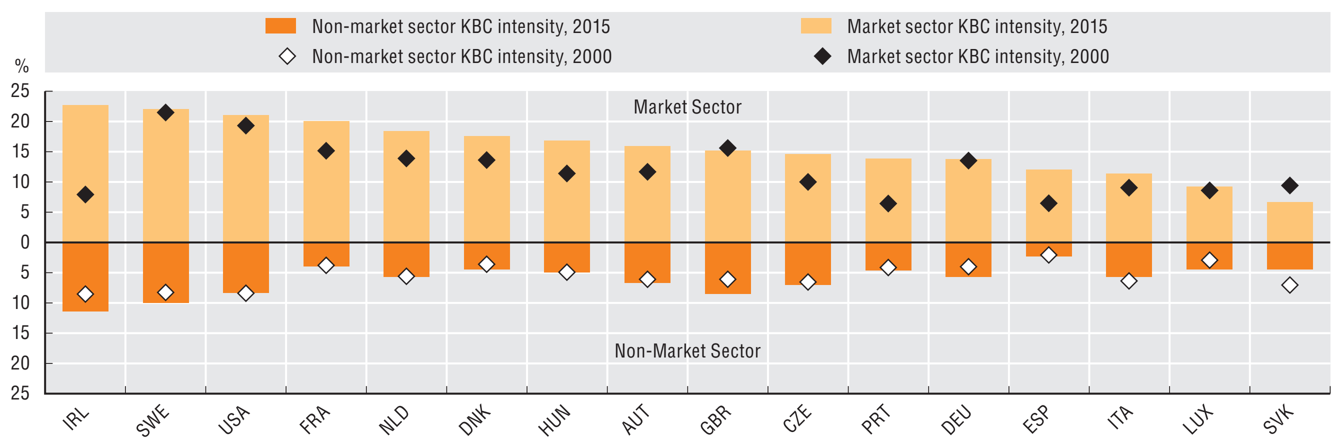


Source: OECD calculations based on the OECD System of National Accounts (SNA) Database, INTAN-Invest data (*http://www.intan-invest.net*); and U.S. Bureau of Economic Analysis data, May 2017. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933618707

Market and non-market sector KBC investment, selected economies, 2000 and 2015

As a percentage of gross value added in the sector



Source: OECD calculations based on the OECD System of National Accounts (SNA) Database, INTAN-Invest data, (*http://www.intan-invest.net*), and SPINTAN data (*http://www.spintan.net*), May 2017. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933618726

Measurability

Training figures are based on the number of employees in the OECD Programme for International Assessment of Adult Competencies (PIAAC) that reported receiving a given type of training at least once in the year, for both public and private sectors. Numbers are weighted to obtain country-wide representativeness. Frequencies may hide differences in the length of the training period. Investment in *KBC assets included in National Accounts* is sourced from the SNA Database. *Other KBC assets* are estimated on the basis of INTAN-Invest data and extrapolated on the basis of the growth rate of SNA KBC investment. The definition of market sector investment applied to the figures in this section covers business investment in all ISIC Rev.4 Divisions 1 to 82 except 68 and 72. Non-market investment follows the SPINTAN definition and includes both public and non-profit entities in the ISIC Rev.4 Divisions 72 and 84 to 93. Intensities are obtained by dividing investment by SNA-based GVA in the corresponding Divisions. The denominator does not correct (i) for the institutional nature of the economic agents, as conversely done for the investment figures at the numerator, nor for (ii) the capitalisation of non-SNA assets.

Notes and references

Cyprus

The following note is included at the request of Turkey:

"The information in this document with reference to 'Cyprus' relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognizes the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Turkey shall preserve its position concerning the 'Cyprus issue'."

The following note is included at the request of all of the European Union Member States of the OECD and the European Union:

"The Republic of Cyprus is recognized by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus."

Israel

"The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities or third party. 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.

"It should be noted that statistical data on Israeli patents and trademarks are supplied by the patent and trademark offices of the relevant countries."

2.1. Investment in knowledge

Expenditure on tertiary education and vocational programmes, 2014

For Chile and Indonesia, data refer to 2015.

For Denmark and Poland, vocational programmes include information from both upper and lower secondary education.

For the Slovak Republic, tertiary education data refer to expenditure on public institutions only.

For Switzerland, data refer to public expenditure only.

Gross domestic expenditure on R&D, by type of R&D, 2015

Data for total GERD (all types of R&D) refer to 2005 and 2015. Where the breakdown of 2015 GERD by type of R&D is not available directly, this is estimated based on the most recent year for which the breakdown is available: 2014 for France, Italy, the Netherlands, Poland, Portugal, Slovenia and the United Kingdom; 2013 for Austria, Belgium, Denmark, Greece, Ireland and Israel.

The breakdown by type of R&D is usually based on total GERD including expenditure on capital inputs to R&D. However, for Chile, Norway and the Russian Federation, shares by type are based on current R&D expenditure, with capital expenditure reported in the "breakdown not available, in total or in part" category. For the United States, and with the exception of GOVERD, which includes expenditure on capital used for R&D, figures reported (both total R&D and R&D by type) refer to current expenditures but include a depreciation component which may differ from the actual level of capital expenditure (reported in the "breakdown not available, in total or in part" category).

These statistics are based on OECD R&D Statistics (*http://oe.cd/rds*) and Main Science and Technology Indicators (*http://oe.cd/msti*). For more information on these data including on issues such as breaks in series, please see those sources.

For Australia, data for total GERD refer to 2004 and 2013.

For Chile, data for total GERD refer to 2007 and 2015.

For Chile, the official GDP figures used to normalise R&D ratios are compiled according to the System of National Accounts (SNA) 1993, rather than the SNA 2008 used in all other cases.

For Ireland, data for total GERD refer to 2014.

For Israel, defence R&D is partly excluded from available estimates.

For South Africa, data for total GERD refer to 2013.

For Switzerland, data for total GERD refer to 2004 and 2015.

ICT investment by asset, 2015

Investment refers to Gross Fixed Capital Formation (GFCF) as defined by the System of National Accounts 2008 (SNA08).

Data for Iceland correspond to business sector investment in office machinery and computers.

Data for Korea are OECD calculations based on detailed national input-output tables supplied by the Bank of Korea and OECD Annual National Accounts SNA08.

2.2. Higher education and basic research

Higher education expenditure on R&D, 2015

Public General University Funds (GUF) estimates identify the component of general institutional grants provided by government to the higher education sector that are ultimately used by the latter for R&D. Estonia, Poland and the United States report no relevant grants fitting the GUF description. No GUF estimates are available for China, the Czech Republic, Germany, Hungary, Korea, Latvia, Luxembourg, the Netherlands, Portugal or Turkey. The GUF figures correspond to the same reference year as HERD or, in their absence, are based on shares for the most recent available year: Belgium (2013), France (2014), Israel (2013), Italy (2014), New Zealand (2013) and Sweden (2013).

These statistics are based on the OECD Main Science and Technology Indicators Database (*http://oe.cd/msti*). For more information on these data including on issues such as breaks in series, please see that source.

For Australia, data refer to 2004 and 2014.

For Chile, data refer to 2007 and 2015.

For Chile, the official GDP figures used to normalise R&D ratios are compiled according to the System of National Accounts (SNA) 1993, rather than the SNA 2008 used in all other cases.

For Israel and Korea, R&D in the social sciences and humanities is not included in 2005 estimates.

For South Africa, data refer to 2013.

For Switzerland, data refer to 2004 and 2015.

For the United States, figures reported refer to current expenditures, but include a depreciation component which may differ from the actual level of capital expenditure.

Basic research performed in the higher education and government sectors, 2015

Data refer to the sum of current and capital expenditures, except for Chile, Norway, the Russian Federation and the United States, for which only current costs are included in estimates reported to the OECD.

These statistics are based upon OECD R&D databases including the R&D Statistics (*http://oe.cd/rds*) and Main Science and Technology Indicators Databases (*http://oe.cd/msti*). For more information on these data including on issues such as breaks in series, please see those sources.

For Austria, Belgium, Denmark, Greece, Ireland, Israel and South Africa data refer to 2013.

For France, Italy, the Netherlands, Portugal, Slovenia and the United Kingdom, data refer to 2014.

For the earlier share of higher education and government basic research in GERD, data refer to 2005, except for Austria and Switzerland which refer to 2004, Chile, Denmark and the United Kingdom which refer to 2007, and Mexico which refers to 2003.

For France, the methodology of the public administration survey was changed in 2010: the method for measuring the resources devoted to R&D in ministries and some public organisations has been modified, leading to better identification of their financing activities and to a drop in GOVERD of 900 million Euros.

For Israel, defence R&D is partly excluded from available estimates.

For the Netherlands, part of expenditure dedicated to experimental development in the higher education sector is reported within basic research. Additionally, PNP expenditures are included in the government sector.

For Poland, the 2005 share of higher education and government basic research in GERD is calculated based on data including current costs only, while 2014 higher education and government data include capital and current expenditure.

For Spain, the 2005 share of higher education and government basic research in GERD is calculated based on data including current costs only, while 2015 higher education and government data include capital and current expenditure.

For Switzerland, the government sector refers to the federal or central government only.

For the United Kingdom, the methodology for distributing GOVERD by type of R&D was improved in 2010, resulting in a break in series.

For the United States, the figures reported comprise current expenditure, but include a depreciation component which may differ from the actual level of capital expenditure; the exception is GOVERD, which includes capital expenditure instead.

Funding of R&D in higher education, 2015

These statistics are based upon OECD R&D databases including the R&D Statistics (*http://oe.cd/rds*) and Main Science and Technology Indicators Databases (*http://oe.cd/msti*). For more information on these data including on issues such as breaks in series, please see those sources.

For all countries except China, “PNP/other not elsewhere classified” consists of funds from PNPs overseas only.

General University Funds (GUF) paid from government to universities for use for R&D are recorded in the Government sector where the funds originate.

For Australia, data refer to 2014.

For Austria, data refer to 2013.

For Belgium, Israel, Luxembourg, Sweden and South Africa, data refer to 2013.

For Germany, France, Italy and Portugal, data refer to 2014.

For Australia, Australian Competitive Grants (ACG) – federal and other schemes – are identified separately and included respectively in direct government and private non-profit.

For China, expenditure by source of funds is divided into government, business enterprise, funds from abroad and “other”. These categories differ slightly from those in the Frascati Manual. Money that has no specific source of financing has been allocated to “other sector (domestic)”. This includes self-raised funding, in particular for independent research institutions (IRIs, formerly GRIs) and the higher education sector, and leftover government money from previous years/grants. This “other” amount is recorded in “PNP/other not elsewhere classified in this presentation”.

For Denmark, higher education funds are included in government funds.

For Israel, defence R&D is partly excluded from available estimates.

For Germany, higher education and private non-profit funds are included in government funds.

In Luxembourg’s survey, R&D data by source of funds are broken down as percentages between: Enterprise group, Ministry of Economy, Partner enterprise of R&D projects, European Commission, International organisations, and Other foreign sources (other national governments, higher education, others).

2.3. Scientists and engineers

Tertiary graduates in natural sciences, engineering and ICTs (NSE & ICT), 2005 and 2015

Tertiary education comprises Levels 5 to 8 of the ISCED-2011 classification.

Fields of study refer to the ISCED-F 2013 Fields of education classification.

For Japan, data on Information and communication technologies are included in the other fields.

For the Netherlands, data exclude doctoral graduates.

For South Africa, data refer to 2014.

Tertiary graduates in Information and communication technologies, by gender, 2015

Tertiary education comprises Levels 5 to 8 of the ISCED-2011 classification.

The Information and communication technologies field of study refers to the ISCED-F 2013 Fields of education classification.

The OECD aggregate is an unweighted average of countries with available data.

Doctorate holders in the working age population, 2016

International comparability may be limited.

Sources (Working age population):

United Nations, Department of Economic and Social Affairs, Population Division (2017), *World Population Prospects: The 2017 Revision*. Custom data acquired via website.

Sources (Doctorate holders):

For Brazil, Canada, Chile, the Czech Republic, Estonia, Germany, Korea, Norway, Portugal and the United Kingdom: OECD Careers of Doctorate Holders 2017 data collection.

For all other countries: OECD (2017).

Data for 2007 are derived from OECD (2009).

2016 and 2007 attainment data are based on two different ISCED classifications (ISCED 2011 and ISCED 97, respectively) and have not been harmonised. Although the definition of a “doctorate holder” is broadly similar across ISCED classifications, comparisons over time must be interpreted with caution.

For Brazil, data refer to doctoral graduates from 1996 to 2014.

For Canada, data refer to 2011 and exclude non-residents or foreign residents, persons living in institutional and non-institutional collective dwellings, Canadian citizens living in other countries, and full-time members of the Canadian Forces stationed outside Canada. Foreign citizens are covered partially.

For Chile, data refer to 2015.

For the Czech Republic data refer to a moving average computed over the period 2014-2016.

For Korea, data refer to 2012 and include foreign citizens, but attainment cannot be disaggregated by citizenship.

For the Russian Federation, there is limited coverage of unemployed graduates, inactive graduates, foreign citizens and non-residents.

2.4. Researchers

R&D personnel, 2015

These statistics are based on the OECD Main Science and Technology Indicators Database (*http://oe.cd/msti*). For more information on these data, including on issues such as breaks in series, please see that source.

For Austria, Greece, Latvia and Spain, R&D personnel include internal as well as some external personnel; some double counting may arise if the same personnel are reported by multiple respondents.

For Canada, Mexico and South Africa, data refer to 2013.

For China, Ireland and Turkey, no R&D survey was carried out in the PNP sector as the corresponding R&D activity is considered to be negligible.

For China and Israel, the military part of defence R&D is excluded.

For China, the data for researchers before 2009 are surveyed according to the UNESCO concept of "scientist and engineer", and according to the Frascati Manual notion of researcher from 2009 onwards. For this reason, there is a break in series between 2008 and 2009.

For Chile, data refer to 2007 and 2015.

For Greece, a change in methodology occurred in 2011 with the extension of coverage of the government and higher education sector to include public hospitals, all institutions administered by the Ministry of Culture, all Technological Educational Institutes (TEI) and post-secondary establishments, which resulted in an increase in the number of researchers.

For Iceland and the reference year 2013, the R&D data collection methodology was changed resulting in breaks in series. The main differences concern the redesign of the questionnaire, the use of business registers, the legal obligation for firms to respond, the definition of key R&D concepts in the questionnaire, and changes in the allocation of institutions into business or government sectors.

For Ireland, a change in methodology occurred in 2014 with the inclusion of PhD students in the higher education sector, which resulted in a substantial increase in the number of researchers.

For Israel, data refer to 2014 and the shares are estimated based on the 2014 available data.

For Korea, 2005 R&D personnel data excludes R&D performed in the social sciences and humanities.

For Luxembourg, a change in methodology occurred in 2012 leading to better identification of R&D in software-related activities, which resulted in a decrease in the number of researchers.

For the Netherlands, a change in methodology occurred in 2012 with modification of the personnel data by function in Dutch surveys, which resulted in a substantial increase in the number of researchers.

For Norway, data refer to university graduates instead of researchers in the business sector.

For Portugal, R&D personnel increased in 2008, mainly due to methodological improvements in the different institutional sectors (government, higher education and private non-profit institutions): the results of the individual survey forms were compared with information from other internal databases resulting, notably, in the inclusion of all permanent academic staff and all researchers funded by the Ministry of Science, Technology and Higher Education in 2008.

For Slovenia, a change in methodology occurred in 2011 leading to the improvement of non-response analysis and new administrative sources to better identify R&D performers, which resulted in a substantial increase in the number of researchers.

For Sweden, data refer to university graduates instead of researchers in the business sector in 2005. A change in methodology occurred in 2013; for the business enterprise sector, PNPs and the government sector, reporting units were asked to report according to two and not three occupations: "researchers" and "other staff". "Other staff" includes "technicians and equivalent staff" and "other supporting staff". A proportion of personnel are from the 2013 reference year reallocated from the category"technicians" to "researchers".

For Switzerland, data refer to 2004 and 2015, and R&D personnel in the PNP sector are not included in total R&D personnel.

For the United States, the proportion of non-business R&D personnel who are researchers has been estimated based on historical data.

Researchers, by sector of employment, 2015

These statistics are based on the OECD R&D Statistics database (*http://oe.cd/rds*). For more information on these data, including on issues such as breaks in series, please refer to this source.

For Austria, Greece, Latvia and Spain, R&D personnel include internal as well as some external personnel; some double counting may arise if the same personnel are reported by multiple respondents.

For Canada, Mexico and South Africa, data refer to 2005 and 2013.

For China, Ireland and Turkey, no R&D survey was carried out in the PNP sector as the corresponding R&D activity is considered to be negligible.

For China and Israel, the military part of defence R&D is excluded.

For Canada, R&D performed in the social sciences and humanities are excluded from the business and PNP sectors.

For Chile, data refer to 2007 and 2015.

For China, the data for researchers before 2009 are surveyed according to the UNESCO concept of "scientist and engineer", and according to the Frascati Manual notion of researcher from 2009 onwards. For this reason, there is a break in series between 2008 and 2009.

For Greece, a change in methodology occurred in 2011 with the extension of coverage of the government and higher education sector to include public hospitals, all institutions administered by the Ministry of Culture, all Technological Educational Institutes (TEI) and post-secondary establishments, which resulted in an increase in the number of researchers.

For Iceland and the reference year 2013, the R&D data collection methodology was changed resulting in breaks in series. The main differences concern the redesign of the questionnaire, the use of business registers, the legal obligation for firms to respond, the definition of key R&D concepts in the questionnaire, and changes in the allocation of institutions into the business or government sectors.

For Ireland, a change in methodology occurred in 2014 with the inclusion of PhD students in the higher education sector, which resulted in a substantial increase in the number of researchers.

For Israel, data refer to 2005 and 2014 and the shares have been estimated based on the 2014 available data.

For Korea, 2005 R&D personnel data excludes R&D performed in the social sciences and humanities.

For Latvia, PNP is included in the business sector.

For Luxembourg, a change in methodology occurred in 2012 leading to better identification of R&D in software-related activities, which resulted in a decrease in the number of researchers.

For the Netherlands, a change in methodology occurred in 2012 with modification of the personnel data by function in Dutch surveys, which resulted in a substantial increase in the number of researchers.

For New Zealand, PNP is included in the business sector.

For Norway, data refer to university graduates instead of researchers in the business sector.

For Portugal, R&D personnel increased in 2008, mainly due to methodological improvements in the different institutional sectors (government, higher education and private non-profit institutions): the results of the individual survey forms were compared with information from other internal databases resulting, notably, in the inclusion of all permanent academic staff and all researchers funded by the Ministry of Science, Technology and Higher Education in 2008.

For Slovenia, a change in methodology occurred in 2011 leading to the improvement of non-response analysis and new administrative sources to better identify R&D performers, which resulted in a substantial increase in the number of researchers.

For Sweden, data refer to university graduates instead of researchers in the business sector in 2005. A change in methodology occurred in 2013, for the business enterprise sector, PNPs and the government sector, reporting units were asked to report according to two and not three occupations: "researchers" and "other staff". "Other staff" includes "technicians and equivalent staff" and "other supporting staff". A proportion of personnel are from the 2013 reference year reallocated from the category"technicians" to "researchers".

For Switzerland, R&D personnel in the PNP sector are not included in total R&D personnel.

For the United States, data refer to 2008 and 2015, and the proportion of non-business R&D personnel who are researchers has been estimated based on historical data.

Women researchers, 2015

These statistics are based on the OECD R&D Statistics database (*http://oe.cd/rds*). For more information on these data, including on issues such as breaks in series, please refer to this source.

For Austria, Greece, Latvia and Spain, R&D personnel includes internal as well as some external personnel. Some double counting is possible if separately reported by their direct employers.

For Denmark, Greece, Ireland, Luxembourg, Sweden and South Africa, data refer to 2013.

For Ireland and Turkey, no R&D survey was carried out in the PNP sector as the corresponding R&D activity is considered to be negligible.

For Italy, the Netherlands, Poland, Portugal and Slovenia, data refer to 2014.

For Austria, data refer to 2004 and 2013.

For Chile, data refer to 2007 and 2015.

For Greece, a change in methodology occurred in 2011 with the extension of coverage of the government and higher education sector to include public hospitals, all institutions administered by the Ministry of Culture, all Technological Educational Institutes (TEI) and post-secondary establishments, which resulted in an increase in the number of researchers.

For Hungary, data refer to 2006 and 2015.

For Latvia, PNP is included in the business sector.

For Luxembourg, a change in methodology occurred in 2012 leading to better identification of R&D in software-related activities, which resulted in a decrease in the number of researchers.

For Norway, data refer to university graduates instead of researchers in the business sector.

For Portugal, R&D personnel increased in 2008, mainly due to methodological improvements in the different institutional sectors (government, higher education and private non-profit institutions): the results of the individual survey forms were compared with information from other internal databases resulting, notably, in the inclusion of all permanent academic staff and all researchers funded by the Ministry of Science, Technology and Higher Education in 2008.

For Slovenia, a change in methodology occurred in 2011 leading to the improvement of non-response analysis and new administrative sources to better identify R&D performers, which resulted in a substantial increase in the number of researchers.

For Sweden, data refer to university graduates instead of researchers in the business sector in 2005. A change in methodology occurred in 2013, for the business enterprise sector, PNPs and the government sector; reporting units were asked to report according to two and not three occupations: “researchers” and “other staff”. “Other staff” includes “technicians and equivalent staff” and “other supporting staff”. A proportion of personnel are from the 2013 reference year reallocated from the category”technicians” to “researchers”.

2.5. Skills in the digital era

Top and low PISA performers in science and mathematics, 2015

The indicators show the sum of the share of top performers (low achievers) in science and mathematics but not in reading and that of top performers (low achievers) in science, mathematics and reading.

Problem solving in technology-rich environments, 2012 or 2015

Calculations are based on data from the problem solving in technology-rich environments tests conducted by the Programme for International Assessment of Adult Competencies (PIAAC).

Medium and high performance in problem solving in technology-rich environments is defined as individuals having reached level 2 or 3 in the assessment test.

Italy, France and Spain have not participated in the assessment tests for problem solving in technology-rich environments.

The data for the following 23 countries from the first round of PIAAC refer to the year 2012: Australia, Austria, Belgium (Flanders), Canada, the Czech Republic, Germany, Denmark, Estonia, Finland, France, Ireland, Italy, Japan, Korea, the Netherlands, Norway, Poland, the Russian Federation (excluding Moscow), the Slovak Republic, Spain, Sweden, the United Kingdom (England and Northern Ireland) and the United States. Data for the remaining countries refer to 2015 and are sourced from the second round of the first wave of the PIAAC survey.

Readiness to learn and creative thinking, 2012 or 2015

The readiness to learn and creative thinking indicator is built using exploratory state-of-the-art factor analysis. It relies on six items related to openness to new experiences and creative thinking. The detailed methodology can be found in Grundke et al. (2017).

The data for the following 23 countries from the first round of PIAAC refer to the year 2012: Australia, Austria, Belgium (Flanders), Canada, the Czech Republic, Germany, Denmark, Estonia, Finland, France, Ireland, Italy, Japan, Korea, the Netherlands, Norway, Poland, the Russian Federation (excluding Moscow), the Slovak Republic, Spain, Sweden, the United Kingdom (England and Northern Ireland) and the United States. Data for the remaining countries refer to 2015 and are sourced from the second round of the first wave of the PIAAC survey.

2.6. Returns to ICT skills

ICT task intensity of jobs, 2012 or 2015

When the mean is below the median, most of the population has above-average task intensities, but a minority has (very) low task intensities.

The ICT task intensity of jobs indicator relies on exploratory state-of-the-art factor analysis and captures the use of ICT on the job. It relies on 11 items from the OECD Programme for International Assessment of Adult Competencies (PIAAC) ranging from simple use of the Internet to the use of Word or Excel software or a programming language. The detailed methodology can be found in Grundke et al. (2017).

The data for the following 23 countries from the first round of PIAAC refer to the year 2012: Australia, Austria, Belgium (Flanders), Canada, the Czech Republic, Germany, Denmark, Estonia, Finland, France, Ireland, Italy, Japan, Korea, the Netherlands, Norway, Poland, the Russian Federation (excluding Moscow), the Slovak Republic, Spain, Sweden, the United Kingdom (England and Northern Ireland) and the United States. Data for the remaining countries refer to 2015 and are sourced from the second round of the first wave of the PIAAC survey.

Labour market returns to ICT tasks, 2012 or 2015

The ICT task intensity of jobs indicator relies on exploratory state-of-the-art factor analysis and captures the use of ICT on the job. It relies on 11 items from the OECD Programme for International Assessment of Adult Competencies (PIAAC) ranging from simple use of the Internet to the use of Word or Excel software or a programming language. The detailed methodology can be found in Grundke et al. (2017).

Labour market returns to task intensities are based on OLS wage regressions (Mincer equations) using data from the OECD Programme for International Assessment of Adult Competencies (PIAAC). Estimates rely on the log of hourly wages as dependent variables and include a number of individual-related control variables (including age, years of education, gender and other skill measures detailed in Grundke et al., 2017) as well as industry dummy variables.

The data for the following 23 countries from the first round of PIAAC refer to the year 2012: Australia, Austria, Belgium (Flanders), Canada, the Czech Republic, Germany, Denmark, Estonia, Finland, France, Ireland, Italy, Japan, Korea, the Netherlands, Norway, Poland, the Russian Federation (excluding Moscow), the Slovak Republic, Spain, Sweden, the United Kingdom (England and Northern Ireland) and the United States. Data for the remaining countries refer to 2015 and are sourced from the second round of the first wave of the PIAAC survey.

Returns to management and communication task intensity of jobs: the ICT bonus, 2012 or 2015

The ICT task intensity of jobs indicator and the management and communication (M&C) task intensity of jobs indicator rely on exploratory state-of-the-art factor analysis. These indicators capture the use of ICT and the performance of management and communication tasks on the job, respectively. The ICT indicator relies on 11 items from the OECD Programme for International Assessment of Adult Competencies (PIAAC) ranging from the simple use of the Internet to the use of Word or Excel software or a programming language. The M&C indicator relies on five items ranging from negotiation tasks to planning the tasks of other workers, as well as advising and instructing others. The detailed methodology can be found in Grundke et al. (2017).

Labour market returns to task intensities are based on OLS wage regressions (Mincer equations) using data from the OECD Programme for International Assessment of Adult Competencies (PIAAC). Estimates rely on the log of hourly wages as dependent variable and include a number of individuals-related control variables (including age, years of education, gender and other skill measures detailed in Grundke et al., 2017), as well as industry dummy variables.

The data for the following 23 countries from the first round of PIAAC refer to the year 2012: Australia, Austria, Belgium (Flanders), Canada, the Czech Republic, Germany, Denmark, Estonia, Finland, France, Ireland, Italy, Japan, Korea, the Netherlands, Norway, Poland, the Russian Federation (excluding Moscow), the Slovak Republic, Spain, Sweden, the United Kingdom (England and Northern Ireland) and the United States. Data for the remaining countries refer to 2015 and are sourced from the second round of the first wave of the PIAAC survey.

2.7 Knowledge capital

Workers receiving training, by type of training, 2012 or 2015

Percentages of trained people are calculated as the ratio of total employed persons receiving training at least once per year, by type of training (formal vs. on-the-job vs. both, as in Squicciarini et al., 2015), over total employment in the economy. Values are reweighted to be representative of the countries' populations.

The data for the following 23 countries from the first round of PIAAC refer to the year 2012: Australia, Austria, Belgium (Flanders), Canada, the Czech Republic, Germany, Denmark, Estonia, Finland, France, Ireland, Italy, Japan, Korea, the Netherlands, Norway, Poland, the Russian Federation (excluding Moscow), the Slovak Republic, Spain, Sweden, the United

Kingdom (England and Northern Ireland) and the United States. Data for the remaining countries refer to 2015 and are sourced from the second round of the first wave of the PIAAC survey.

Business investment in fixed and knowledge-based capital, 2015

Data, in current prices, refer to the private market sector and follow the definition of INTAN-Invest (i.e. ISIC Rev.4 Divisions 01 to 82 excluding 68 and 72).

Intensities are defined as investment over Gross Value Added as sourced from the OECD System of National Accounts (SNA) Database. Non-residential Gross Fixed Capital Formation (GFCF) is calculated as total GFCF excluding investment in Dwellings and Intellectual Property, and is sourced from the OECD System of National Accounts (SNA) Database. KBC assets in National Accounts are also sourced from the SNA Database, and correspond to the Intellectual Property GFCF. R&D investment by sector for the United States is sourced from the US Bureau of Economic Analysis. Data on Other KBC Assets are sourced from INTAN-Invest and extrapolated, where necessary, using the growth rate of Intellectual Property GFCF from the OECD SNA Database. "Other KBC Assets" include Design, New Financial Products, Brands, Training and Organisational Capital.

Market and non-market sector KBC investment, selected countries, 2000 and 2015

The definition of the market sector follows the definition of INTAN-Invest (i.e. ISIC Rev.4 Divisions 01 to 82 excluding 68 and 72). The non-market sector follows the definition proposed by SPINTAN and covers both public and non-profit entities in the ISIC Rev.4 Divisions 72 and 84 to 93.

Intensities are defined as investment over Gross Value Added data as sourced from the OECD System of National Accounts (SNA) Database. For the non-market sector, KBC investment data are sourced from SPINTAN and extrapolated, where needed, using the cross-country average growth rate of non-market investment as found in SPINTAN. For the market sector, investment in SNA assets corresponds to the Gross Fixed Capital Formation (GFCF) in Intellectual Property assets from the OECD System of National Accounts (SNA) Database. Data on investment in other, non-SNA KBC assets are sourced from INTAN-Invest and extrapolated, where needed, using the growth rate of Intellectual Property GFCF from the OECD SNA Database. All data are in current prices.

References

Grundke, R. et al. (2017), "Skills and global value chains: A characterisation", *OECD Science, Technology and Industry Working Papers*, No. 2017/05, OECD Publishing, Paris, *http://dx.doi.org/10.1787/cdb5de9b-en*.

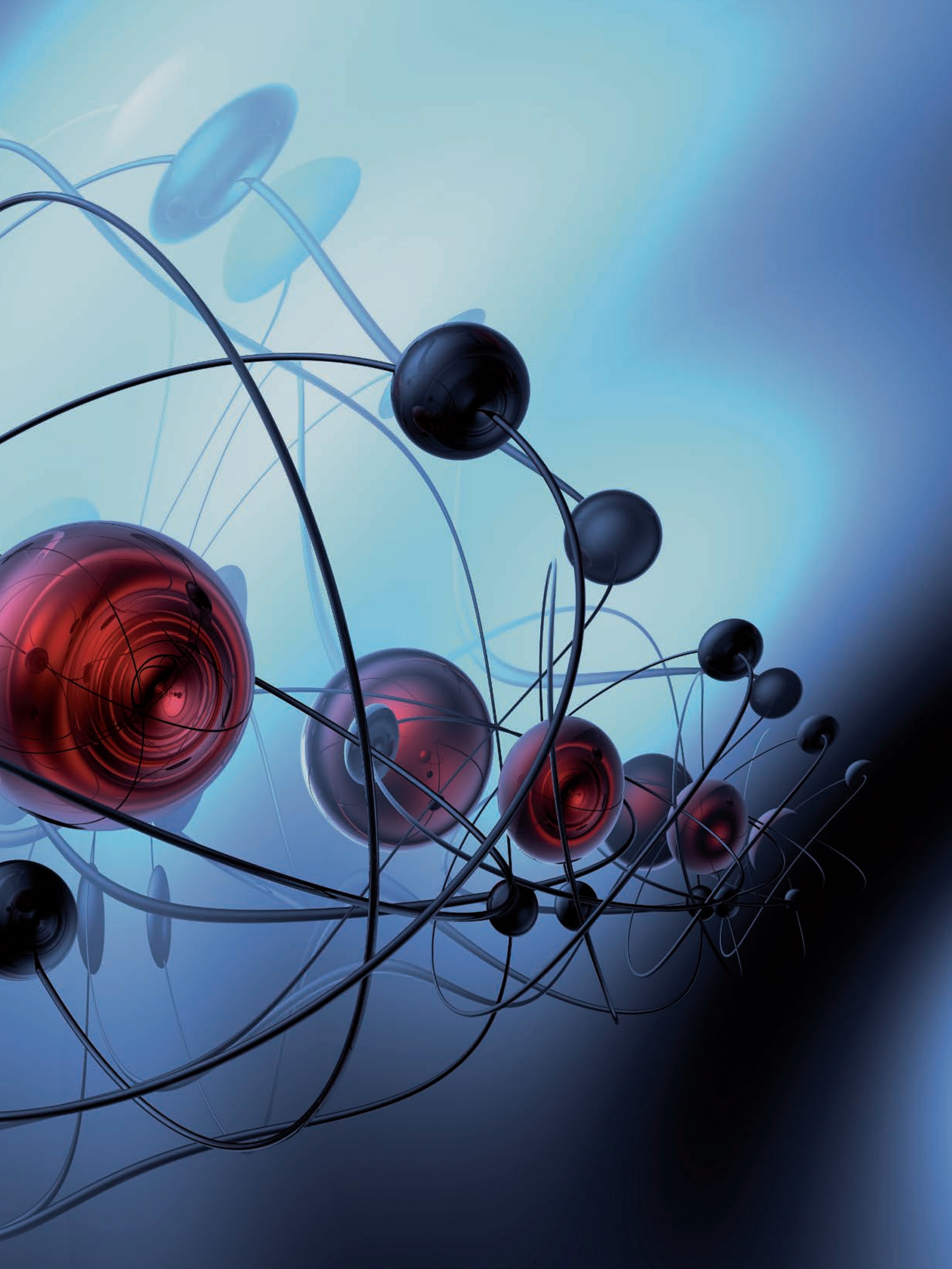
Grundke, R. et al. (forthcoming), "Which skills for the digital era? A returns to skills analysis".

OECD (2009), *Education at a Glance 2009: OECD Indicators*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/eag-2009-en*.

OECD (2015), *Frascati Manual 2015: Guidelines for Collecting and Reporting Data on Research and Experimental Development*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/9789264239012-en*.

OECD (2017), *Education at a Glance 2017: OECD Indicators*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/eag-2017-en*.

Squicciarini, M., L. Marcolin and P. Horvát (2015), "Estimating Cross-Country Investment in Training: An Experimental Methodology Using PIAAC Data", *OECD Science, Technology and Industry Working Papers*, No. 2015/09, OECD Publishing, Paris. *http://dx.doi.org/10.1787/5jrs3sftp8nw-en*

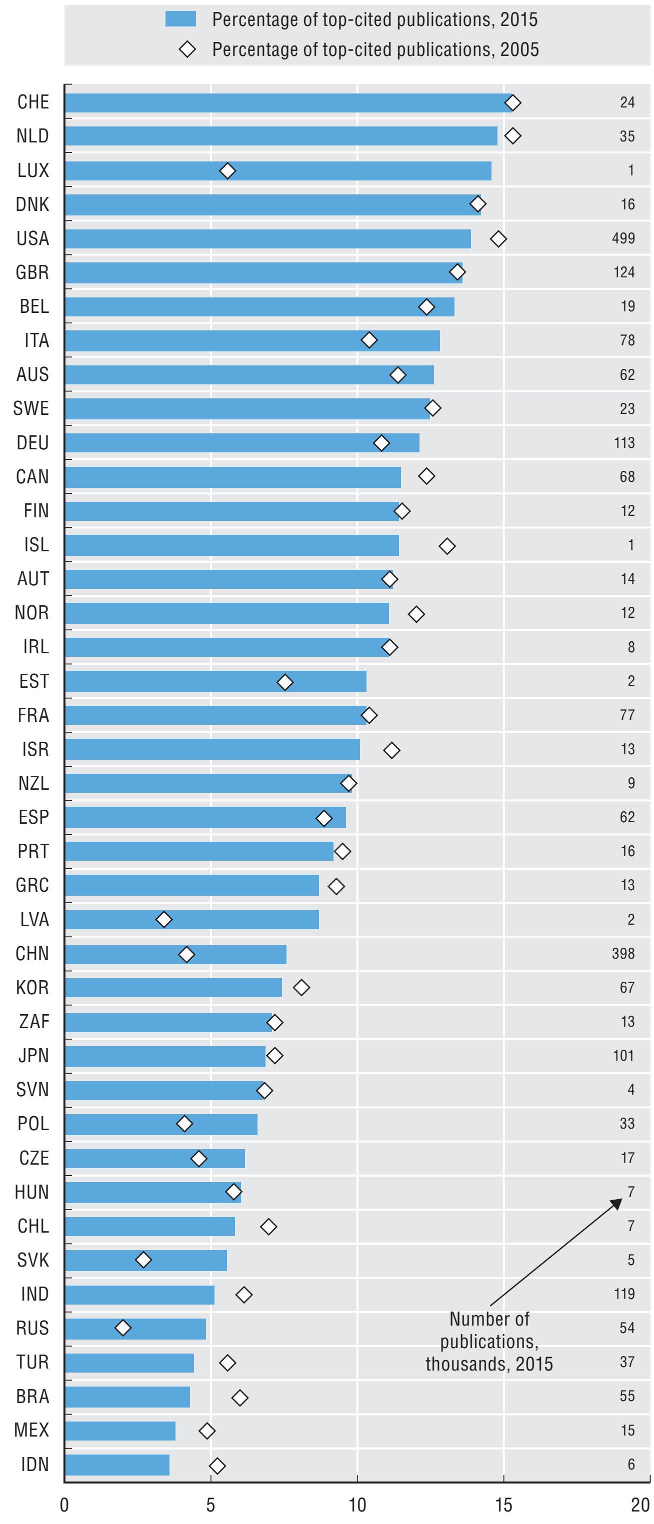


3. RESEARCH EXCELLENCE AND COLLABORATION

1. Research excellence and specialisation

Quantity and quality of scientific production, 2005 and 2015

Number of documents and percentage among the world's 10% most cited publications, fractional counts



Source: OECD calculations based on Scopus Custom Data, Elsevier, Version 4.2017; and 2015 Scimago Journal Rank from the Scopus journal title list (accessed June 2017), July 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933618745

Did you know?

Scientific production is 20-30% higher in China than the United States in fields such as computer or materials science, but is 70% lower in neuroscience.

The indicator of top-cited publications provides a "quality adjusted" measure of research output. In 2015, the United States led the production of scientific publications with nearly half a million. China accounts for the second largest number of top-cited documents, with nearly as many as Germany and the United Kingdom combined. Switzerland has the largest share of domestic scientific documents with a high citation impact, closely followed by the Netherlands.

Countries exhibit specialisation in different scientific domains. A specialisation index provides evidence of the fields in which a given country accounts for a relatively high share of scientific production, compared to the global distribution of scientific output across fields. The relationship between specialisation and citation impact is analysed in four selected domains: Biochemistry, Computer science, Materials science and Neuroscience. While higher specialisation is associated with greater citation impact in the case of biochemistry, this is not the case for other domains. Most countries appear to be similarly specialised in biochemistry, while there is wider heterogeneity for neurosciences. India exhibits high levels of specialisation and output in the area of computer science. The Russian Federation is highly specialised in Materials science. For countries with high levels of scientific output, normalised impact scores are similar across fields. For smaller countries, pockets of excellence can be found in specific areas.

Definitions

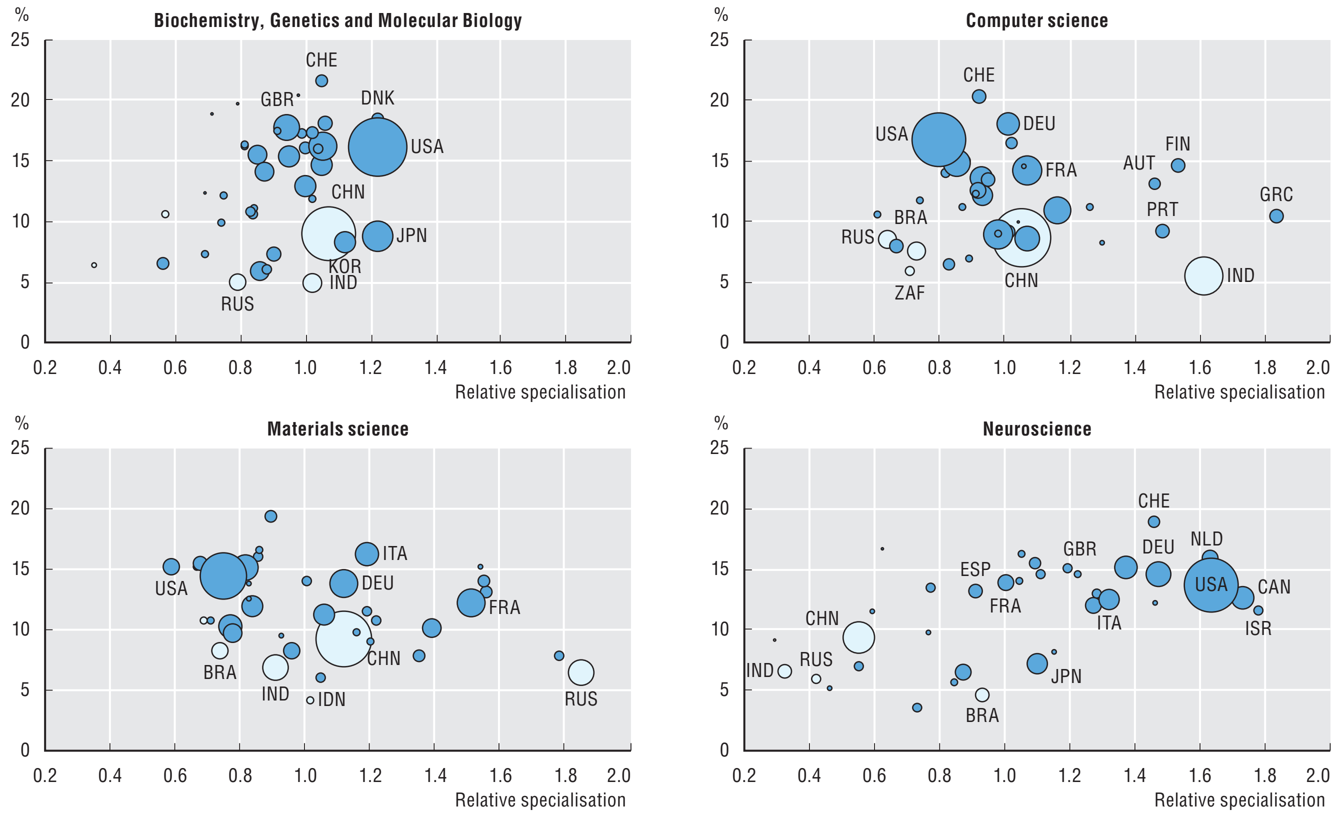
Estimates of scientific publication output are based on counts of citable documents (articles, reviews and conference proceedings), indexed within Elsevier's Scopus database, by authors with affiliations in each country. Documents are assigned on a fractional basis, according to the number of authors and their respective affiliations in that particular country.

The specialization indicator is calculated by dividing a field's share of documents within a given country by the global share of that particular field. Economies that have field distributions very similar to that of the entire world exhibit specialisation values very close to 1.

The indicator of scientific excellence (top-cited publications) shows the percentage of a country's scientific output that is included in the group of the 10% most-cited publications in their respective scientific fields. The 2015 Scimago Journal Rank indicator is used as a complement to sort publications with identical numbers of citations within each class.

Specialisation and citation impact in science, selected fields, 2015

Percentage of documents in the top 10% ranked documents and relative specialisation, by field, fractional counts



Source: OECD calculations based on Scopus Custom Data, Elsevier, Version 4.2017; and 2015 Scimago Journal Rank from the Scopus journal title list (accessed June 2017), July 2017. StatLink contains more. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933618764

Measurability

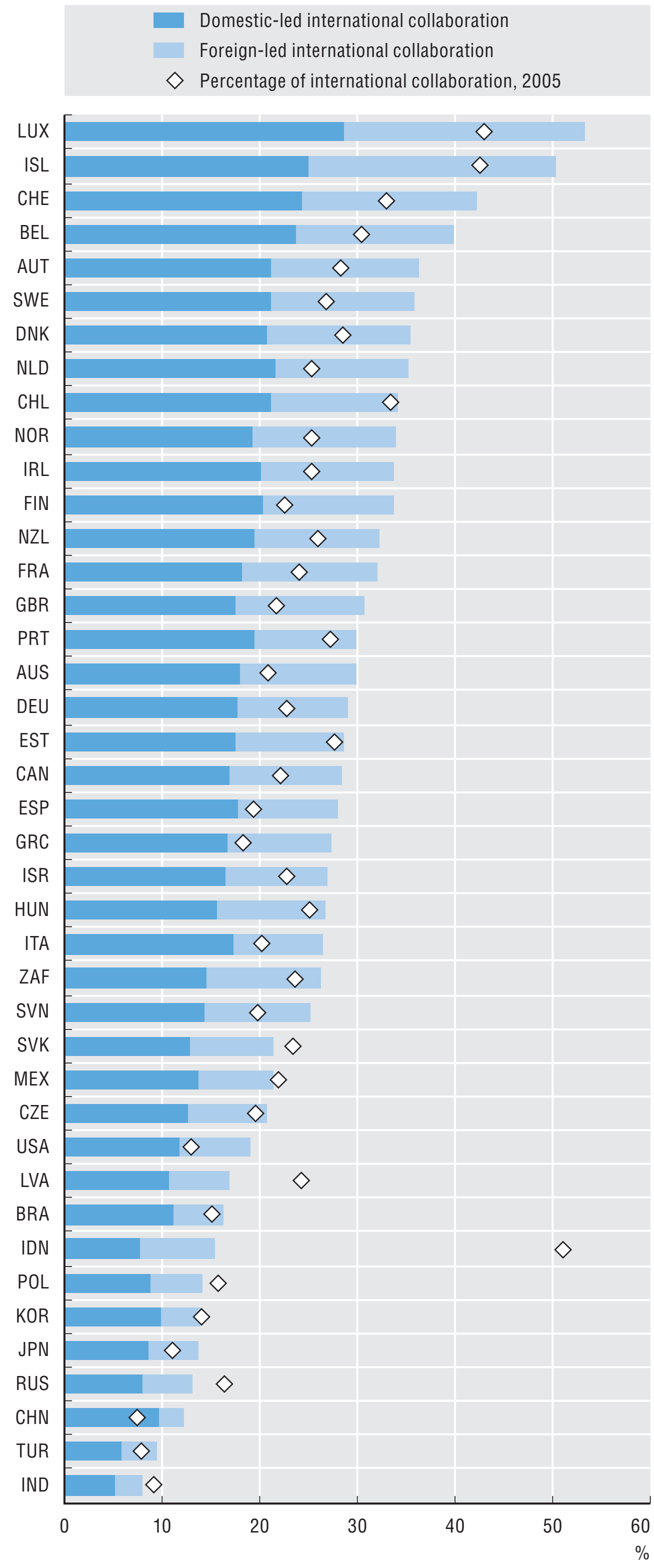
Scientific publications provide a measure of scientific production activity based on the numbers of documents published in peer-reviewed journals and indexed by data providers. Publication norms vary by field and sector (OECD and CSIC, 2016), depending on the use of review and dissemination mechanisms as well as organisational disclosure practices. Indexing may also exhibit language-related biases. Scientific excellence is approximated by measures of the distribution of citation "impact" normalised by year of publication, type of document and field(s). High citation rates may incorporate self-citation, refer to retracted papers, and fail to capture relevance to non-publishing communities.

In the case of Scopus, Elsevier uses its All Science and Journal Classification (ASJC) to classify each journal under one or more field subject. Field assignment on a journal basis is approximate, as a given journal's classification may not provide an accurate representation of each document's thematic content. To minimise this problem, documents published in generic multidisciplinary journals have been allocated on a fractional basis to the ASJC codes found in both citing and cited papers.

2. Excellence in scientific collaboration

International scientific collaboration, 2015

As a percentage of domestically authored documents, fractional counts



Source: OECD calculations based on Scopus Custom Data, Elsevier, Version 4.2017, July 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933618783

Did you know?

In the last decade, coauthorship-based international scientific collaboration increased in 32 out of 35 OECD countries.

Over the 2005-15 period, international collaboration on scientific research intensified on a worldwide scale. China almost doubled its collaboration rate, albeit from a very low base. In 2015, Luxembourg, Iceland, Switzerland and Belgium were the OECD countries with the largest propensity to collaborate internationally.

Measures of scientific research collaboration and citation impact (a quality measure of scientific publishing) at the country level are positively correlated, especially for economies with lower levels of scientific production. These smaller economies attempt to overcome their limited scale by participating more intensively in global networks.

Joint analysis of excellence and leading authorship (i.e. affiliation of the leading author) provides further insight into the source of a country's top-cited publications, as many are underpinned by international collaborations, often led by authors with foreign affiliations. The United States accounts for the largest share of top-cited publications led by domestic authors, followed by the Netherlands, Switzerland, Denmark and the United Kingdom. Some countries have high overall excellence rates thanks to the contribution of collaborative articles led by authors abroad.

Definitions

International collaboration is defined as the number of domestically authored publications incorporating institutional affiliations of other countries or economies, as a percentage of all citable publications (articles, reviews and conference proceedings) attributed to authors with an affiliation in the reference economy.

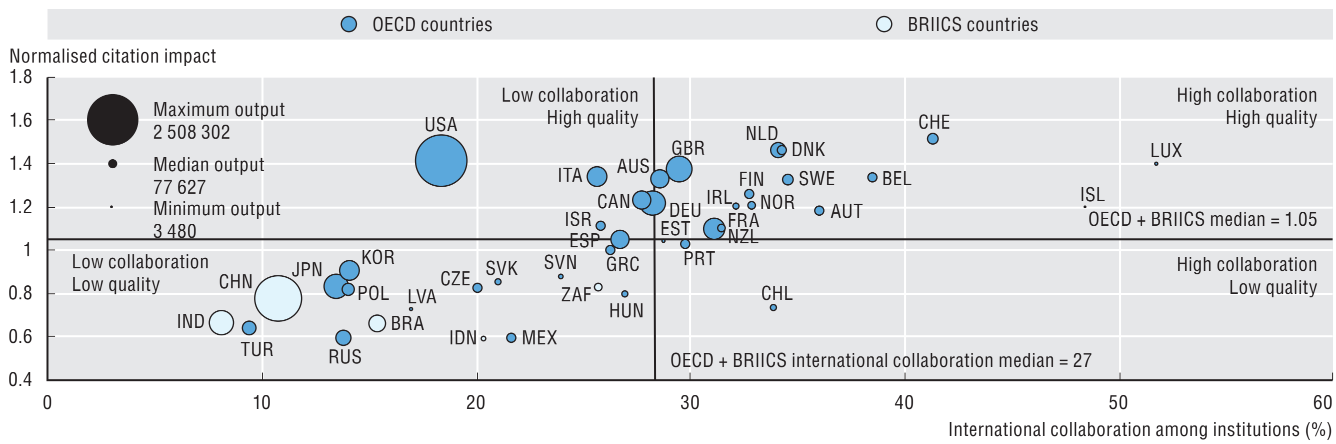
International collaboration can apply to documents where the leading author has as first affiliation the reference economy and those where the lead author's first reported affiliation is abroad. The *leading author* is identified from the identity of the designated *corresponding author*.

The *normalised citation impact* measure is the ratio between the average number of citations received by documents published by authors affiliated to an institution in a given economy and the world average of citations, over the same time period, by document type and subject area.

Scientific excellence indicates the amount (in percentage) of a unit's scientific output that is included in the global set of the *10% most cited* papers in their respective scientific fields. This indicator can be used in combination with data on the affiliation of the corresponding author – see Measurability box – to better describe the role of international collaboration as a driver of scientific excellence.

The citation impact of scientific production and the extent of international collaboration, 2012-16

As an index and percentage of all citable documents, based on fractional counts

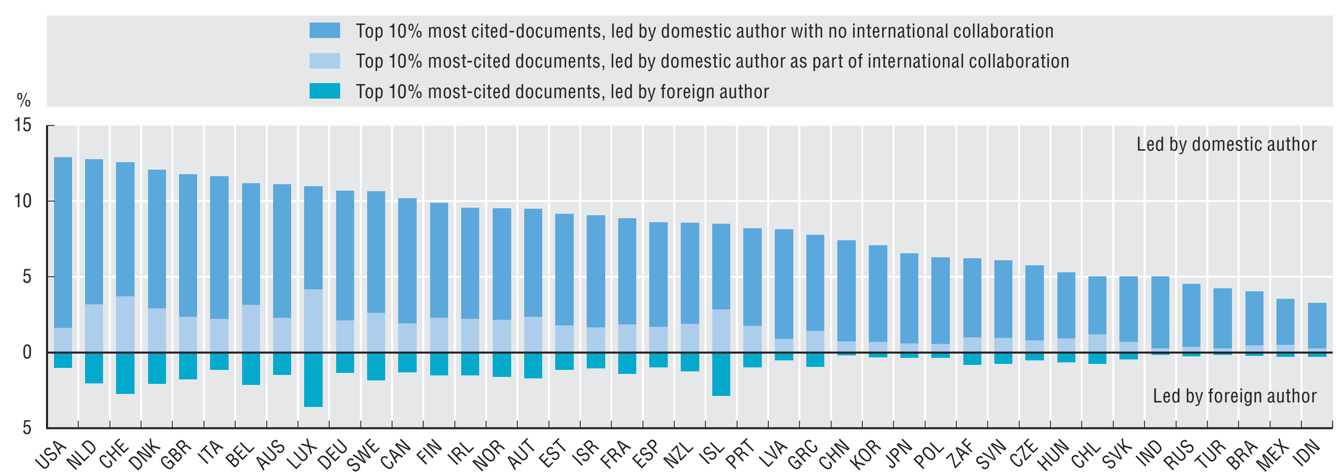


Source: OECD calculations based on Scopus Custom Data, Elsevier, Version 4.2017, July 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933618802

Top 10% most-cited documents and patterns of international collaboration, 2015

Domestic and foreign-led top cited, as a percentage of all documents, fractional counts



Source: OECD calculations based on Scopus Custom Data, Elsevier, Version 4.2017; and 2015 Scimago Journal Rank from the Scopus journal title list (accessed June 2017), July 2017. StatLink contains more data. See chapter notes

StatLink http://dx.doi.org/10.1787/888933618821

Measurability

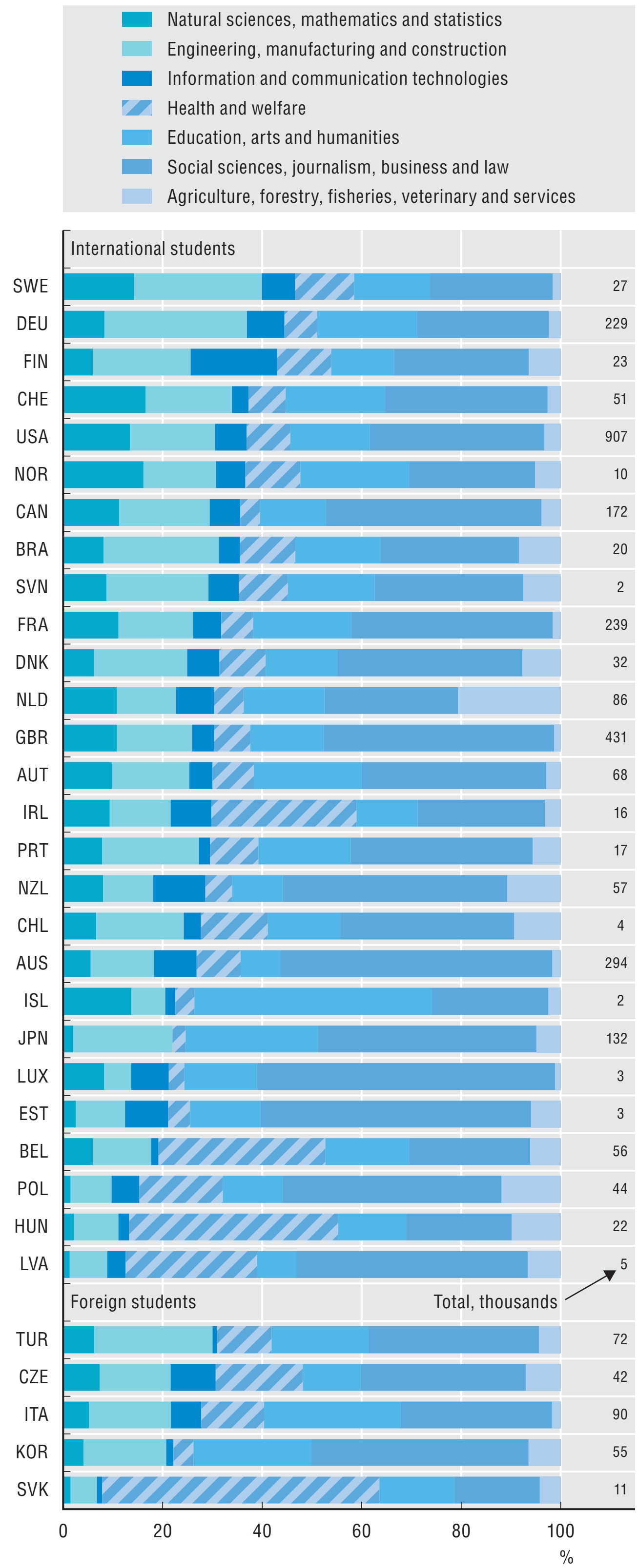
Publications are attributed to countries on the basis of their authors' institutional affiliations. Whole and fractional counting methods have advantages and limitations, with the choice of a given method having potentially significant effects on reported figures, especially collaboration rates. Fractional counting methods have been used in this edition in order to avoid distortions caused by rising numbers of documents with very large affiliation lists which may inflate results.

A complementary approach is to investigate the leading author's affiliation (Moya-Anegón et al., 2013). Attribution of leadership to the corresponding author can help inform the role of a given institution or country in collaboration activities. This leadership indicator shows the share of scientific output (in this case, highly cited documents) where a domestic author is listed as a corresponding author. The fractionalized documents attributed to any given country can be analysed according to whether the leading author is domestic, working in collaboration with the rest of the world or not, or foreign-based.

3. International mobility of the highly skilled

Internationally mobile students enrolled in tertiary education, 2015

Total and breakdown by field of education



Source: OECD, based on OECD (2017), *Education at a Glance 2017: OECD Indicators*, OECD Publishing, Paris. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933618840

Did you know?

In the United States, NSE & ICT subjects are pursued by less than one-quarter of domestic students, compared to nearly 70% of internationally mobile doctoral students.

International mobility among highly educated individuals at different stages of their personal development and professional careers constitutes a key driver of knowledge circulation worldwide. The United States attracts the largest number of international tertiary students (close to 1 million), followed by the United Kingdom with close to 400 000. The field distribution of international students is indicative of each country's perceived strengths. For example, relatively high shares are found in Finland for ICTs, the United Kingdom for social sciences and humanities, Switzerland for the natural sciences and mathematics, and Germany for engineering.

At the doctorate level, international students in the OECD area are generally more attracted to the natural sciences, engineering and ICT (NSE & ICT) than their domestic counterparts. This is particularly the case for Canada, the United States and Switzerland.

The extent of international mobility after the completion of tertiary education is also significant in a number of cases. In several OECD countries, such as Canada and Israel, the share of the working-age population educated at tertiary level is higher among the foreign-born population than among the native-born. These countries often shape their immigration policies to attract highly skilled individuals. In the case of France, Germany, Japan, Italy and the United States, the native population exhibits higher or comparable educational attainment rates.

Definitions

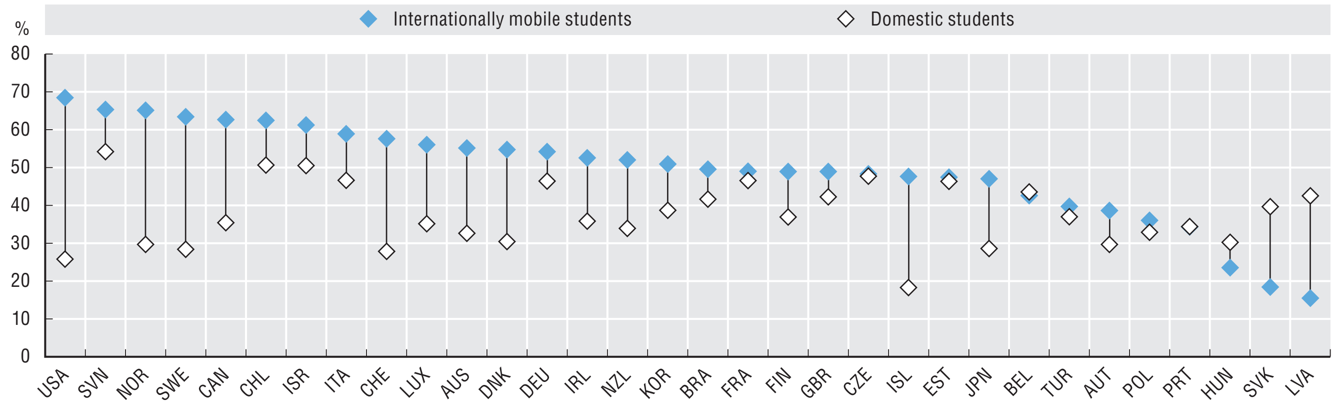
International students are students that have crossed borders expressly with the intention to study. The UNESCO Institute for Statistics (UIS), the OECD and Eurostat define international students as students who are not residents of their country of study or students who received their prior education in another country.

The *natural sciences*, *engineering* and *ICT* (NSE & ICT) correspond to specific fields in the International Standard Classification of Education ISCED-2013: 05 Natural sciences, mathematics and statistics; 06 Information and Communication Technologies; and 07 Engineering, manufacturing and construction.

Tertiary education comprises Levels 5 to 8 of the ISCED-2011 Levels classification. Highly educated individuals in immigrant and native-born populations have completed education at the tertiary level. Doctorate holders are individuals that have received an advanced research qualification at Level 8 of ISCED-2011.

International and domestic doctoral students in natural sciences, engineering and ICT (NSE & ICTs), 2015

Share of NSE & ICT students within each group by mobility status

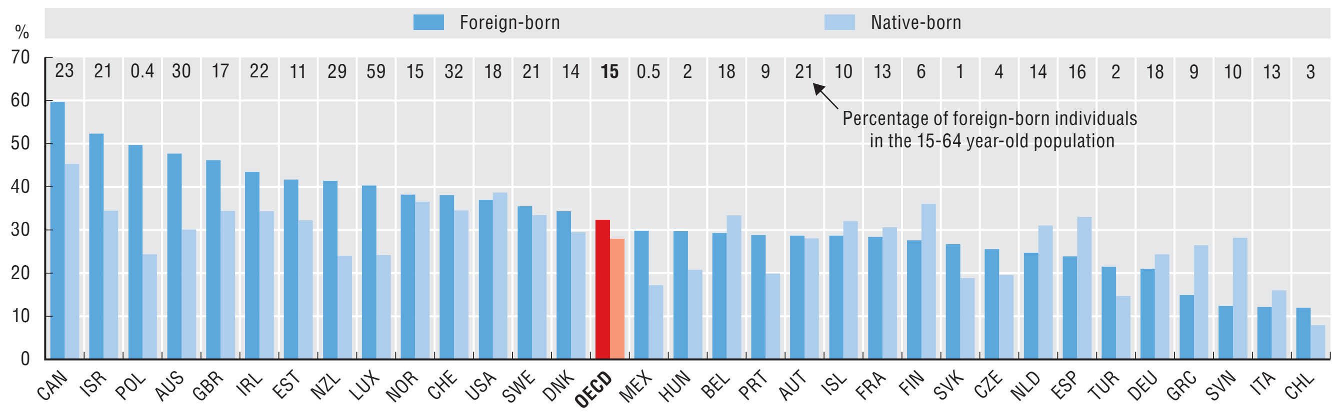


Source: OECD calculations based on OECD Education Database, September 2017. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933618859

Highly educated individuals in the working-age population, by place of birth, 2015

As a percentage of relevant group, 15-64 year-old population



Source: OECD calculations based on Eurostat Labour Force Survey and national sources, July 2017. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933618878

Measurability

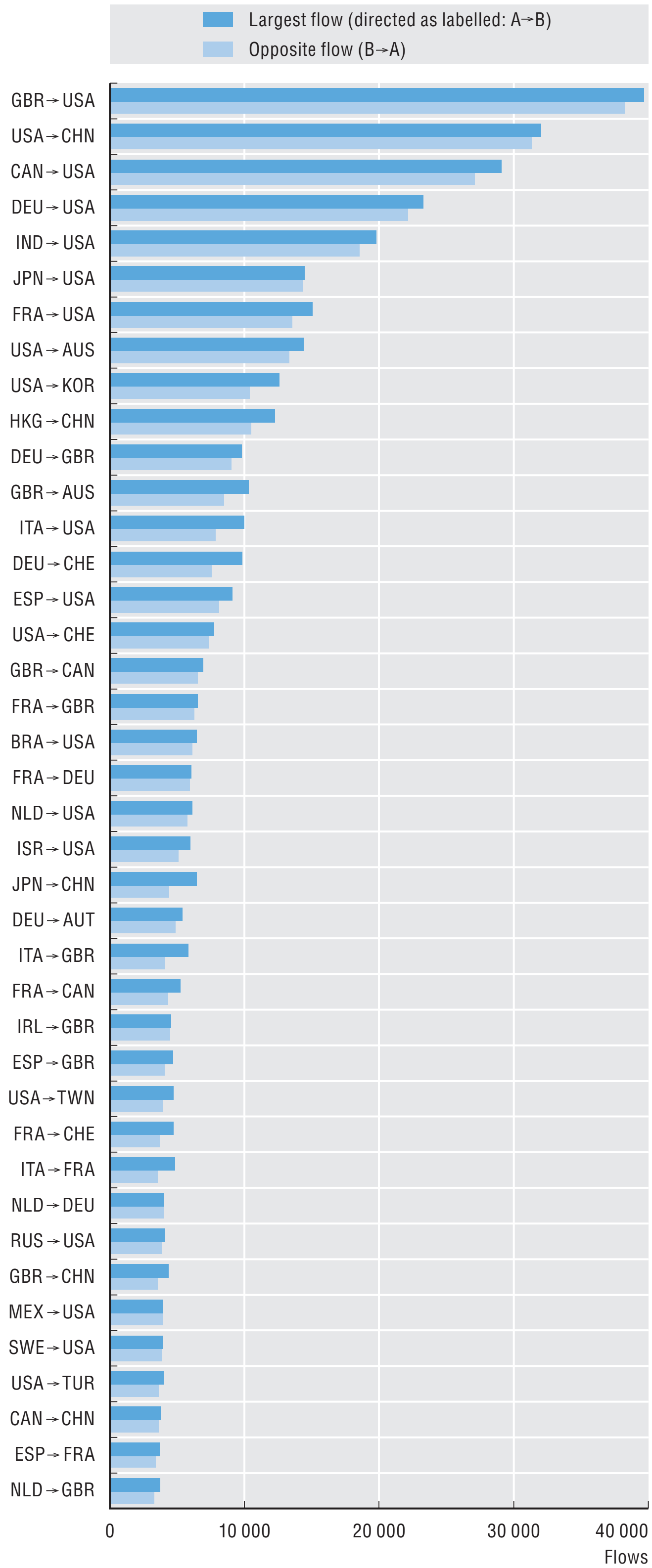
The UNESCO-OECD-Eurostat (UOE) collection of education statistics is the primary source of data on tertiary enrolment and graduation by source and destination country. The concept of international students is more directly relevant for the analysis of student mobility. When data on international students are not available, data on foreign students are used to obtain a more complete picture.

The Database on Immigrants in OECD Countries provides the most comprehensive and comparative information on the characteristics of immigrants living in OECD countries. Its main data sources are population censuses and registers, complemented by labour force surveys, which are less precise for small populations. Since most censuses take place on a ten-year-cycle, timely data were not available to provide a detailed picture at the doctorate level of educational attainment.

4. Scientists on the move

International bilateral flows of scientific authors, 2006-16

Largest bilateral flows, by first and last recorded main affiliation



Source: OECD calculations based on Scopus Custom Data, Elsevier, Version 4.2017, July 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933618897

Did you know?

Scientists who undertake research abroad and return to the economy in which they first published contribute to raising the overall quality of domestic research by 20% on average.

Scientist mobility facilitates the circulation of scientific knowledge. One way to track the mobility of scientists is to trace changes in institutional affiliation over their list of publications in scholarly journals. This approach shows that brain circulation (churn) is far more important than brain gain/drain (net flows). The nine largest international bilateral flows of scientists over the period 2006-2016 involved exchanges with the United States. Of the top 40 connections, this country was a net beneficiary in 14 cases, followed by the United Kingdom with 6 and China with 5.

In 2016, authors based in Luxembourg and Switzerland experienced the highest mobility rates within the OECD. For the median economy, 95% of scientists in 2016 were already based there at the time of their previous publication. Mobility patterns vary across economies; for example, in Israel and Italy, a majority of inflows are returnees originally affiliated to an institution in the country. In Switzerland, the majority of researchers with an international mobility record represented new inflows.

With few exceptions, individuals not changing economy affiliations (stayers) are more likely to publish in journals of lower "prestige". Outflows tend to be associated with higher rated publications than their staying or returning counterparts, although in the case of the United States, outflows display lower journal scores. The scores of inflows are still higher than those for stayers in this country, pointing to a continued ability to attract top scientists.

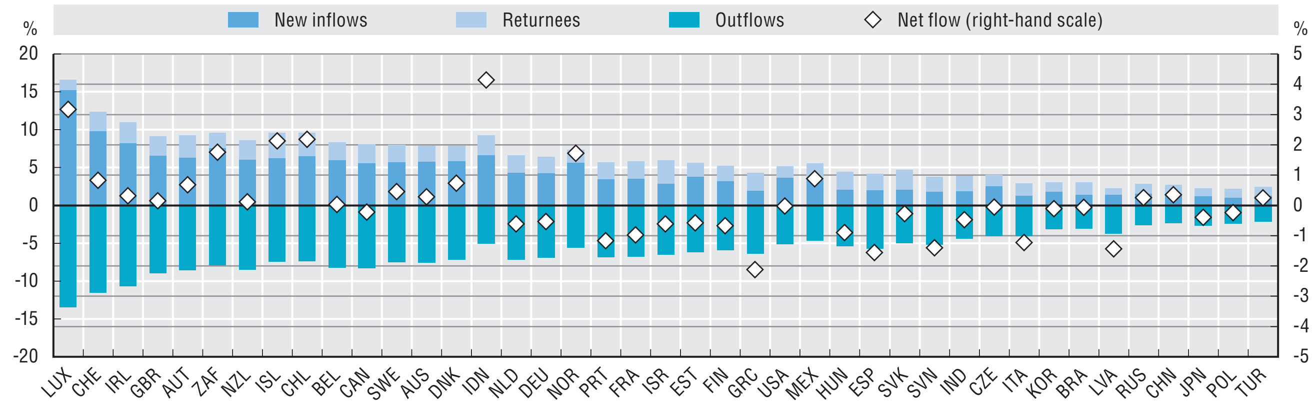
Definitions

Scientific authors are listed in the Scopus database of peer-reviewed scientific publications and identified by a unique author ID assigned by Elsevier. International mobility is inferred from authors with at least two publications over the reference period and is based on changes in institutional affiliation and sequence of publications. *Stayers* maintain the same economy of affiliation over the reference period. Among inflows, *returnees* are authors observed to move to an economy in which they were first affiliated, in contrast to new inflows. Outflows are measured in terms of the affiliation at the beginning of the reference period.

The *Scimago Journal Rank* (SJR) score is a measure of scientific influence of scholarly journals that accounts for both the number of citations received by a journal and the importance or prestige of the journals where the citations are made (González-Pereira et al., 2010).

International mobility of scientific authors, 2016

As a percentage of authors, by last main recorded affiliation in 2016



Source: OECD calculations based on Scopus Custom Data, Elsevier, Version 4.2017, July 2017. StatLink contains more data. See chapter notes.

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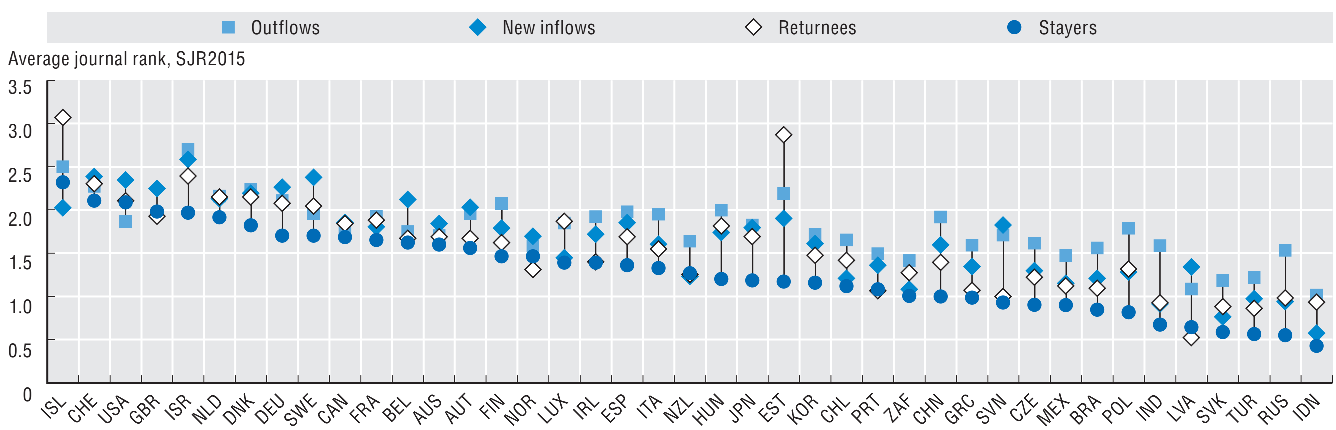
Expected citation impact of scientific authors, by mobility profile in 2016

Average 2015 Scimago Journal Rank (SJR) scores



Source: OECD calculations based on Scopus Custom Data, Elsevier, Version 4.2017; and 2015 Scimago Journal Rank from the Scopus journal title list (accessed June 2017), July 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933618935

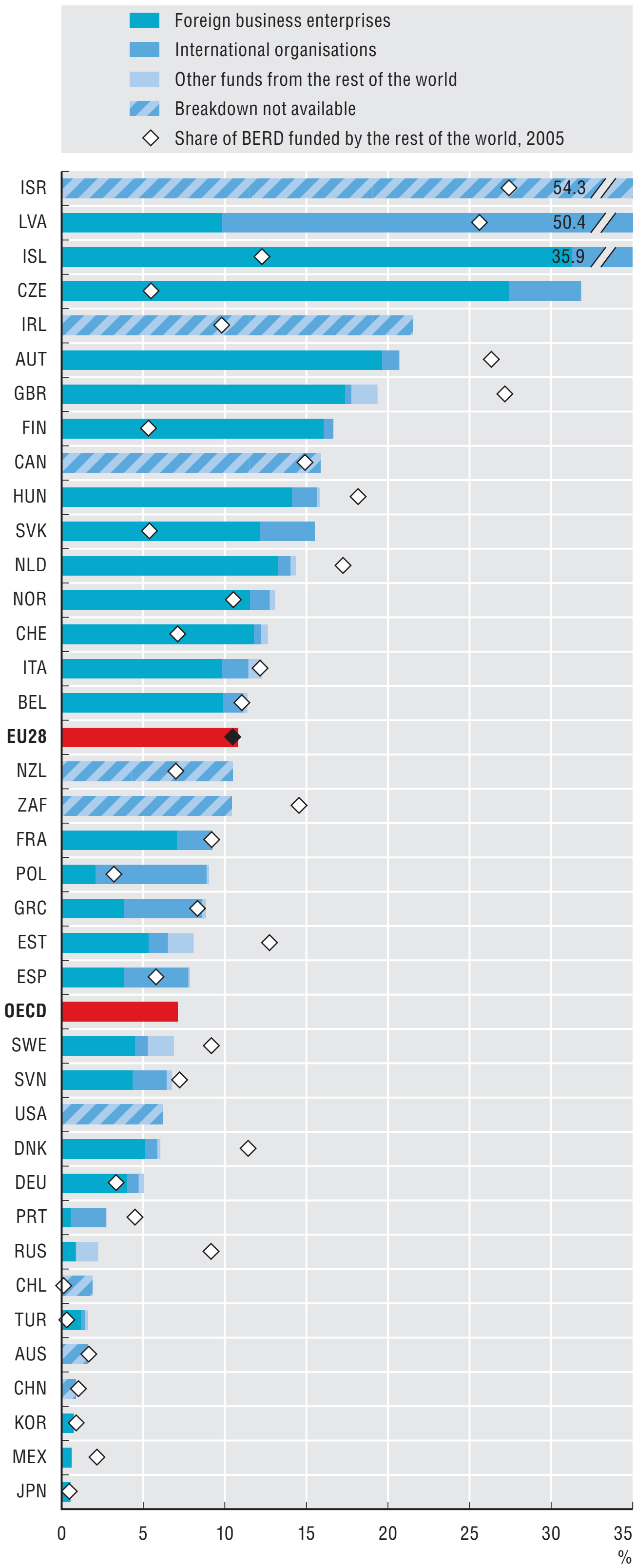
Measurability

Bibliometric indicators provide a complementary picture of global researcher mobility. First developed by Elsevier (2011), these indicators are experimental and require careful interpretation (Moed et al., 2013). Mobility is less accurately measured or missing for less prolific authors and for those who move from and into non-academic roles. Affiliations may be recorded with a lag and may not reflect where the research took place. In this version, authors with multiple affiliations are assigned a "main economy" per document, with one economy picked at random in the case of equal weights. More importantly, failure to assign author IDs consistently can distort mobility estimates by understating mobility when an individual has multiple IDs, or overstating it for individuals with common names. The open researcher and contributor ID (ORCID) promotes the use of unique identifiers linkable to an individual's research output. An OECD analysis of the international scientist mobility network and its main drivers is available (Appelt et al., 2015).

5. The globalisation of R&D

Business R&D funded from abroad, by source of funds, 2015

As a percentage of business enterprise expenditure on R&D



Source: OECD, Research and Development Statistics Database, *http://oe.cd/rds*, June 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933618954

Did you know?

The UK receives the most EU funding for higher education R&D, EUR 615 million in 2014 – or 8% of higher education R&D.

In today's global economy, companies finance their R&D activities in various ways including using their own funds (e.g. retained earnings) and funds from domestic and international sources. The main international source is payments for R&D from companies abroad, including from enterprises with which there are ownership and control linkages. Research grants and contracts from international organisations are another key source. In many countries, funds from abroad underpin a considerable part of business R&D; more than 20% in Austria, the Czech Republic, Iceland and Ireland, and over 50% in Israel where a large share of Business R&D is performed by foreign-controlled affiliates (FCAs), and Latvia where EU funds underpin almost 40% of BERD.

In many countries, FCAs are responsible for considerable business R&D, accounting for over one-fifth in most countries and over half in Austria, Belgium, the Czech Republic, Ireland, Israel, the Slovak Republic and the United Kingdom. This trend highlights the globalisation of business R&D and its importance in multi-national enterprises. Japan ranks lowest for international funding and FCA performance of business R&D, indicating a relatively low level of integration with the international R&D environment.

Funding from international organisations – notably the European Union – underpins over 40% of business R&D in Latvia. Funds provided by the European Commission (EC) can also be especially important for R&D performed by higher education institutions and government research organisations, the largest sums of which flow to Germany and the United Kingdom. These play a more important role in the United Kingdom, underpinning 7.4% of higher education and government R&D, compared to 3.9% in Germany – a share larger than that of any other Western European country, apart from Greece or Ireland.

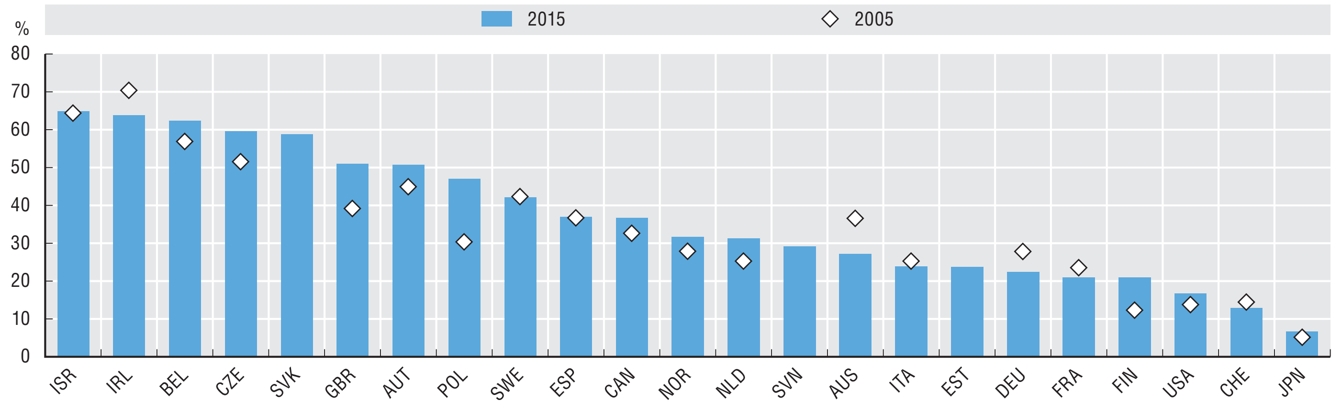
Definitions

The *Rest of the World sector* includes all institutions and individuals *without* a location, place of production or premises within the economic territory on which or from which the unit engages in economic activities and transactions on a significant scale. It refers to all businesses (including parts of enterprises, universities, governments, non-profits, etc.) not resident in the reference country. International organisations and supranational entities, including facilities and operations within the country's borders, are also recorded in the Rest of the World sector.

Foreign-controlled affiliates are enterprises within the reference country that are majority-owned by foreign parent companies.

Business R&D expenditures by foreign-controlled affiliates, selected countries, 2015 or latest available

As a percentage of business enterprise expenditure on R&D

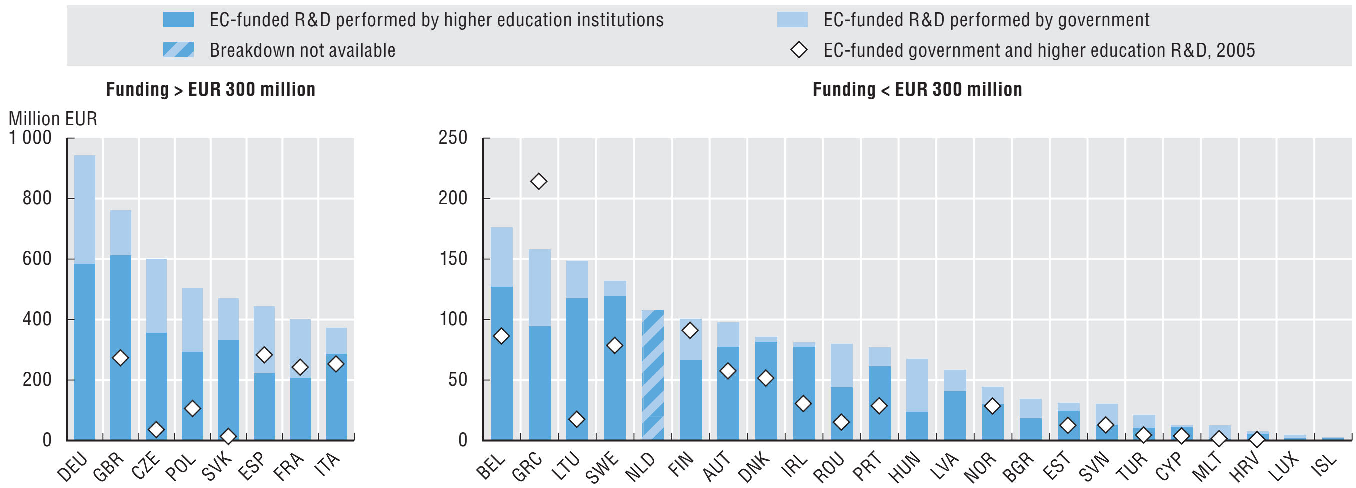


Source: OECD, Activity of Multinational Enterprises Database, *http://oe.cd/amne*; Eurostat Inward FATS Database and Research and Development Statistics Database, *http://oe.cd/rds*, June 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933618973

European Commission funding of government and higher education R&D in Europe, 2015

EUR million PPPs, 2010 prices



Source: OECD, Research and Development Statistics Database, *http://oe.cd/rds*; Eurostat, Statistics on Research and Development; Eurostat, PPPs for ESA 2010 aggregates, July 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933618992

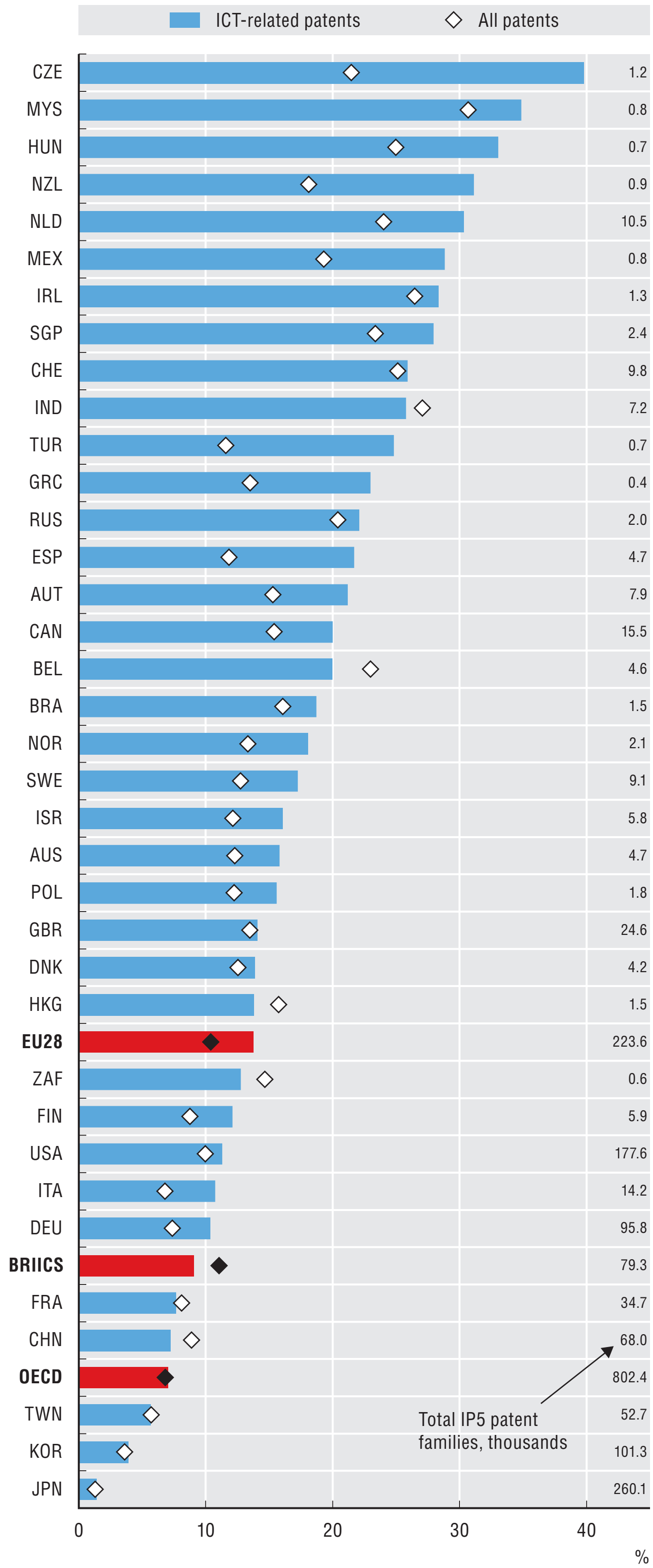
Measurability

The increasing internationalisation of R&D and other economic activities makes it challenging to accurately identify R&D-related financial flows between companies, as well as the precise nature of such flows. R&D surveys are used to collect relevant information, but they focus mainly on domestic intramural R&D performance. Therefore, in most countries, little or no information is collected on the foreign R&D activities of multinationals. Furthermore, it is very difficult to collect accurate information on the value and economic nature of cross-border R&D flows between affiliated firms, as multinationals' practices – including R&D funding and exploitation of the resulting intellectual outputs – tend to reflect strategies to minimise tax liabilities. The measurement of R&D globalisation among governments and other non-business institutions is also at a very preliminary stage and data comparability is still limited and concentrated in a few countries. The latest edition of the Frascati Manual (OECD, 2015) includes a chapter dedicated to the measurement of various aspects of R&D globalisation, see *http://oe.cd/frascati*.

6. Inventions across borders

International co-inventions in ICT, 2012-15

As a percentage of economies' IP5 patent families



Source: OECD, *STI Micro-data Lab: Intellectual Property Database, http://oe.cd/ipstats*, June 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933619011

Did you know?

More than 70% of ICT patents owned by companies in the Bermuda, Barbados, Cayman Islands and Virgin British Islands are invented abroad.

Inventions often stem from collaborations within and across economies, as diversity boosts creativity and innovation. Information contained in patented inventions about the economy where owners and inventors reside helps to shed light on cross-country collaborations in innovation. It also shows the extent to which innovators are accessing knowledge in other economies to find the competencies and skills that best meet their needs.

With the exception of health-related technologies, international collaboration among inventors has increased across all technology fields, especially so in the case of ICT-related patents. International co-inventions are more common in ICT than in other technology fields, and account for one-third or more of all ICT patents in economies like the Czech Republic or Malaysia.

Furthermore, with few exceptions (notably China) ICT-patented inventions rely, on average, on inventors located in a relatively larger number of economies. This implies that ICT companies generally access knowledge from a larger number of economies, compared to the knowledge-sourcing strategies pursued in other fields.

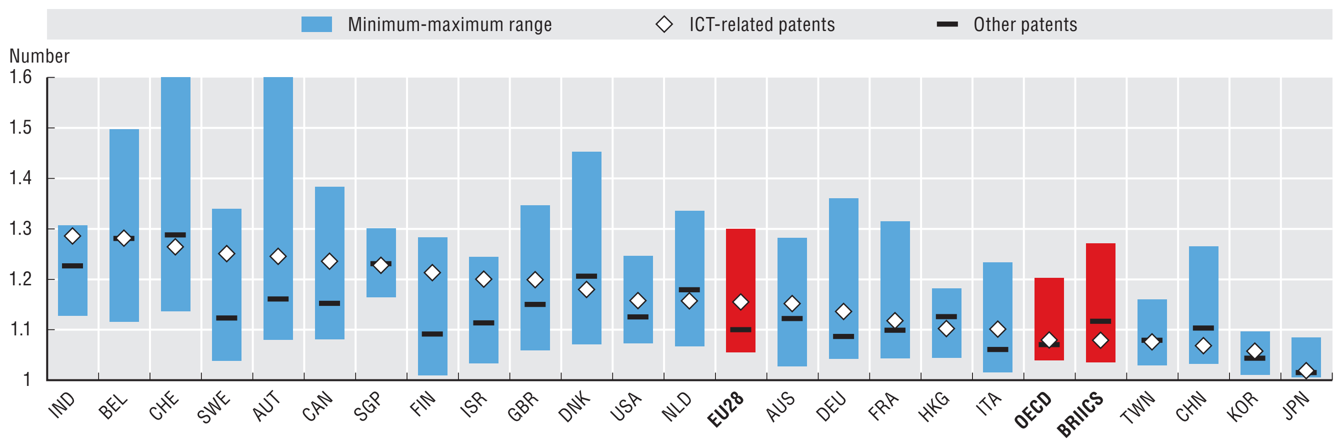
Inventorship and ownership of patented ICT inventions are often decoupled, generally more so than in other technology areas – on average, 7.6% for ICT compared to 6.4% across all technologies. In OECD economies, the share of owned foreign ICT inventions varies between 57% (Luxembourg) and 0.6% (Italy).

Definitions

IP5 patent families are patents within the *Five IP offices (IP5)*. *International co-inventions* are IP5 patent families featuring at least one foreign co-inventor. Shares are calculated by dividing the number of international co-inventions by the total number of IP5 patent families invented domestically, by field. The number of economies in which inventors are located is an indicator based on the average number of economies in which inventors of IP5 patent families owned by residents of an economy are located. *Foreign inventions owned by economies* relate to the share of IP5 patent families owned by a resident of an economy for which no inventors reside in the given economy, as a share of total IP5 patent families owned by that economy. Patents in ICT are identified using the International Patent Classification (IPC) codes (see Inaba and Squicciarini, 2017) and align with the OECD definitions of the ICT sector (2007) and of ICT products (2008).

Number of economies in which inventors are located, by technology, 2012-15

Average across technologies, IP5 patent families, by residence of the patent owner

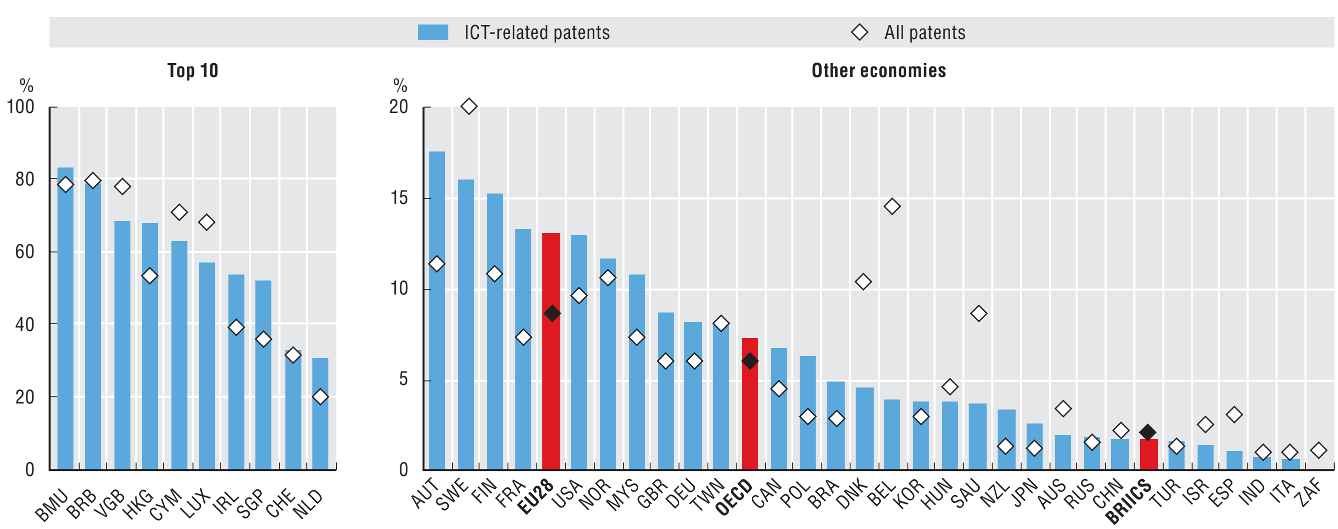


Source: OECD, *STI Micro-data Lab: Intellectual Property Database, http://oe.cd/ipstats* , June 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933619030

Domestic ownership of ICT inventions from abroad, 2012-15

As a percentage of economies' total IP5 patent families



Source: OECD, *STI Micro-data Lab: Intellectual Property Database, http://oe.cd/ipstats* , June 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933619049

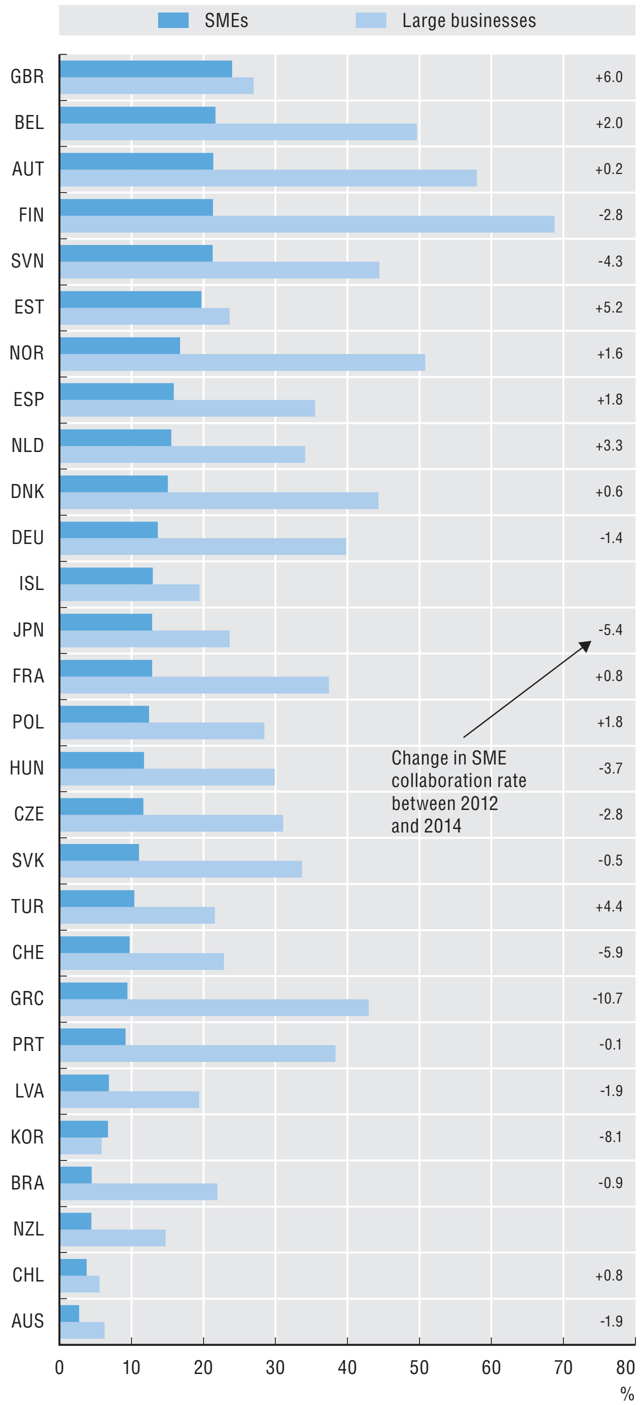
Measurability

Collaborations may take a variety of forms including international co-inventions involving several firms, both small and large, joint research ventures by private and public entities (e.g. firms and universities or public research organisations), and formal and informal networks of scientists. In the case of multinational corporations, international collaboration often reflects a process whereby companies rely on research and innovation facilities located in several economies to draw upon geographically dispersed knowledge and/or develop complementarities with foreign inventors. The degree to which inventors collaborate internationally may be shaped by a wide array of factors including the structure of the company or institution they belong to, the technology domain of the inventions, as well as language or cultural proximity. ICT patents encompass 13 areas defined according to the specific technical features and functions they accomplish (e.g. mobile communication, high-speed network, high-speed computing and large-capacity information analysis). As most inventions are only protected in certain economies, using data from different patent offices may lead to different results.

7. Collaboration on innovation

Businesses collaborating on innovation with higher education or research institutions, by size, 2012-14

As a percentage of product and/or process-innovating businesses in each size category



Note: International comparability may be limited due to differences in innovation survey methodologies and country-specific response patterns. European countries follow harmonised survey guidelines with the CIS.

Source: OECD, based on the 2017 OECD survey of national innovation statistics and the Eurostat, Community Innovation Survey (CIS-2014), *http://oe.cd/inno-stats*, June 2017. StatLink contains more data. See chapter notes.

StatLink *http://dx.doi.org/10.1787/888933619068*

Did you know?

On average, only 13% of innovating SMEs develop their innovations in collaboration with universities or research institutions, compared to 31% for large firms.

Businesses specialise in order to be more competitive and collaboration enables them to make use of a broader pool of resources and knowledge while sharing risks. Patterns of collaboration are influenced by business characteristics and their innovation objectives. For example, R&D-based forms of innovation may call for different types of partners. Collaboration with higher education or public research institutions constitutes an important source of knowledge transfer for large firms. In most countries, such firms are usually two to three times more likely to engage in this type of collaboration than small and medium-sized enterprises (SMEs).

Collaboration for innovation is more frequent with suppliers and customers. Among large firms, suppliers play a dominant role as value chains become increasingly integrated. For countries such as Finland, Korea, Germany and the United Kingdom, collaboration with clients is equally or more important especially for innovating SMEs. This may be an indication of the importance of users in driving innovation.

Foreign partners can play an important role in the innovation process, as global value chains gain in significance. International innovation collaboration rates vary widely across countries. In some small open economies, collaboration with partners abroad is particularly high. This may reflect factors such as sectoral specialisation, limited opportunities for domestic collaboration and, in some cases, proximity to external centres of knowledge. Business size appears to be a strong determinant of international collaboration: large firms have a much higher propensity to collaborate internationally than SMEs, regardless of the overall rate of international collaboration.

Definitions

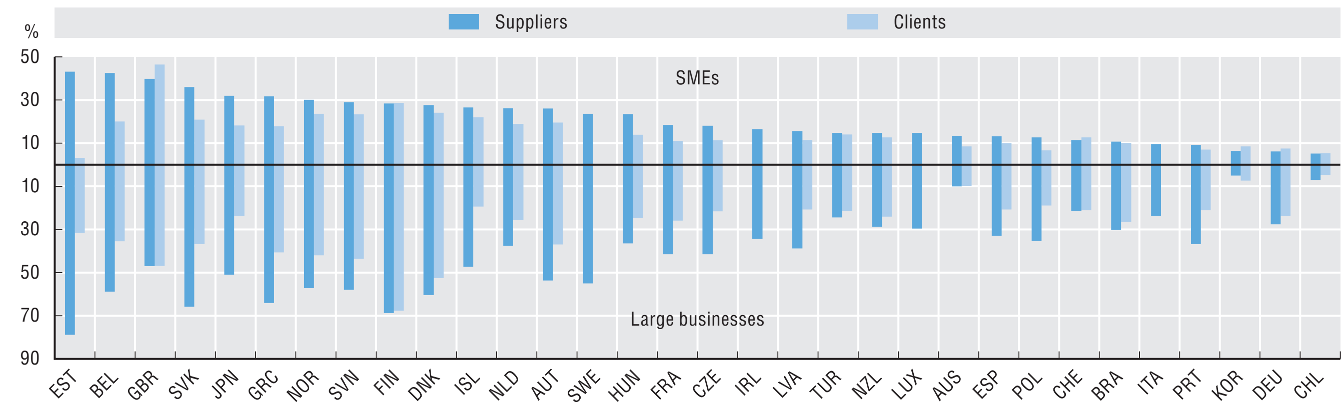
Innovation collaboration involves active participation with other organisations in joint innovation projects (i.e. those aimed at introducing a new or significantly improved product or process), but excludes pure contracting out of innovation-related work. It can involve the joint implementation of innovations with customers and suppliers, as well as partnerships with other firms or organisations.

International collaboration on innovation refers to active cross-border participation in innovation collaborations.

The classification of firms by size follows the recommendations of the Oslo Manual. In a majority of countries, size is calculated on the basis of numbers of persons employed. SMEs are defined as firms with 10-249 employees, with exceptions noted in the chapter notes.

Businesses collaborating on innovation with suppliers and clients, by size, 2012-14

As percentage of product and/or process-innovating businesses in each size category



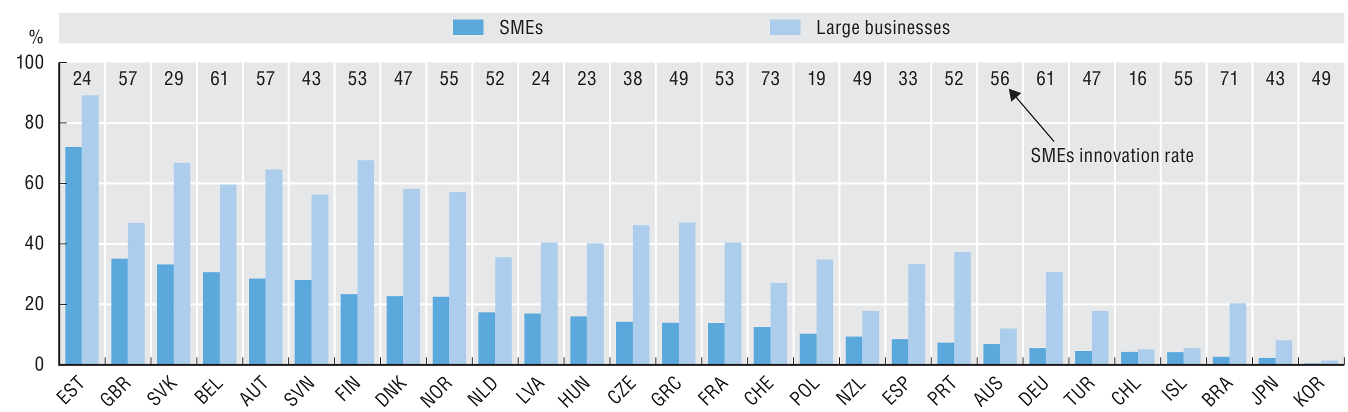
Note: International comparability may be limited due to differences in innovation survey methodologies and country-specific response patterns. European countries follow harmonised survey guidelines with the CIS.

Source: OECD, based on the 2017 OECD survey of national innovation statistics and the Eurostat, Community Innovation Survey (CIS-2014), *http://oe.cd/inno-stats*, June 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933619087

Businesses engaged in international collaboration for innovation, by size, 2012-14

As a percentage of product and/or process-innovating businesses in each size category



Note: International comparability may be limited due to differences in innovation survey methodologies and country-specific response patterns. European countries follow harmonised survey guidelines with the CIS.

Source: OECD, based on the 2017 OECD survey of national innovation statistics and the Eurostat, Community Innovation Survey (CIS-2014), *http://oe.cd/inno-stats*, June 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933619106

Measurability

In surveys adopting the Community Innovation Survey (CIS) model, collaboration rates apply to firms with product or process innovations. In other innovation surveys this information applies to all types of innovative firms. The concept of innovation collaboration differs across different survey models when the group of firms for which collaboration is measured varies.

Results may also reflect survey design and features that impact on firms' responses. Design features such as question order, scope or combination with other types of surveys may influence answers to questions on innovation activity and follow-on questions regarding collaboration with other parties. These comparability challenges are being reviewed as part of the ongoing revision of the OECD/Eurostat Oslo Manual on measuring innovation in business (*http://oe.cd/oslomanual*).

Notes and references

Cyprus

The following note is included at the request of Turkey:

"The information in this document with reference to 'Cyprus' relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognizes the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Turkey shall preserve its position concerning the 'Cyprus issue'."

The following note is included at the request of all of the European Union Member States of the OECD and the European Union:

"The Republic of Cyprus is recognized by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus."

Israel

"The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities or third party. 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.

"It should be noted that statistical data on Israeli patents and trademarks are supplied by the patent and trademark offices of the relevant countries."

3.1. Research excellence and specialisation

Quantity and quality of scientific production, 2005 and 2015

"Top-cited publications" are the 10% most-cited papers normalised by scientific field and type of document (articles, reviews and conference proceedings). The Scimago Journal Rank indicator is used to rank documents with identical numbers of citations within each class. This measure is a proxy indicator of research excellence. Estimates are based on fractional counts of documents by authors affiliated to institutions in each economy.

Specialisation and citation impact in science, selected fields, 2015

"Top-cited publications" are the 10% most-cited papers normalised by scientific field and type of document (articles, reviews and conference proceedings). The Scimago Journal Rank indicator is used to rank documents with identical numbers of citations within each class. This measure is a proxy indicator of research excellence. Estimates are based on fractional counts of documents by authors affiliated to institutions in each economy. Documents published in multidisciplinary/generic journals are allocated on a fractional basis to the ASJC codes of citing and cited papers.

The relative specialisation indicator has been calculated as the ratio of a given field's share in a country's total scientific production, relative to the world's equivalent. A ratio higher than 1 signifies a high degree of specialisation, with the field's share in that country exceeding the relative importance of the field in overall global scientific output, as captured by the Scopus database. Figures have been rounded. Instances with too few documents in a given economy and field have been suppressed.

3.2. Excellence in scientific collaboration

International scientific collaboration, 2015

International collaboration is defined as the number of domestically authored publications incorporating institutional affiliations of other countries or economies, expressed as a percentage of all publications attributed to authors with an affiliation in the reference economy. This includes a relatively small proportion of documents by single authors with affiliations in different economies.

International collaboration is broken down into documents where the leading author has as first affiliation the reference economy and those where the lead author's first reported affiliation is abroad. The leading author is identified in most cases from the identity of the designated corresponding author. For the relatively small fraction of documents where that information is not available, the identity of the leading author is imputed from the first listed author.

The citation impact of scientific production and the extent of international collaboration, 2012-16

Scientific production/Output/Number of documents is the total number of citable documents (articles, reviews and conference proceedings) published in scholarly journals indexed in Scopus.

The normalised citation impact measure is derived as the ratio between the average number of citations received by documents published by authors affiliated to an institution in a given economy and the world average of citations, over the same time period, by document type and subject area.

The normalisation of citation values is item oriented (i.e. carried out at the level of the individual article). If a document is published in a journal classified as belonging to more than one subject area, an average across fields is calculated. The values show the relationship of the unit's average impact to the world average in the relevant field and type of document, which is 1 (i.e. a score of 0.8 means the unit cited is 20% below average and 1.3 means the unit cited is 30% above average).

International collaboration is defined as the number of domestically authored publications incorporating institutional affiliations of other countries or economies, expressed as a percentage of all publications attributed to authors with an affiliation in the reference economy. Single-authored documents with multiple affiliations across boundaries can therefore count as institutional international collaboration.

Multi-year figures are averages (or totals) of yearly estimates.

Top 10% most-cited documents and patterns of international collaboration, 2015

This figure provides a decomposition of each country or economy's top-cited publications. These are the 10% most-cited papers normalised by scientific field and type of document (articles, reviews and conference proceedings). The Scimago Journal Rank indicator is used to rank documents with identifiable numbers of citations within each class. This measure is an indicator of research excellence. Estimates are based on fractional counts of documents by authors affiliated to institutions in each economy.

Top-cited documents are distributed according to whether these documents are domestic or foreign-led (i.e. whether the leading author has as first affiliation the reference economy or whether the lead author's first reported affiliation is abroad). The leading author is identified in most cases from the identity of the first designated corresponding author. For the relatively small fraction of documents where that information is not available, the identity of the leading author is imputed from the first listed author. Domestically led documents may or may not entail international collaboration, leading to a distinction between domestic-led international collaborations and domestic-only documents.

3.3. International mobility of the highly skilled

Internationally mobile students enrolled in tertiary education, 2015

Data refer to foreign students for the Czech Republic, Italy, Korea, the Slovak Republic and Turkey. Foreign students are defined on the basis of their country of citizenship; these data are not comparable with data on international students and are therefore presented separately in the table and figure.

Total enrolments include all international or foreign students. The distribution is based on the number of students with a known field of education.

Tertiary education comprises Levels 5 to 8 of the ISCED-2011 classification.

Fields of study refer to the ISCED-F 2013 Fields of education classification.

For Japan, data on Information and communication technologies are included in other fields.

For the Netherlands, total tertiary education excludes the doctorate level.

For the United States, Health and welfare includes all inter-disciplinary programmes, including those without a specific arts and humanities component.

International and domestic doctoral students in natural sciences, engineering and ICT (NSE & ICTs), 2015

Tertiary education comprises Levels 5 to 8 of the ISCED-2011 classification.

Fields of study refer to the ISCED-F 2013 Fields of education classification.

For Japan, data on Information and communication technologies are included in the other fields.

Highly educated individuals in the working-age population, by place of birth, 2015

Highly educated individuals are defined as an individual who's highest level of successfully completed education or training corresponds to ISCED-11 level 5 and above.

For Korea, data refer to 2013. The immigrant status is defined on the basis of nationality, not on the basis of country of birth.

For the United States, data include people over 55 who are still in education.

The indicator is computed based on the following data sources: European Labour Force Survey (EULFS); Labour Force Survey (Australia, Canada, Israel and New Zealand); Encuesta de Caracterización Socioeconómica Nacional (CASEN) (Chile); Foreign Labour Force Survey (Korea); Encuesta Nacional de Ocupación y Empleo (ENOE) (Mexico); and United States Current Population Survey (CPS).

3.4. Scientists on the move

International bilateral flows of scientific authors, 2006-16

Data are based on the main country affiliation for authors captured in at least two documents published and indexed in the Scopus database over the 2006-2016 period. Counts are based on the number of authors with distinct country affiliations in their first and last recorded publication within this period. Flows to and from interim affiliations are not taken into account in this figure. In the case of multiple country affiliations (approximately 2% of documents), the most recurrent country (modal) affiliation for that author is used.

International mobility of scientific authors, 2016

Estimates are based on the comparison between the main affiliation of a given author with a Scopus Author ID publishing in 2016 and the closest available publication in a previous year. Only authors with two or more publications are considered. A mobility episode is identified in 2016 when an author who is affiliated to an institution in a given economy in his/her last publication in 2016 was previously affiliated to an institution in a different economy. Authors are assigned a given status from the perspective of the last destination in 2016. The "stayers" status is assigned if the main affiliation for both 2016 and pre-2016 correspond to the reference economy. The "returnee" status is assigned to those who move affiliation into the reference economy, but were affiliated to it in their first recorded publication. From the perspective of the previous economy of author affiliation, individuals can be computed as outflows, and the count is incorporated in the data presentation. Data are presented sorted by the share of outflows in the extended sum of possible mobility profiles from the perspective of a reference economy (stayers, returnees, inflows and outflows).

The indicator is represented as the ratio between the number of authors in the relevant category, divided by the (absolute) sum of authors in the reference economy in 2016, plus the outflows from that economy recorded in 2016. The indicator can be adjusted to focus on the profiles of authors from the perspective of the final country of affiliation, as shown in additional variables where shares for new inflows, returnees and stayers add up to 100.

Expected citation impact of scientific authors, by mobility profile in 2016

This is an experimental indicator.

Estimates are based on the comparison of 2015 Scimago Journal Rank (SJR) scores for the documents published by scientific authors, based on the journal rank corresponding to an author publishing in 2016, and on their mobility record up to 2016 counting from 2001. Only authors with two or more publications are considered. A mobility episode is identified in 2016 when an author who is affiliated to an institution in a given economy in his/her last publication in 2016 was previously affiliated to an institution in another economy. Authors are assigned a mobility status from the perspective of the last destination in 2016: The "stayers" status is assigned if the main affiliation for both 2016 and pre-2016 correspond to the reference economy. The "returnee" status is assigned to those who move affiliation into the reference economy, but were affiliated to it in his/her first recorded publication. From the perspective of the previous economy of author affiliation, individuals can be computed as outflows, and the count incorporated in the data presentation.

The indicator is represented as the average SJR2015 among authors in the relevant category and economy.

3.5. The globalisation of R&D

Business R&D funded from abroad, by source of funds, 2015

When a breakdown by source of funds is not available, the share of BERD funded by the Rest of the World (abroad) is presented.

These statistics are based on OECD R&D databases including the R&D Statistics (*http://oe.cd/rds*) and Main Science and Technology Indicators Databases (*http://oe.cd/msti*). For more information on these data, including on issues such as breaks in series, please see those sources.

For Australia, Belgium, Denmark, Germany, Sweden and South Africa, data refer to 2013.

For Denmark and Estonia, BERD funded by international organisations only includes European commission funding.

For the EU 28 zone, France, Israel, Italy, the Netherlands, the OECD zone, Poland, Portugal, Slovenia and the United Kingdom, data refer to 2014.

For Austria, data refer to 2004 and 2013.

For Israel, defence R&D is partly excluded from available estimates.

For Mexico, only funds from foreign business enterprises are available.

For Switzerland, data refer to 2004 and 2015.

Business R&D expenditures by foreign-controlled affiliates, selected countries, 2005 and 2015 or latest available year

For the Netherlands, Poland, Slovenia and Spain, only sections B to F of ISIC Revision 4 are covered.

For Estonia and Finland, only sections B to E of ISIC Revision 4 are covered.

For Austria and the Netherlands, figures refer to 2004.

For Australia and Israel, figures refer to 2006.

For Switzerland, figures refer to 2008.

For Israel and Slovenia, figures refer to 2011.

For Norway, figures refer to 2012.

For Australia, Austria, Belgium, Canada, Estonia, Finland, Germany, Poland and Spain, figures refer to 2013.

For France, Italy, Japan, the Netherlands and the United States, figures refer to 2014.

European Commission funding of government and higher education R&D in Europe, 2015

These statistics are based on OECD R&D databases including the R&D Statistics (*http://oe.cd/rds*) and Main Science and Technology Indicators Databases (*http://oe.cd/msti*). For more information on these data, including on issues such as breaks in series, please see those sources.

A breakdown is not available for the Netherlands.

For Austria, the data refer to 2013 and 2006.

For Belgium, Denmark and Sweden, data refer to 2013.

For Bulgaria, Croatia, Cyprus, Germany, France, Italy, Lithuania, Luxembourg, the Netherlands, Poland, Portugal, Romania, and Slovenia, data refer to 2014.

For the Czech Republic, the earlier period data refer to 2007.

For the Slovak Republic, the earlier period data refer to 2006.

3.6. Inventions across borders

International co-inventions in ICT, 2012-15

International co-inventions are measured as the share of IP5 patent families featuring inventors located in at least two economies, out of the total number of IP5 patent families having inventors located in the economy considered. Data refer to IP5 families, by filing date, according to the inventors' residence using fractional counts. Patents in ICT are identified using the list of IPC codes in Inaba and Squicciarini (2017). Only economies with more than 100 families in total and at least 50 families in ICT in 2012-15 are included. 2014 and 2015 figures are estimated based on available data for those years.

Number of economies in which inventors are located, by technology, 2012-15

Data refer to the average number of inventors' economies in IP5 families, by technology fields and filing date, according to the location of the patent assignee. Patent families are allocated to technology fields on the basis of their International Patent Classification (IPC) codes, following the concordance provided by WIPO (2013). IP5 patent families in ICT are identified using the list of IPC codes in Inaba and Squicciarini (2017). Only economies with more than 100 families by technology are included.

Domestic ownership of ICT inventions from abroad, 2012-15

Foreign inventions owned by economies relate to the number of IP5 patent families owned by a resident of an economy for which no inventors reside in the given economy, as a share of total IP5 patent families owned by that economy. Data refer to IP5 families, by filing date, according to the applicant's residence using fractional counts. IP5 patent families in ICT are identified using the list of IPC codes in Inaba and Squicciarini (2017). Only economies with more than 100 families in total and at least 50 families in ICT in 2012-15 are included. 2014 and 2015 figures are estimated based on available data for those years.

3.7. Collaboration on innovation

Businesses collaborating on innovation with higher education or research institutions, by size, 2012-14

International comparability may be limited due to differences in innovation survey methodologies and country-specific response patterns. European countries follow harmonised survey guidelines with the Community Innovation Survey. Please see *www.oecd.org/sti/inno-stats.htm*.

Size is calculated on the basis of numbers of persons employed. SMEs are defined as businesses with 10 to 249 employees and large firms as businesses with 250 employees or more.

For countries following the Eurostat CIS 2014, data on innovation collaboration include product process, and ongoing and abandoned innovative firms. The Industry core coverage includes ISIC Rev.4 Sections and Divisions B, C, D, E, G46, H, J, K and M71-72-73. Only enterprises with 10 or more employees are covered.

For Australia, data come from the Business Characteristics Survey (BCS) and refer to the financial year 2014/15. Data on innovation collaboration with higher education or research institutions are calculated by including enterprises who collaborated with (f) Universities or other higher education institutions, (g) Other research institutions (all options) or (h) Government agencies. Data include product, process, marketing or organisational innovative firms (including ongoing or abandoned innovation activities). Marketing and organisational innovators are less likely to be involved in collaboration. The sectoral and size coverage of enterprises matches the CIS scope.

For Brazil, data come from the Brazil Innovation Survey 2014 (PINTEC) and refer to 2012-14. Data on innovation collaboration include product or process innovative firms (including ongoing or abandoned innovation activities). The industries surveyed differ from the CIS core coverage. ISIC Rev.4 Section E is not included and only a selection of services is covered (Divisions and groups: 592, 61, 62, 631, 71 and 72).

For Chile, data come from the 9th Chilean Innovation Survey and refer to 2013-14. The data on innovation collaboration include product, process, marketing or organisational innovative firms. Ongoing or abandoned innovative activities are not identified. Marketing and organisational innovators are less likely to be involved in collaboration. The survey covers firms with more than UF 2 400 in annual revenue; no cut-off by size is applied. Sectoral coverage is larger for the industrial sector and in addition to CIS core activities includes: ISIC Rev.3 Section A, Agriculture, hunting and forestry; B, Fishing and F, Construction. The services covered are ISIC Rev.3 (G, I, J and K).

For Estonia, CIS-2014 data were the subject of a methodological review. This caused a break in series when comparing with previous CIS editions.

For Japan, data come from the Japanese National Innovation Survey (J-NIS 2015). Data refer to the financial years 2012/13, 2013/14 and 2014/15. Data on innovation collaboration include product or process innovative firms (including ongoing or abandoned innovation activities). The sectoral and size coverage of enterprises matches the CIS scope.

For Korea, data come from the Korean Innovation Survey. The survey is carried out separately for manufacturing and services, but all data refer to the period 2013-15. Data on innovation collaboration include product or process innovative firms (including ongoing or abandoned innovation activities). The sectoral coverage is smaller than CIS for the industrial sector and includes ISIC Rev.4 Section C Manufacturing only. All services are covered except for Section (O) Public administration and defence; compulsory social security.

For New Zealand, data refer to the financial years 2012/13 and 2013/14, and firms with six or more employees and with an annual Goods and Services Tax (GST) turnover figure greater than NZD 30 000. Data refer to enterprises that collaborated with universities or polytechnics or crown research institutes, other research institutes or research associations, including Callaghan Innovation. Data refer to product, process, organisational and marketing innovating firms (including ongoing or abandoned innovation activities).

For Switzerland, data come from the Survey of Innovation Activities in the Swiss Economy, and refer to the period 2012-14. Data on collaboration only refer to collaboration on R&D.

Businesses collaborating on innovation with suppliers and clients, by size, 2012-14

International comparability may be limited due to differences in innovation survey methodologies and country-specific response patterns. European countries follow harmonised survey guidelines with the Community Innovation Survey. Please see *www.oecd.org/sti/inno-stats.htm* for more details.

Size is calculated on the basis of numbers of persons employed. SMEs are defined as businesses with 10 to 249 employees and large firms as businesses with 250 employees or more.

For countries following the Eurostat CIS 2014, data on innovation collaboration include product or process innovative firms (including ongoing or abandoned innovation activities). The Industry core coverage includes ISIC Rev.4 Sections and Divisions B, C, D, E, G46, H, J, K and M71-72-73. Only enterprises with 10 or more employees are covered.

For Australia, data come from the Business Characteristics Survey (BCS) and refer to financial year 2014/15. Data on innovation collaboration with higher education or research institutions are calculated by including enterprises who collaborated with (f) Universities or other higher education institutions, (g) Other research institutions (all options) or (h) Government agencies. Data include product, process, marketing or organisational innovative firms (including ongoing or abandoned innovation activities). Marketing and organisational innovators are less likely to be involved in collaboration. The sectoral and size coverage of enterprises matches the CIS scope.

For Brazil, data come from the Brazil Innovation Survey 2014 (PINTEC) and refer to 2012-14. Data on innovation collaboration include product or process innovative firms (including ongoing or abandoned innovation activities). The industries surveyed differ from the CIS core coverage. ISIC Rev.4 Section E is not included and only selections of services are covered (Divisions and groups: 592, 61, 62, 631, 71 and 72).

For Chile, data come from the 9th Chilean Innovation Survey and refer to years 2013-14. The data on innovation collaboration include product, process, marketing or organisational innovative firms. Ongoing or abandoned innovative activities are not identified. Marketing and organisational innovators are less likely to be involved in collaboration. The survey covers firms with more than UF 2 400 in annual revenue; no cut-off by size is applied. Sectoral coverage is larger for the industrial sector and in addition to CIS core activities includes: ISIC Rev.3 Section A, Agriculture, hunting and forestry; B, Fishing and F, Construction. The services covered are ISIC Rev.3 (G, I, J and K).

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For Japan, data come from the Japanese National Innovation Survey (J-NIS 2015). Data refer to the financial years 2012/13, 2013/14 and 2014/15. Data on innovation collaboration include product or process innovative firms (including ongoing or abandoned innovation activities). The sectoral and size coverage of enterprises matches the CIS scope.

For Korea, data come from the Korean Innovation Survey. The survey is carried out separately for manufacturing and services, but all data refer to the period 2013-15. Data on innovation collaboration include product or process innovative firms (including ongoing or abandoned innovation activities). The sectoral coverage is smaller than CIS for the industrial sector and includes ISIC Rev.4 Section C Manufacturing only. All services are covered except for Section (O) Public administration and defence; compulsory social security.

For New Zealand, data refer to the financial years 2012/13 and 2013/14, and firms with six or more employees and with an annual Goods and Services Tax (GST) turnover figure greater than NZD 30 000. Data on innovation collaboration with higher education or research institutions are calculated by including enterprises that collaborated with universities or polytechnics or crown research institutes, other research institutes or research associations, including Callaghan Innovation. Data refer to product, process, organisational and marketing innovating firms (including ongoing or abandoned innovation activities).

For Switzerland, data come from the Survey of Innovation Activities in the Swiss Economy, and refer to the period 2012-14. Data on collaboration only refer to collaboration on R&D.

Businesses engaged in international collaboration for innovation, by size, 2012-14

International comparability may be limited due to differences in innovation survey methodologies and country-specific response patterns. European countries follow harmonised survey guidelines with the Community Innovation Survey. Please see *www.oecd.org/sti/inno-stats.htm* for more details.

Size is calculated on the basis of numbers of persons employed. SMEs are defined as businesses with 10 to 250 employees and large firms as businesses with more than 250 employees.

For countries following the Eurostat CIS 2014, data on innovation collaboration include product or process innovative firms (including ongoing or abandoned innovation activities). The Industry core coverage includes ISIC Rev.4 Sections and Divisions B, C, D, E, G46, H, J, K and M71-72-73. Only enterprises with 10 or more employees are covered.

For Australia, data come from the Business Characteristics Survey (BCS) and refer to the financial year 2014/15. Data on innovation collaboration include product, process, marketing or organisational innovative firms (including ongoing or abandoned innovation activities). Marketing and organisational innovators are less likely to be involved in collaboration. The sectoral and size coverage of enterprises matches the CIS scope.

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For Chile, data come from the Chilean Innovation Survey 2015 and refer to 2013-14. The data on innovation collaboration include product, process, marketing or organisational innovative firms. Ongoing or abandoned innovative activities are not identified. Marketing and organisational innovators are less likely to be involved in collaboration. The survey covers firms with more than UF 2 400 in annual revenue; no cut-off by size is applied. Sectoral coverage is larger for the industrial sector and in addition to CIS core activities includes: ISIC Rev.3 Section A, Agriculture, hunting and forestry; B, Fishing and F, Construction. The services covered are ISIC Rev.3 (G, I, J and K).

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For New Zealand, data refer to the financial years 2012/13 and 2013/14, and firms with six or more employees and with an annual Goods and Services Tax (GST) turnover figure greater than NZD 30 000. Data refer to product, process, organisational and marketing innovating firms (including ongoing or abandoned innovation activities).

For Switzerland, data come from the Survey of Innovation Activities in the Swiss Economy, and refer to the period 2012-14. Data on collaboration only refer to collaboration on R&D.

References

Appelt, S., F. Galindo-Rueda, R. de Pinho and B. van Beuzekom (2015), “Which factors influence the international mobility of research scientists?”, *OECD Science, Technology and Industry Working Papers*, No. 2015/02, OECD Publishing, Paris, *http://dx.doi.org/10.1787/5js1tmrr2233-en*.

Elsevier (2011), *International Comparative Performance of the UK Research Base: 2011*, Report commissioned by the UK Department for Business, Innovation and Skills.

González-Pereira, B., Guerrero-Bote, V.P. and Moya-Anegón, F. (2010), “A new approach to the metric of journals’ scientific prestige: The SJR indicator”, *Journal of Informetrics*, Vol. 4/3, pp. 379-391.

Inaba, T. and M. Squicciarini (2017), “ICT: A new taxonomy based on the international patent classification”, *OECD Science, Technology and Industry Working Papers*, No. 2017/01, OECD Publishing, Paris. *http://dx.doi.org/10.1787/ab16c396-en*.

Moed, H., M. Aisati and A. Plume (2013), “Studying scientific migration in Scopus”, *Scientometrics*, Vol. 94/3, pp. 929-942.

Moya-Anegón, F., V.P. Guerrero-Bote, L. Bornmann and H. Moed (2013), "The research guarantors of scientific papers and the output counting: A promising new approach", *Scientometrics*, Vol. 97/2, pp. 421-434.

OECD/Eurostat (2005), *Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data, 3rd edition*, The Measurement of Scientific and Technological Activities, OECD Publishing, Paris, *http://dx.doi.org/10.1787/9789264013100-en*.

OECD (2015), *Frascati Manual 2015: Guidelines for Collecting and Reporting Data on Research and Experimental Development*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/9789264239012-en*.

OECD and SCImago Research Group (CSIC) (2016), *Compendium of Bibliometric Science Indicators*, *http://oe.cd/scientometrics*.


earth
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success
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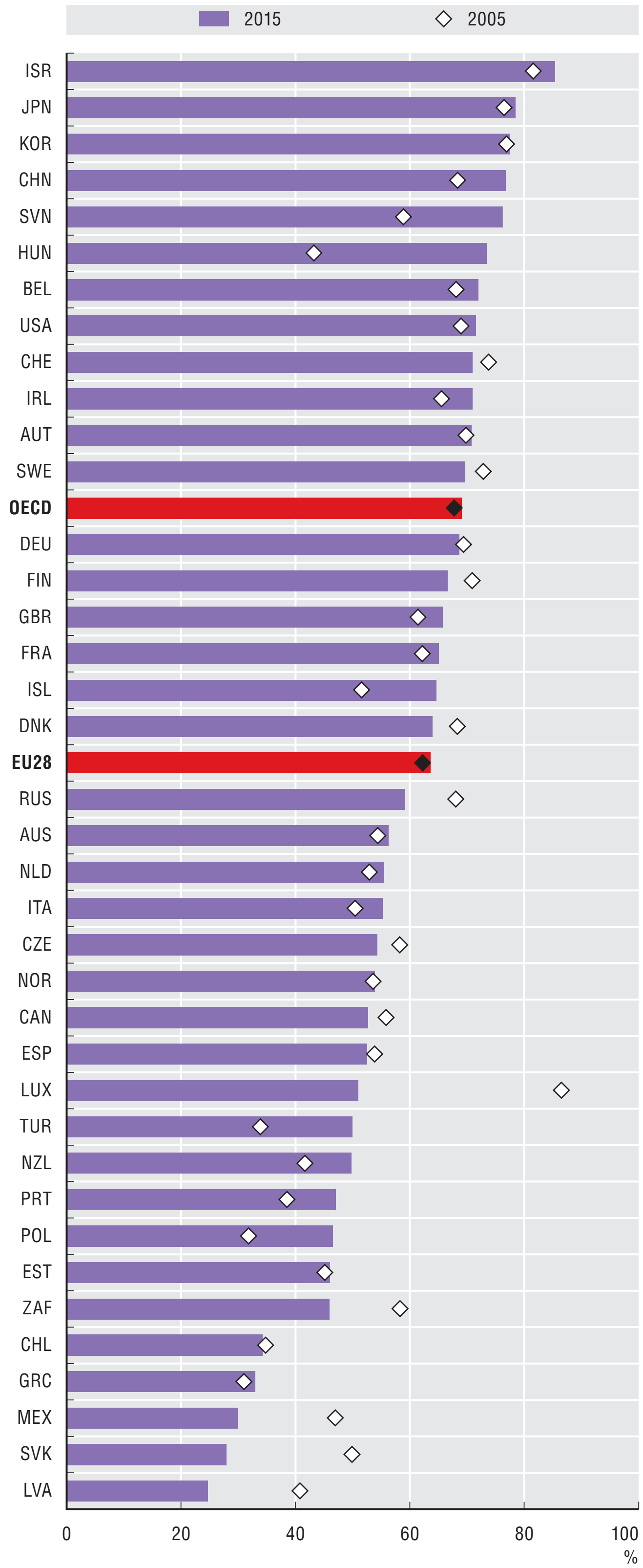
plan
design
solution
inspiration
sky
concept
light
environment
electric
technical
creativity
intelligence
innovative
equipment
future
ecology
supply
lamp
image
hand
human
isolated
green
background
business
object
new
environment
blue
eco
renewable

4. INNOVATION IN FIRMS

1. Business R&D

Business R&D, 2005 and 2015

As a percentage of gross domestic expenditure on R&D



Source: OECD, Main Science and Technology Indicators Database, *http://oe.cd/msti*, July 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933619125

Did you know?

SMEs undertake 35% of business R&D on average but receive almost 60% of government R&D funding to businesses.

Businesses undertake the largest share of R&D in most economies and more than 60% of OECD R&D expenditure. This share remained fairly stable from 2005 to 2015 across the OECD area, the EU, and the United States but increased markedly in China and Turkey, while falling in Mexico, the Russian Federation, and South Africa; several EU states also show sizeable changes.

R&D activity is typically concentrated in a relatively small portion of the business population, especially in large firms. In some countries, small and medium-sized enterprises (SMEs) account for a significant share of business expenditure on R&D (BERD), averaging 35% and ranging from over two-thirds in Iceland, Latvia, and New Zealand, to less than 15% in Germany, Japan, and the United States. The government sector is generally a relatively minor R&D performer but a major funder of R&D in the higher education and business sectors. SMEs typically receive a relatively large share of this funding, 60% on average and reaching 100% in Estonia and Latvia.

R&D intensity varies between industries and countries. Industries relating to digital technologies, such as "ICT equipment" and "information services", are among the most R&D-intensive; ICT equipment (i.e. manufacture of computer, electronic, and optical equipment) is the most R&D-intensive industry (24.7%), after pharmaceuticals (25.1%). The average R&D intensity across all industries is 5%. R&D in areas such as vehicle efficiency and automation has made the automotive industry one of the top 10 most R&D intensive in the OECD area, with R&D intensity reaching 17% in Germany and 19% in Sweden.

Definitions

Gross domestic expenditure on R&D is reported for sectors performing R&D. Business enterprise expenditure on R&D (BERD) records the gross expenditures on R&D performed by all firms, organisations and institutions (public and private), whose primary activity is the production of goods and services (other than higher education) for sale to the general public at an economically significant price, and any private, non-profit institutions mainly serving them.

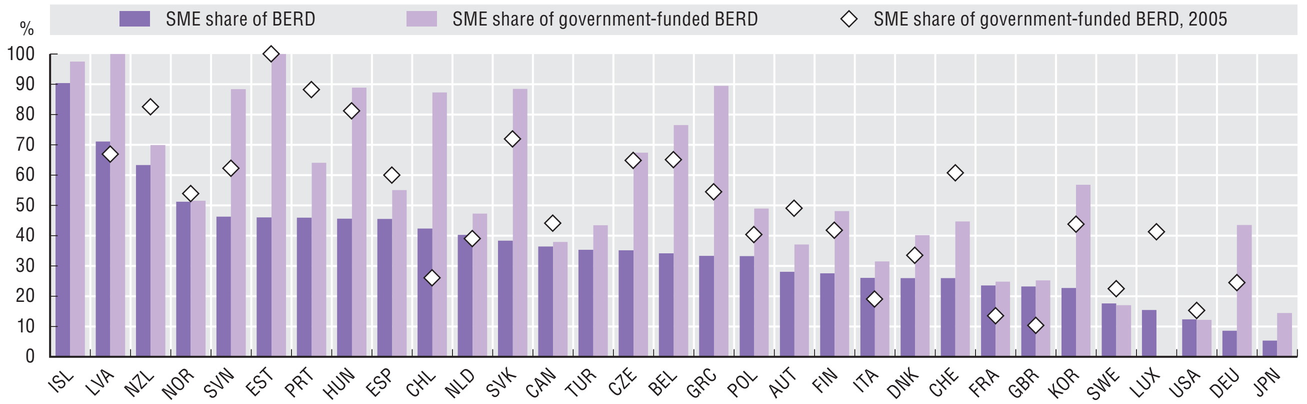
Government-funded business R&D is the component of R&D performed by business enterprises that they attribute to direct government funding. It includes grants and payments for R&D contracts for procurement, but not R&D tax incentives, repayable loans or equity investments.

R&D intensity is the R&D expenditure expressed as a share of value added for a unit, industry, sector or country.

Small and medium-sized enterprises (SMEs) are businesses with up to 249 persons employed.

Business R&D and government support for business R&D, by size, 2015

Share corresponding to SMEs, as a percentage of the relevant total

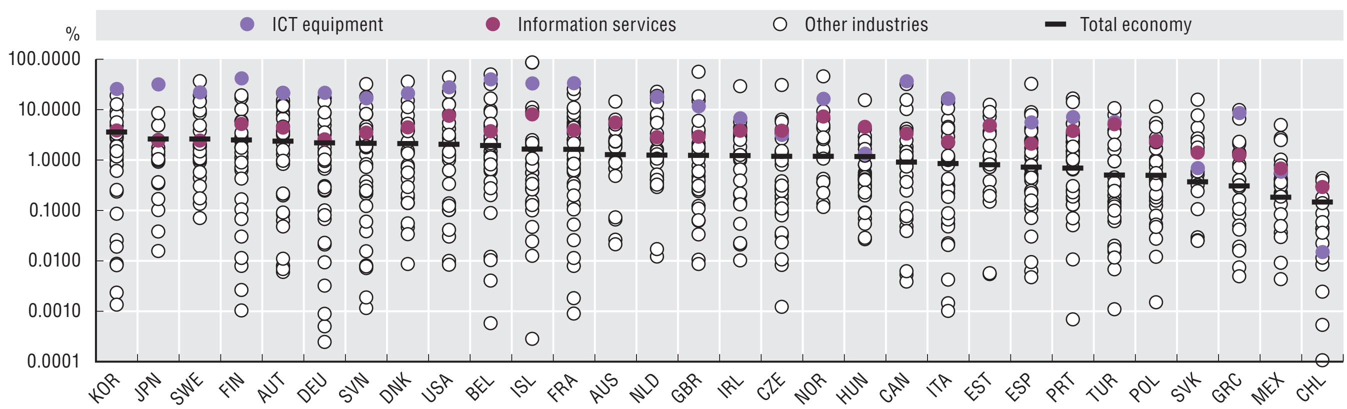


Source: OECD, Research and Development Statistics Database, *http://oe.cd/rds*, June 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933619144

R&D intensity by industry, 2015

As a percentage of gross value added, log scale



Source: OECD calculations based on ANBERD, *http://oe.cd/anberd*, STAN, *http://oe.cd/stan*, National Accounts (SNA), and Research and Development Statistics (*http://oe.cd/rds*) Databases, June 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933619163

Measurability

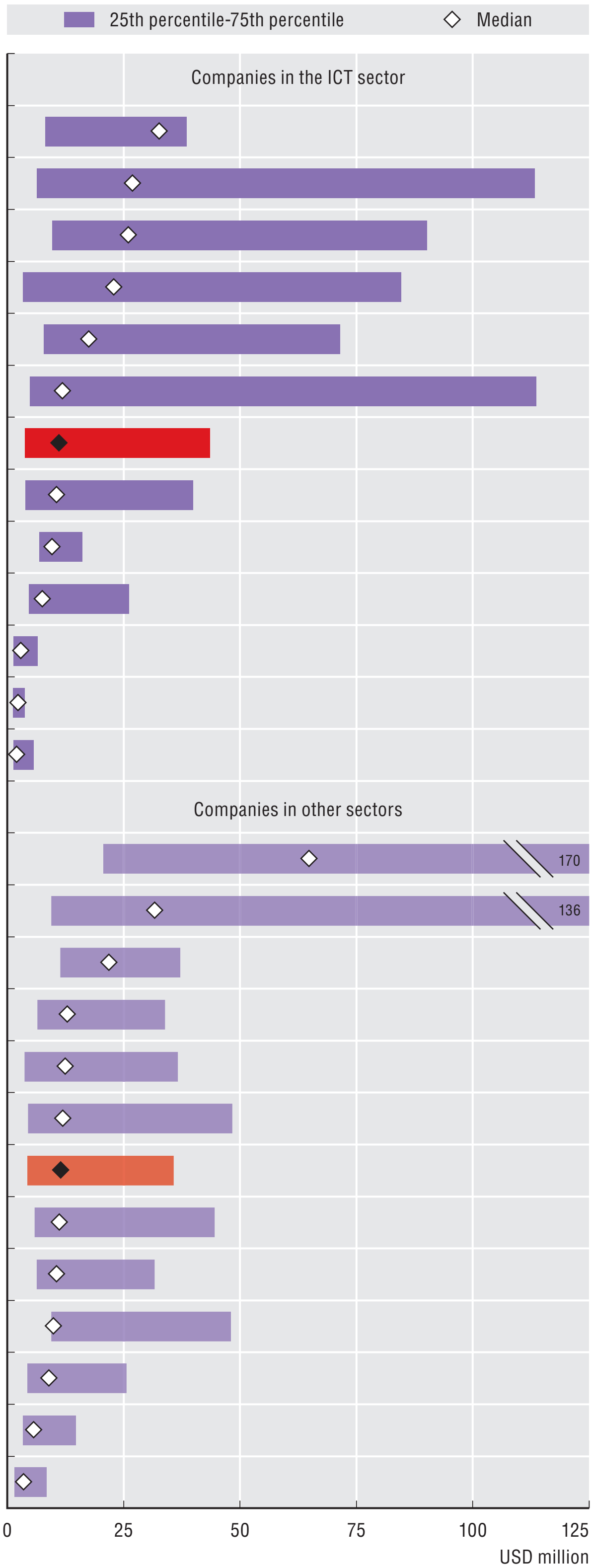
BERD is typically measured through official surveys on the volume and nature of businesses' R&D expenditures including the sources of funding used. The surveys, or related sources such as business registers, also provide relevant contextual information such as the number of persons employed and the main productive activity undertaken (i.e. main source of value added). This is the primary way in which R&D activities are classified by industries, as recommended in the OECD Frascati Manual 2015 (*http://oe.cd/frascati*). However, in practice, several countries also undertake an element of redistribution based upon more detailed information about the type of product(ion) to which the R&D relates (i.e. R&D broken down by "industry orientation"). Countries where the disaggregation level for R&D is too low and where there is no comparable SNA data on value added by industry have been excluded.

Data on government funding of BERD only covers direct support. Indirect support (e.g. foregone revenue from R&D tax credits) is also important. Data on public support by firm size do not distinguish between SMEs that form part of a larger group and those that are independent.

2. Top R&D players

R&D investment per patent of top corporate R&D investors, by headquarters' location, 2012-14

Million USD per IP5 patent family



Source: OECD calculations based on JRC-OECD, COR&DIP© Database v.1., June 2017. Statlink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933619182

Did you know?

On average, top ICT corporations worldwide invest more than USD 11 million in R&D per IP5 patent family and up to USD 33 million in Israel.

The world's top corporate research and development (R&D) investors are leading global players at the technology frontier and account for about 64% of all patent families filed at the five largest intellectual property offices worldwide (IP5). Looking at the extent to which these global players invest in R&D, diversify their technological and industrial activities, and use trademarks to compete helps to understand global trends and possible future developments.

The median investment in R&D by top corporate R&D investors in ICT industries varies between about USD 33 million (Israel) and USD 1.9 million (Korea) per IP5 patent family. Median R&D investment per patent in other industries varies between over USD 65 million (China) and USD 3.4 million (Japan). The latter may reflect different propensities to patent worldwide as well as the overall industry composition of economies.

Technological and industrial specialisation do not seem to go hand in hand among top corporate R&D investors. The top four technology areas in which companies specialise vary between median levels of less than 40% in Machinery and Construction to 85% or more in the case of Telecommunications and Scientific R&D. Conversely, in all sectors, 50% or more of the affiliates of top R&D investors operate in only four industries. This share goes above 80% in the case of food products. The median number of economies in which affiliates are located also varies, with most top R&D performers having affiliates in more than ten economies.

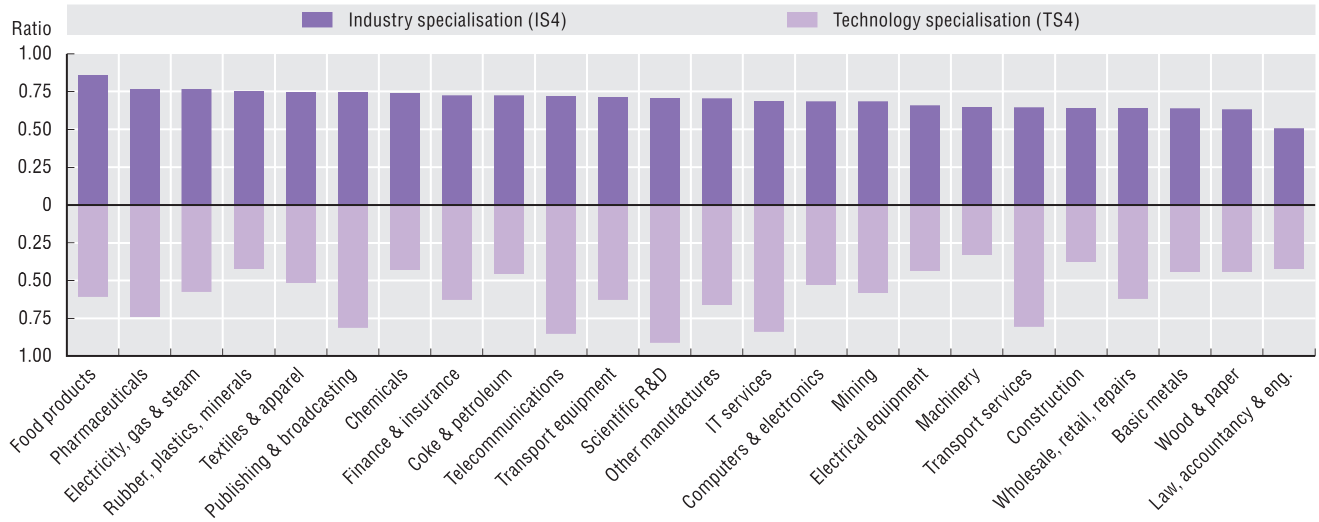
Remarkable differences also exist in terms of the extent to which top R&D investors rely on trademarks. In ICT industries, the median net sales per trademark amount to USD 285 million, compared to almost USD 320 million in other industries. In the latter case, the median values stem from more diversified industry and economy-specific patterns than have been observed for ICT companies, and from their upstream or downstream position in global value chains.

Definitions

Industry and technology specialisation ratios are built in a similar way to concentration ratios (CR). *Industry specialisation* (IS4) ratios reflect the share of affiliates accounted for by the top four industries in which companies' affiliates operate over the total number of affiliates of these top R&D investors in a given industry. *Technology specialisation* (TS4) ratios reflect the share accounted for by the top four technology fields in which companies file patents over the total number of patents filed by these R&D investors in a given industry.

Industrial and technological specialisation of top R&D investors, 2012-14

Specialisation in terms of Concentration Ratio (4) at the industry and technology level

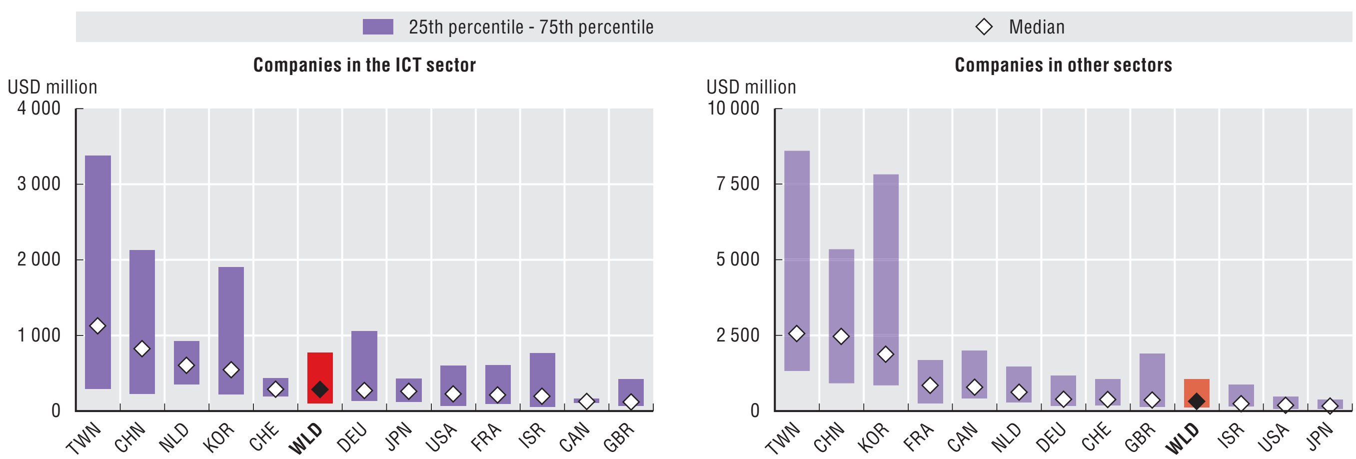


Source: OECD calculations based on JRC-OECD, COR&DIP© Database v.1., June 2017. Statlink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933619201

Net sales per trademark of top corporate R&D investors in the ICT sector, by headquarters' location, 2012-14

USD million per trademark application, EUIPO, JPO and USPTO



Source: OECD calculations based on JRC-OECD, COR&DIP © Database v.1., June 2017. Statlink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933619220

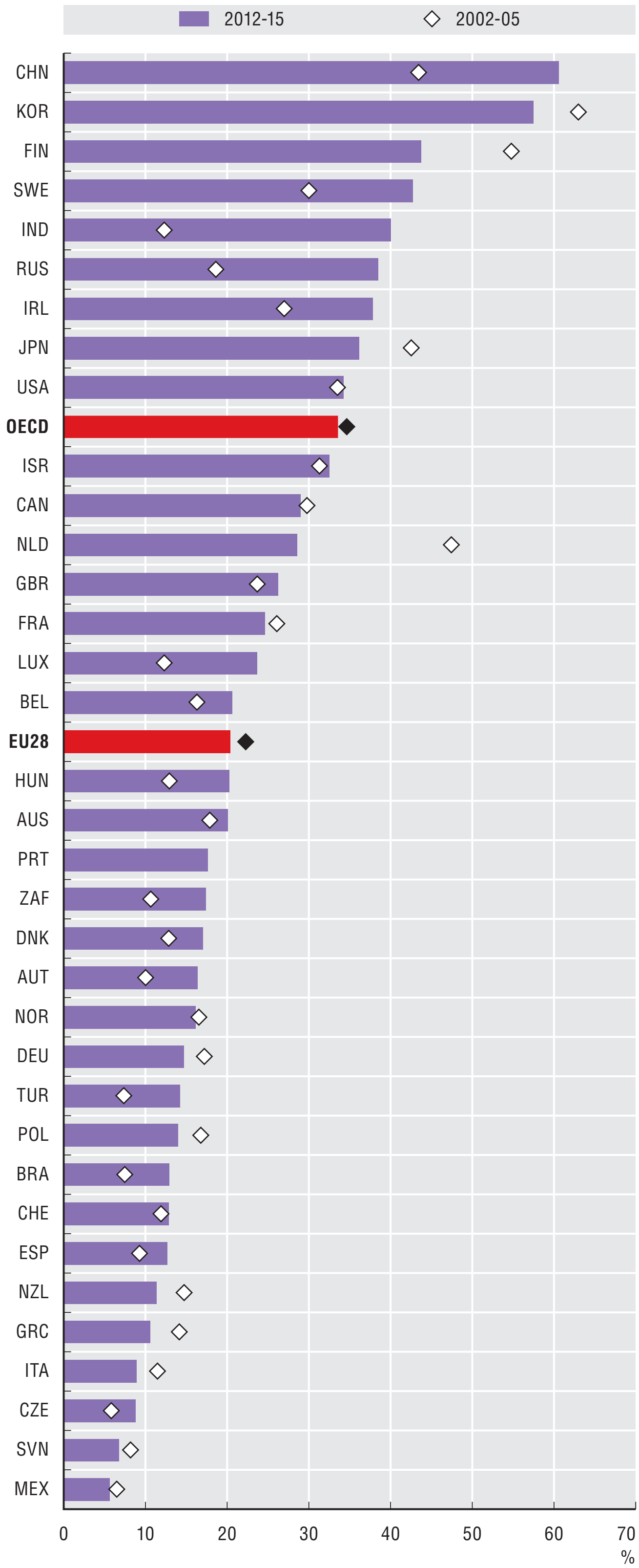
Measurability

Industries are defined according to ISIC Rev. 4. The ICT sector comprises: ICT manufacturing industries (classes 2610, 2620, 2630, 2640 and 2680), ICT trade industries (4651 and 4652), ICT services industries (5820), Telecommunications (61), Computer programming (62), Data processing (631), and Repair of computers and communication equipment (951). Patent data refer to patent families filed at the top five intellectual property (IP) offices worldwide: the IP5 (*www.fiveipoffices.org*). Trademark data refer to new trademark applications filed at the European Union Intellectual Property Office (EU IPO), the Japan Patent Office (JPO) and the US States Patent and Trademark Office (USPTO). R&D expenditures and net sales figures are in USD millions. Patent families are allocated by first filing date; trademarks by filing date. Patents and trademarks are allocated using information about the main industry of the applicant's headquarters and rely on fractional counts. Figures may differ if different patent family types, IP authorities and/or time frames are considered. Comparisons across years are not provided, as top R&D performers and their structure are likely to change over time.

3. IP bundles

ICT-related patents, 2002-05 and 2012-15

As a percentage of total IP5 patent families owned by economies



Source: OECD, STI Micro-data Lab: Intellectual Property Database, *http://oe.cd/ipstats*, June 2017. StatLink contains more data. See chapter notes.

StatLink *http://dx.doi.org/10.1787/888933619239*

Did you know?

Korea' IP portfolio is mostly made of ICT-related assets with patents (57%), trademarks (up to 65%) and designs (up to 62%).

Competing in Information and Communication Technology (ICT) markets worldwide requires innovations and technological developments to be bundled with appealing designs, while making consumers able to recognise the new and often complex products on offer.

Over 2012-15, ICT patents accounted for about 34% of all IP5 patent families filed by OECD countries - almost the same share observed a decade earlier. In contrast, China increased its share by 40% and its IP5 patent portfolio became the most specialised in ICT.

In the decade leading to 2015, for OECD countries the look and feel of ICT products protected through designs grew in importance in the United States (+14%) and the European markets (+9%), and decreased in Japan (-32%). Similarly, BRIICS economies tripled the share of ICT design patents filed in the United States, increased by more than 60% the share of ICT designs registered in Europe, and decreased by about 17% the share in Japan.

The share of ICT-related trademarks conversely grew in all markets considered, with the highest share observed in 2012-15 on the European market (+35%), followed by the Japanese (+27%) and the United States' (+21%) markets.

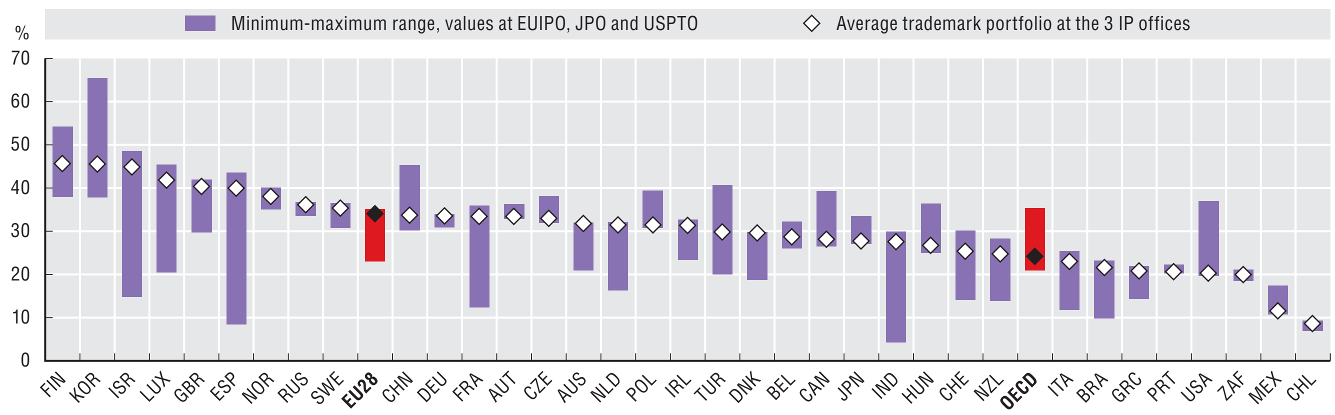
Overall, OECD countries seem to progressively move towards ICT IP bundle strategies which put less emphasis on technological innovation and leverage more on the look and feel of products and on extracting value from branding. Conversely BRIICS countries are seemingly pursuing technological catch-up strategies, while ring-fencing their products through designs and brands.

Definitions

Patents protect technological inventions, i.e. products or processes providing new ways of doing something or new technological solutions to problems. *IP5 patent families* are patents within the *Five IP offices* (*IP5*). Patents in ICT are identified using the International Patent Classification (IPC) codes (see Inaba and Squicciarini, 2017). *Designs* protect new and/or original shapes, configurations or ornament aspects of products. *Trademarks* are distinctive signs, e.g. words and symbols, used to identify the goods or services of a firm from those of its competitors. ICT-related designs and trademarks are identified following an experimental OECD approach based on the Locarno and Nice Classifications, respectively, and combine a normative approach with the use of ICT-related keywords.

ICT-related trademarks, 2012-15

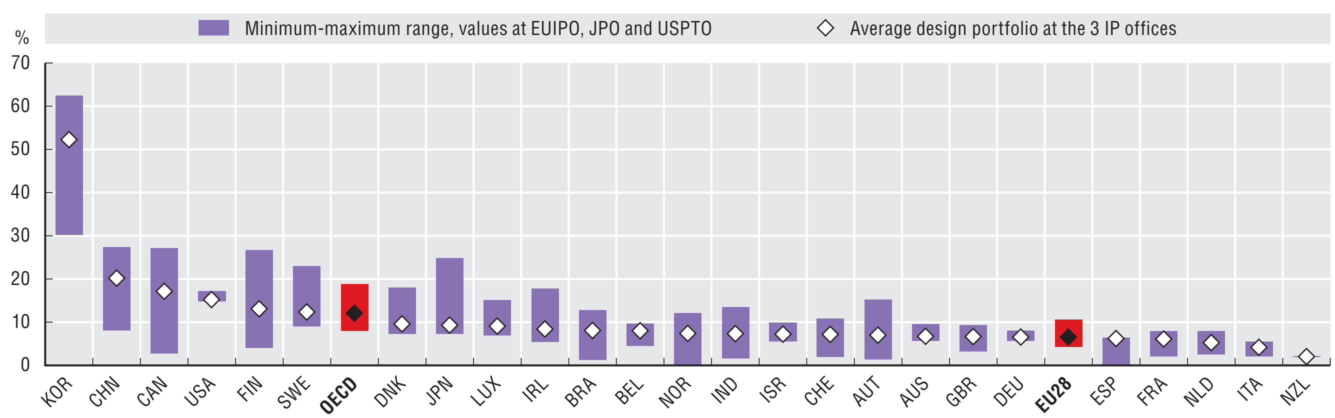
As a percentage of total trademarks, EUIPO, JPO and USPTO



Source: OECD, STI Micro-data Lab: Intellectual Property Database, *http://oe.cd/ipstats*, June 2017. StatLink contains more data. See chapter notes.
StatLink *http://dx.doi.org/10.1787/888933619258*

ICT-related designs, 2012-15

As a percentage of total designs, EUIPO, JPO and USPTO



Source: OECD, STI Micro-data Lab: Intellectual Property Database, *http://oe.cd/ipstats*, June 2017. StatLink contains more data. See chapter notes.
StatLink *http://dx.doi.org/10.1787/888933619277*

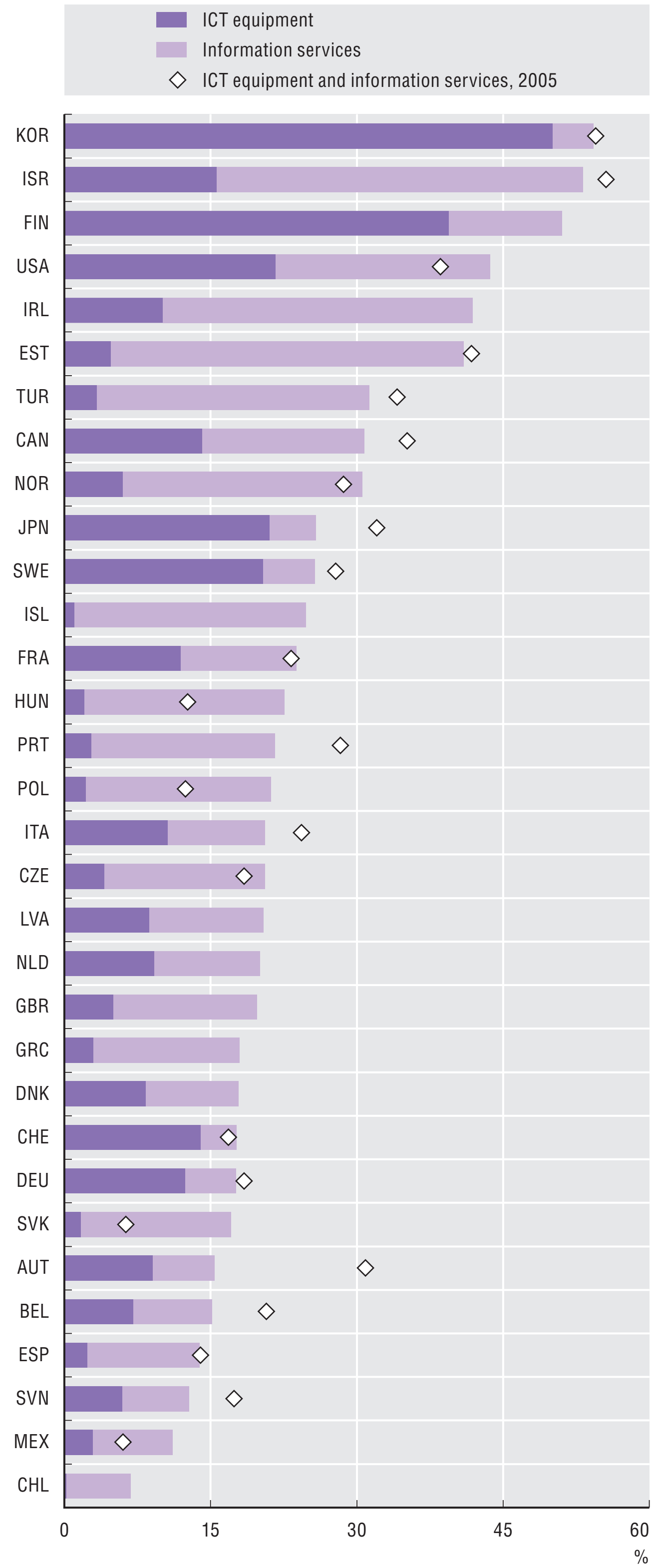
Measurability

Intellectual property (IP) rights follow a territoriality principle. Patents, designs and trademarks are protected only in the countries where they are registered. Using information on the priority date of patents, i.e. the date of the first filing of a patent whose protection has subsequently been extended to other IP jurisdictions, allows reconstructing patent families and avoiding duplications when counting IP assets. The same cannot be done for trademarks and designs, as information about identical registrations happened elsewhere is seldom available, if ever provided. In the United States designs are protected through design patents (at the United States Patents and Trademark Office, USPTO), whereas in Europe (at the European Union Intellectual Property Office, EUIPO) and in Japan (at the Japan Patent Office, JPO) design is protected through registration of industrial designs. As opposed to the case of patents, data availability constraints do not allow reconstructing design and trademark portfolios protected at the IP5 offices. The definition of ICT patents in Inaba and Squicciarini (2017) aligns with the OECD definitions of the ICT sector (2007) and of ICT products (2008).

4. ICT and innovation

R&D expenditure by ICT equipment and information services industries, 2015

As a percentage of business enterprise expenditure on R&D



Source: OECD, ANBERD Database, *http://oe.cd/anberd*, and Research and Development Statistics Database, *http://oe.cd/rds*, June 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933619296

Did you know?

China, Japan, Korea and the United States account for between 70% and 80% of all patented inventions in ICT technologies.

Information and communication technologies (ICT) are key enablers of innovation. In most OECD economies, these "information industries" account for about a quarter of business enterprise expenditure on R&D (BERD). In Finland, Israel, Korea and the United States, they account for 40% to over 50% of BERD. ICT BERD alone represents about 0.8% to 1.9% of GDP, reflecting the high research intensity of these economies and the sector itself.

Patents shed light on the extent to which investment in R&D translates into innovative output. During the period 2012-15, the majority of ICT inventions continued to be patented in three main areas, namely information and communication devices (about 27%), imaging and sound technologies (about 15%) and high-speed networks (about 12%). The United States accounted for the highest relative shares of such patents in 7 out of the 13 ICT fields, including high-speed computing, large-capacity information analysis (about 33% both) and security (28%); Japan did so in five fields, including imaging and sound technology (37%), and Korea led in human interface technologies (24%). China, conversely, contributed between 5% and 17% of the inventions patented in the different ICT fields.

Innovation encompasses a broader array of activities than R&D. As distinct from patents or other valuable ideas, innovations (products, processes and methods) need to be brought to market or adopted by businesses. On average, 74% of firms in ICT manufacturing introduced innovations in 2012-14, against an average of 51% for total manufacturing. ICT services also account for a larger share of innovative firms than service industries covered by innovation surveys (64% against 50%).

Definitions

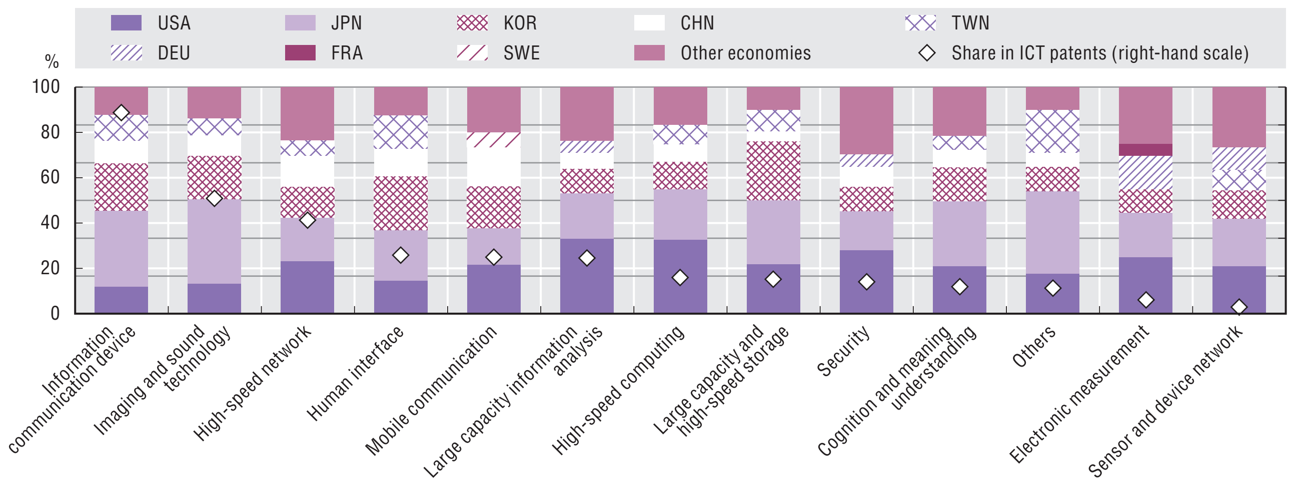
Business expenditure on R&D (BERD) includes all expenditure on R&D performed by business enterprises, irrespective of funding sources. Expenditures are classified according to the main source of value added of the enterprise. Information industries are defined as the aggregate of ICT and digital media and content industries.

IP5 patent families are patents within the *Five IP offices* (IP5, *www.fiveipoffices.org*). ICT patents are identified using the International Patent Classification (IPC) codes (see Inaba and Squicciarini, 2017) and align with OECD definitions of the ICT sector (2007) and ICT products (2008).

Innovative enterprises are defined as businesses that have introduced a new or significantly improved product or process or a new marketing or organisational method over the reference period.

Patents in ICT-related technologies and major players, 2012-15

Share of the top five players in the field

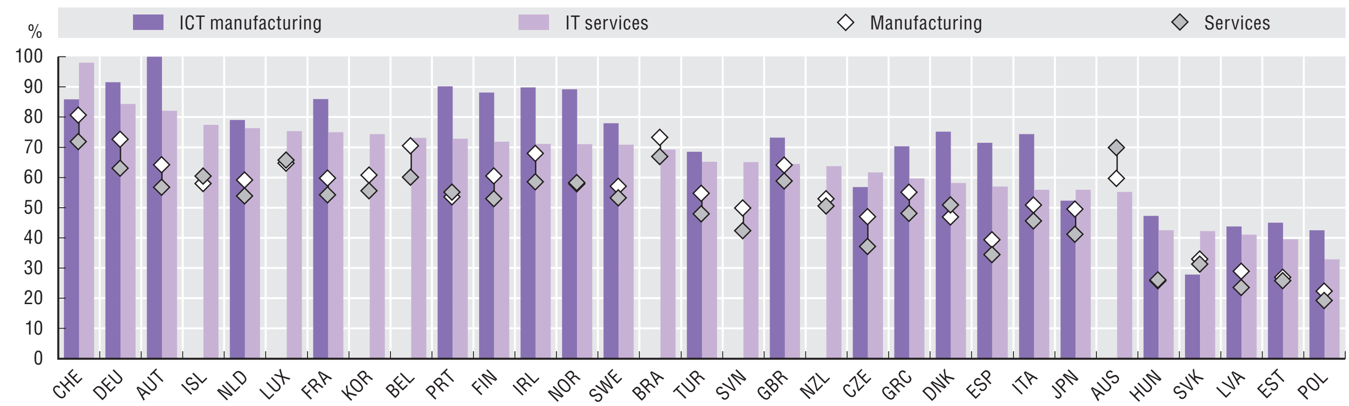


Source: OECD, STI Micro-data Lab: Intellectual Property Database, *http://oe.cd/ipstats*, June 2017. StatLink contains more data. See chapter notes.

StatLink *http://dx.doi.org/10.1787/888933619315*

Innovative businesses in ICT manufacturing and IT services, 2012-14

As a percentage of businesses in the relevant category



Note: International comparability may be limited due to differences methodologies and economy-specific response patterns. European countries follow harmonised survey guidelines with the CIS.

Source: OECD, based on the 2017 OECD survey of national innovation statistics and the Eurostat, Community Innovation Survey (CIS-2014), *http://oe.cd/inno-stats*, June 2017. StatLink contains more data. See chapter notes.

StatLink *http://dx.doi.org/10.1787/888933619334*

Measurability

Differences exist in the ways economies collect and report R&D data by economic activity. Interpretation may vary depending on whether data are collected on the basis of the main activity of the R&D performer, the industry or product at which the R&D is targeted, or a mix of the two. The Frascati Manual (OECD, 2015) advocates separate reporting of both types of data. A specific effort is also made to encourage the separate reporting of software-related R&D to understand the overlap between R&D and software investment statistics. The proliferation of software R&D within all sectors (e.g. automotive) may also explain the apparent lack of growth in the share of information industries' BERD.

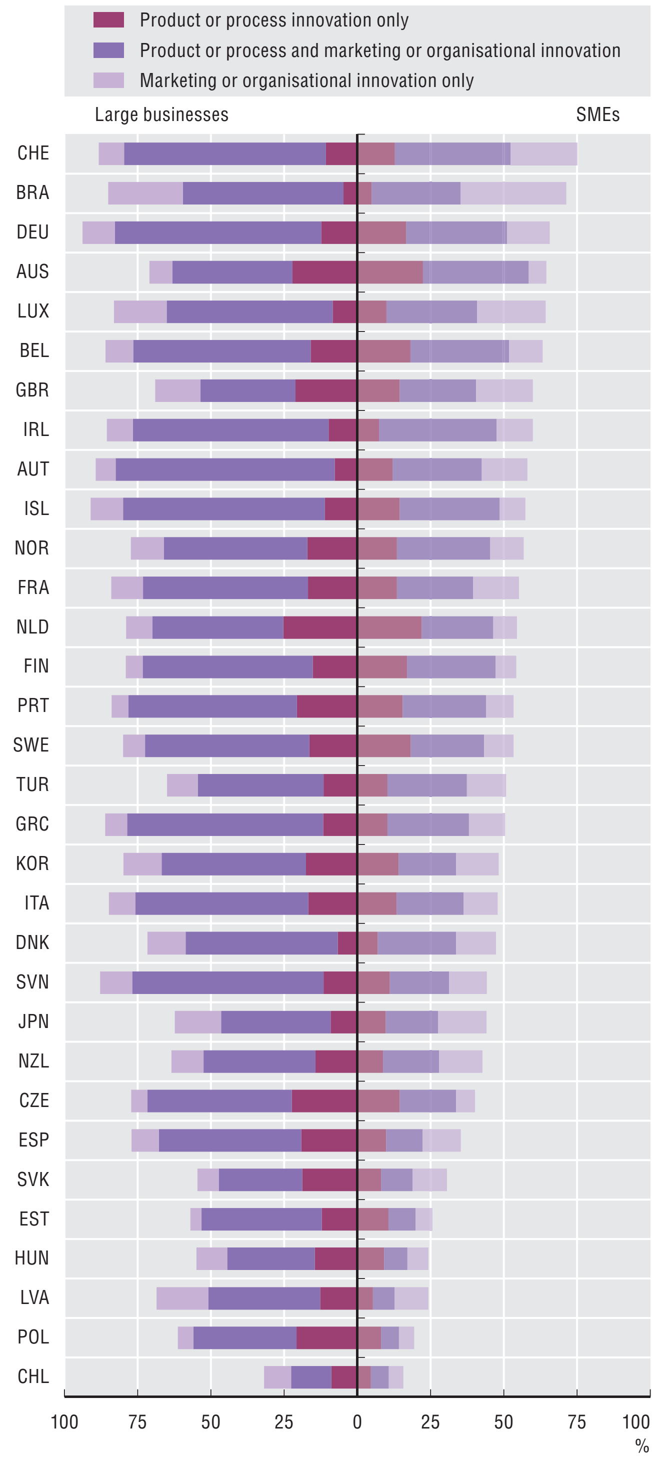
ICT patents encompass 13 areas defined according to the specific technical features and functions they accomplish (e.g. mobile communication, high-speed network, high-speed computing and large-capacity information analysis). As most inventions are only protected in certain economies, using data from different patent offices may lead to different results.

The main features and challenges of indicators derived from innovation surveys are described in dedicated sections within this chapter.

5. Mixed modes of innovation

Innovation types, by business size, 2012-14

As a percentage of all businesses in each size category within the scope of national innovation surveys



Note: International comparability may be limited due to differences in innovation survey methodologies and country-specific response patterns. European countries follow harmonised survey guidelines with the Community Innovation Survey.

Source: OECD, based on the 2017 OECD survey of national innovation statistics and the Eurostat, Community Innovation Survey (CIS-2014), *http://oe.cd/inno-stats*, June 2017. StatLink contains more data. See chapter notes.

StatLink *http://dx.doi.org/10.1787/888933619353*

Did you know?

In most countries, large businesses are between two to three times more likely than SMEs to introduce products that are new to market.

Business-level data reveal that businesses adopt innovation strategies combining different and complementary types ("mixed modes") of innovation. Innovative firms – both large firms and SMEs – tend to introduce new marketing or organisational methods alongside product or process innovations.

The indicators, which show the percentage of businesses that introduced at least one innovation over the reference period, reveal a considerable gap between SMEs and large firms across all countries. Reported product or process innovation incidence rates are generally lower in services than in manufacturing firms.

Identifying the subset of new-to-market product innovators provides a quality-adjusted measure of product innovation by businesses. Overall, new-to-market product innovations are more common for manufacturing than services. In Germany, new-to-market product innovation rates for manufacturing are almost twice as large as for services. Innovation in the manufacturing sector is overall on the rise within a majority of OECD countries.

Differences in new-to-market product innovation rates are very marked between large businesses and SMEs (i.e. those with less than 250 employees). For many countries, new-to-market product innovation is a rare event in the general SME population. This may reflect challenges to the scaling-up of such firms, which affects their ability to transform or disrupt markets.

Definitions

The 2005 edition of the Oslo Manual (OECD and Eurostat, 2005), currently undergoing revision, identifies four types of innovation by object:

Product innovation: the introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses. This includes changes in technical specifications, incorporated software or components, user friendliness or other functional characteristics.

Process innovation: the implementation of a new or significantly improved production or delivery method. This includes changes in techniques, equipment and/or software.

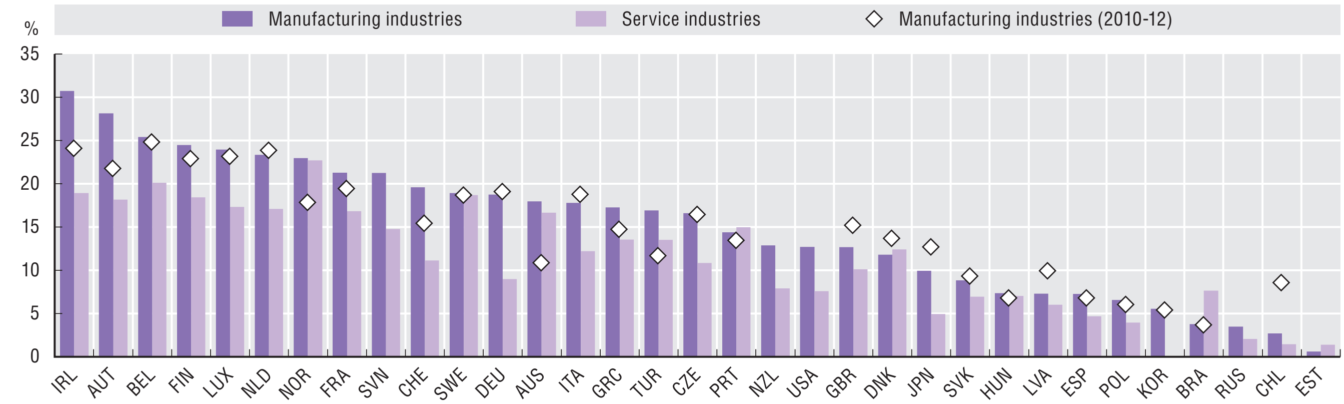
Marketing innovation: the implementation of a new marketing method involving changes in product design or packaging, product placement, product promotion or pricing.

Organisational innovation: the implementation of a new organisational method in the firm's business practices, workplace organisation or external relations.

New-to-market product innovation refers to the introduction of a new or significantly improved product into the firm's market before any other competitors (the product may have already been available in other markets).

New-to-market product innovators, manufacturing and services, 2012-14

As a percentage of all businesses in each sector within the scope of national innovation surveys



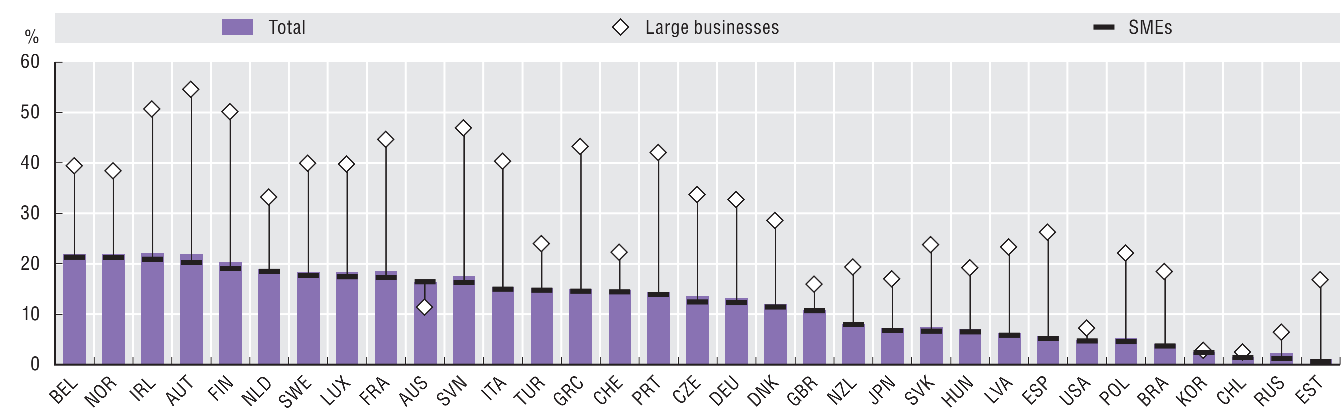
Note: International comparability may be limited due to differences in innovation survey methodologies and country-specific response patterns. European countries follow harmonised survey guidelines with the Community Innovation Survey.

Source: OECD, based on the 2017 OECD survey of national innovation statistics and the Eurostat, Community Innovation Survey (CIS-2014), *http://oe.cd/inno-stats*, June 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933619372

New-to-market product innovators, by firm size, 2012-14

As a percentage of all businesses in each size category within the scope of national innovation surveys



Note: International comparability may be limited due to differences in innovation survey methodologies and country-specific response patterns. European countries follow harmonised survey guidelines with the Community Innovation Survey.

Source: OECD, based on the 2017 OECD survey of national innovation statistics and the Eurostat, Community Innovation Survey (CIS-2014), *http://oe.cd/inno-stats*, June 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933619391

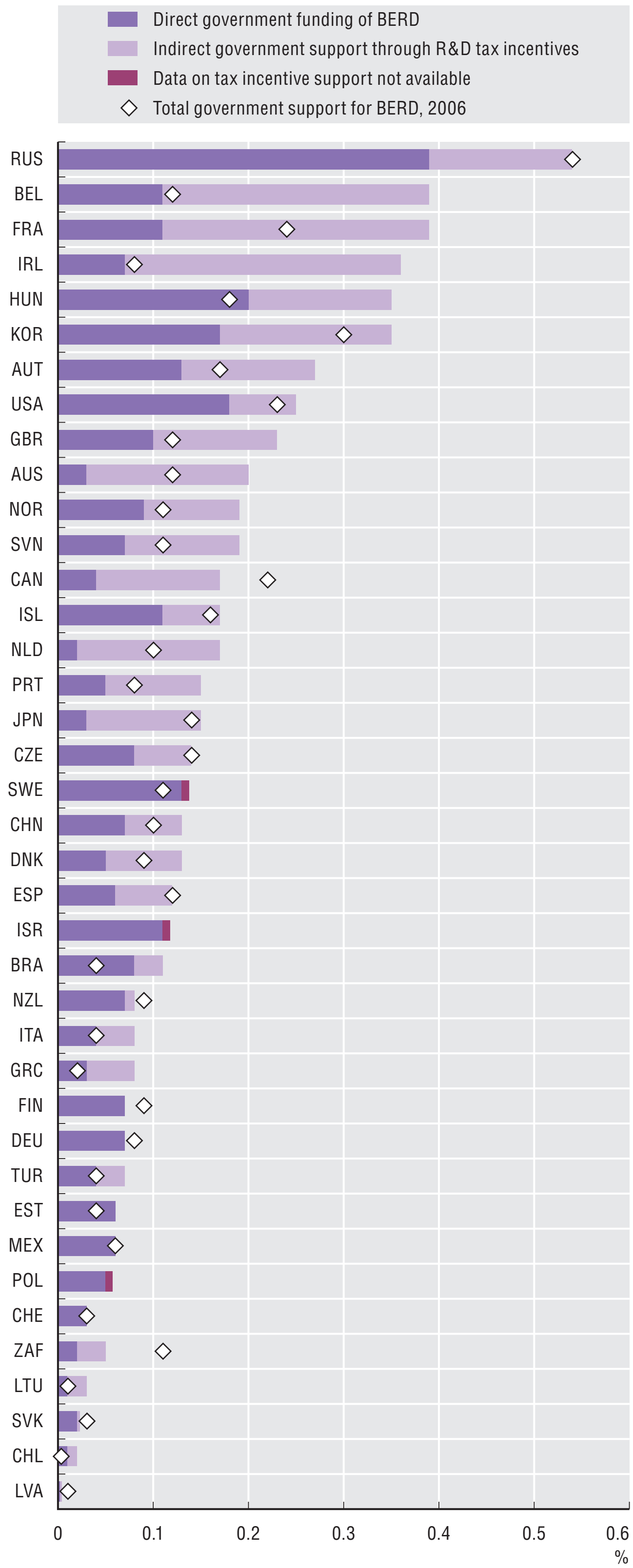
Measurability

A wide range of methodological features impact on the comparability of innovation indicators, in particular those relating to the incidence of innovations. Major drivers of challenges to international comparability include whether countries collect information on innovation within R&D surveys or not (which influences how respondents frame new and improved products and processes), and differences in the extent to which survey response is mandatory. Although an effort has been made by national correspondents to align differences in reference period, as well as sectoral and firm size coverage for non-European countries with the "core" coverage of the Community Innovation Survey (CIS), this was not always possible. Qualitative incidence indicators based on the concept of at least one innovation of a given type do not provide a full view of an economy's innovation intensity, especially if results are weighted on the basis of counts of businesses. These issues are being addressed as part of the ongoing revision of the Oslo Manual.

6. R&D tax incentives

Direct government funding and tax support for business R&D, 2015

As a percentage of GDP



Source: OECD, R&D Tax Incentive Indicators, *http://oe.cd/rdtax*, July 2017. StatLink contains more data. See chapter notes.

StatLink *http://dx.doi.org/10.1787/888933619410*

Did you know?

In 2015, R&D tax incentives accounted for nearly half of total government support for business R&D in the OECD area, up from one-third in 2006.

R&D tax incentives have become a major tool for promoting business R&D in OECD and partner economies. In 2017, 30 OECD countries gave preferential tax treatment to business R&D expenditures, up from 16 OECD countries in 2000. Over the 2006-15 period, total government support for business R&D expenditure as a percentage of GDP increased in 25 out of 37 countries for which data are available, with the Russian Federation, Belgium and France providing the largest support as a percentage of GDP in 2015.

A comparison of public support provided in 2006 and 2015 shows an increase in the relative importance of tax incentives among 22 out of 33 countries for which data are available. Canada, Hungary and Portugal, starting from a high share of tax support, rebalanced their support mix by increasing their reliance on direct funding. Mexico abolished its previous tax relief scheme in 2009, but reintroduced the instrument in 2017.

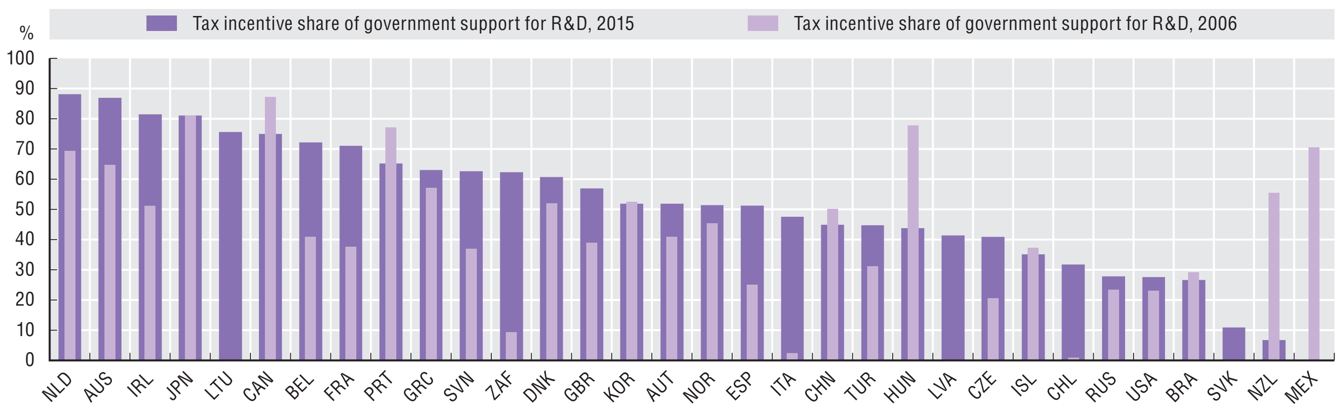
Differences in the cost of R&D tax relief reflect not only applicable credit or allowance rates, but also eligibility rules and application decisions by firms. It is possible to calculate the notional level of tax support per additional unit of R&D to which firms with defined characteristics are in principle entitled. This level is largest for France, Portugal and Spain in the case of SMEs. Refunds and carry-forward provisions are sometimes used to promote R&D in firms that may not otherwise use their credits or allowances. 18 OECD countries offer refundable (payable) or equivalent incentives. Provisions such as these tend to be more generous for SMEs and young firms vis-à-vis large enterprises, as in the cases of Australia, Canada and France.

Definitions

Tax incentives for business R&D include allowances and credits, as well as other forms of advantageous tax treatment of business R&D expenditure. Estimates exclude income-based incentives such as patent boxes and incentives to taxpayers other than firms. The tax subsidy rate is calculated as 1 minus the B-index, a measure of the "before-tax income needed to break even on an additional unit of R&D outlay" (Warda, 2001). This measure of marginal tax support may differ from the average tax subsidy rate if ceilings and thresholds apply and some firms are prevented from claiming extra support. Each measure can be relevant for R&D investment decisions – the average at the extensive margin (whether to invest in a country), and the marginal at the intensive margin (how much to invest within a country).

Change in government support for business R&D through direct funding and tax incentives, 2006 and 2015

As a percentage of total support

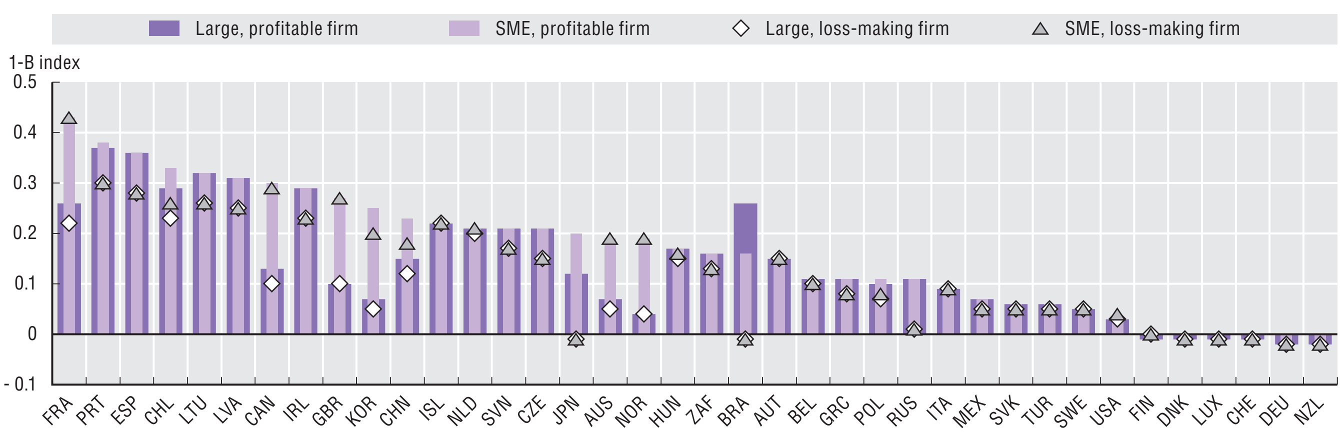


Source: OECD, R&D Tax Incentive Indicators, *http://oe.cd/rdtax*, July 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933619429

Tax subsidy rates on R&D expenditures, 2017

1-B-Index, by firm size and profit scenario



Source: OECD, R&D Tax Incentive Indicators, *http://oe.cd/rdtax*, July 2017. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933619448

Measurability

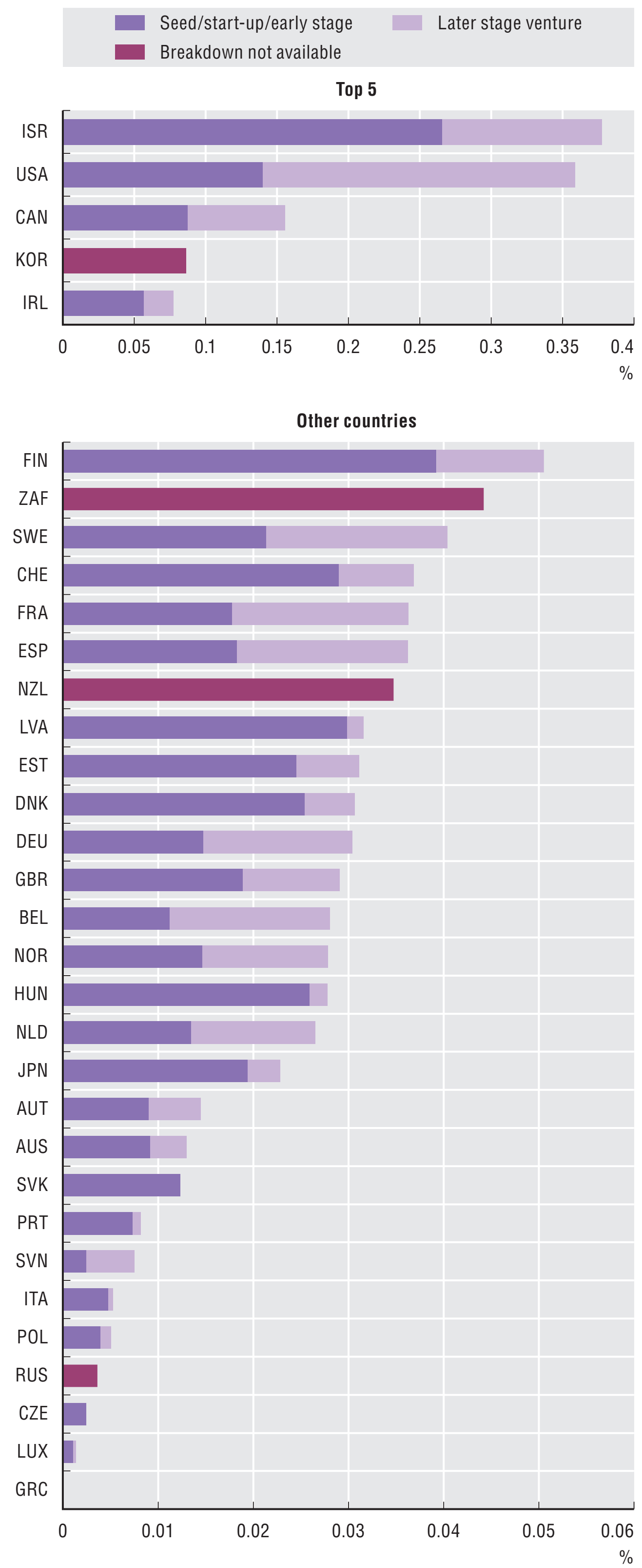
There are several ways to measure the value of R&D tax relief, as tax expenditures represent deviations from a benchmark tax system (OECD, 2010). These indicators adopt a common reference framework based on full deductibility of current R&D and a country's treatment of capital investments. Estimates are typically based on tax records and calculated in terms of initial revenue loss with no or minimal adjustments for behaviour effects. The latest edition of the Frascati Manual (OECD, 2015) summarises the guidance on reporting data on tax relief for R&D.

To provide a more accurate representation of different scenarios, B-indices are calculated for "representative" firms according to whether they can claim tax benefits against their tax liability in the reporting period. When credits or allowances are fully refundable, the B-index of a firm in such a position is identical to the profit scenario. Carry-forwards are modelled as discounted options to claim incentives in the future. Adjustments for ceilings on claimable R&D or tax relief are modelled whenever possible (see chapter notes).

7. Policy environment and demand for innovation

Venture capital investment, 2016

As a percentage of GDP



Source: OECD, based on OECD (2017a), *Entrepreneurship at a Glance 2017*, OECD Publishing. Paris. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933619467

Did you know?

In most countries, large innovating firms are more likely to benefit from public support for innovation than their SME counterparts.

The policy environment plays an important role in encouraging factors that promote the supply and demand for innovation in the economy. Access to finance and markets are among the main challenges experienced by firms aiming to introduce new products or adopt new and improved practices.

Young innovative firms encounter difficulties in obtaining seed and early stage financing because of uncertain profit expectations and riskier growth perspectives. Venture capital investments have not recovered to pre-crisis levels in most countries and showed few signs of improvement in 2016. Likewise, public equity markets have remained stagnant in recent years (OECD, 2017b). There are wide differences in the size of venture capital activities across countries. Relative to the size of the economy, venture capital investments in Canada, Israel and the United States are much higher than those found in Europe. It should also be noted that venture and growth capital investments are much less commonly used than other funding sources, such as bank lending, asset-based finance or trade credit.

Participation in international and public sector markets is a major source of demand for innovation. Access to both types of markets is more common among larger firms than among SMEs and, with remarkably few exceptions, is far more likely among innovative than non-innovative firms.

In addition to providing a source of demand for new products, governments support innovation by subsidising the cost of innovation activities in firms. In most countries, large innovating firms are more likely to receive public support for innovation than their SME counterparts, especially because the latter are less likely to undertake R&D-based forms of innovation.

Definitions

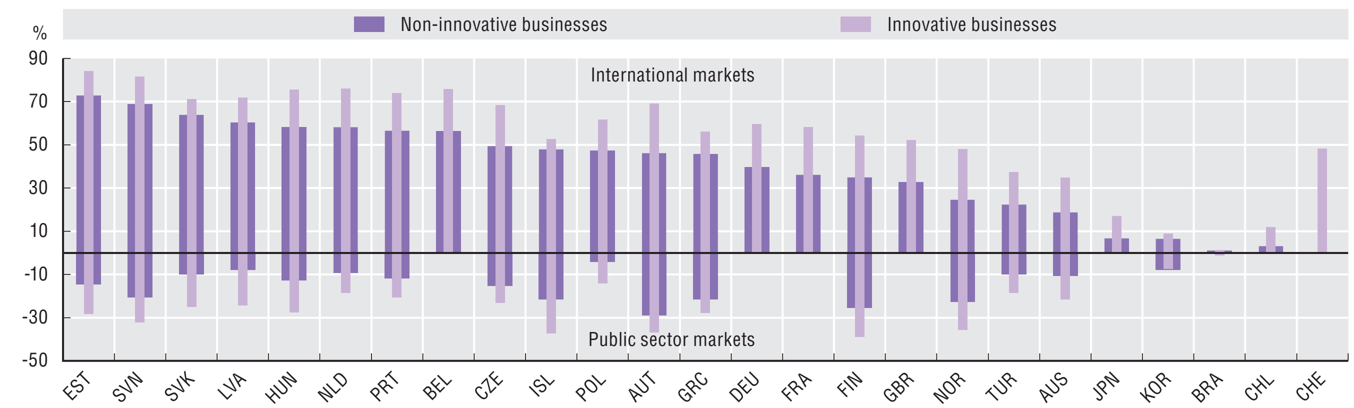
Venture capital is private capital provided by specialised firms acting as intermediaries between primary sources of finance (insurance, pension funds, banks, etc.) and private start-up and high-growth companies whose shares are not freely traded on any stock market.

Participation in international markets is defined as firms selling goods or services to customers abroad. Public sector markets refer to government-controlled organisations such as local, regional and national administrations and agencies, schools, hospitals and government service providers.

Public support for innovation includes financial support via tax credits or deductions, grants, subsidised loans and loan guarantees. Countries use slightly different formulations of this question.

SMEs participating in international and public sector markets, by innovation status, 2012-14

As a percentage of businesses in the relevant category

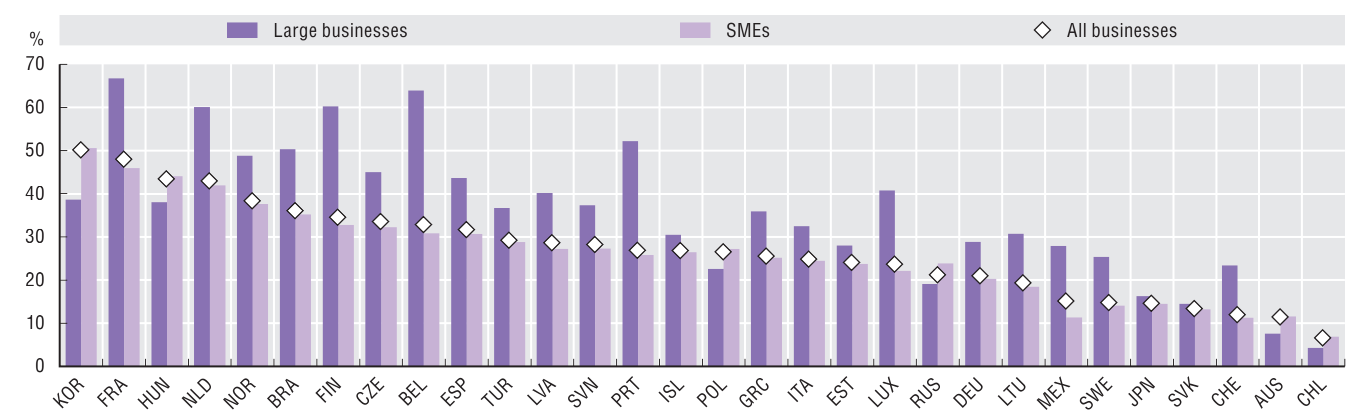


Note: International comparability may be limited due to differences methodologies and country-specific response patterns. European countries follow harmonised survey guidelines with the CIS.
Source: OECD, based on the 2017 OECD survey of national innovation statistics and Eurostat Community Innovation Survey (CIS-2014), June 2017. *http://oe.cd/inno-stats*. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933619486

Businesses receiving public support for innovation, by size, 2012-14

As a percentage of product and/or process-innovating businesses in each size category



Note: International comparability may be limited due to differences methodologies and country-specific response patterns. European countries follow harmonised survey guidelines with the CIS.
Source: OECD, based on the 2017 OECD survey of national innovation statistics and Eurostat Community Innovation Survey (CIS-2014), June 2017. *http://oe.cd/inno-stats*. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933619505

Measurability

Data on venture capital are drawn from national or regional venture capital associations and commercial data providers. There is not a standard international definition of venture capital or the breakdown by stage of development. The OECD Entrepreneurship Financing Database aggregates original data to fit the OECD classification of venture capital by stages.

Questions included in innovation surveys provide evidence of the markets served by business and the extent to which they receive government support such as grants, subsidised loans and loan guarantees. The OECD has recently explored ways to measure the link between public procurement and innovation (Appelt and Galindo-Rueda, 2016), and recommends the use of targeted questions and innovation survey microdata to investigate the relationship between demand and innovation. The ongoing revision of the Oslo Manual on measuring innovation in firms is addressing requests for guidance to collect comparable evidence on the external drivers of business innovation.

Notes and references

Cyprus

The following note is included at the request of Turkey:

"The information in this document with reference to 'Cyprus' relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognizes the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Turkey shall preserve its position concerning the 'Cyprus issue'."

The following note is included at the request of all of the European Union Member States of the OECD and the European Union:

"The Republic of Cyprus is recognized by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus."

Israel

"The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities or third party. 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.

"It should be noted that statistical data on Israeli patents and trademarks are supplied by the patent and trademark offices of the relevant countries."

4.1 Business R&D

Business R&D, 2005 and 2015

These statistics are based on the OECD Main Science and Technology Indicators Database (*http://oe.cd/msti*). For more information on these data, including on issues such as breaks in series, please see that source.

For Australia, data refer to 2004 and 2013.

For Chile, data refer to 2007 and 2015.

For Ireland, data refer to 2014.

For Israel, defence R&D is partly excluded from available estimates.

For South Africa, data refer to 2013.

For Switzerland, data refer to 2004 and 2015.

Business R&D and government support for business R&D, by size, 2015

For BERD and government-funded BERD, SMEs figures refer to enterprises with less than 250 persons employed.

These statistics are based on the OECD R&D Statistics database (*http://oe.cd/rds*). For more information on these data, including on issues such as breaks in series, please refer to this source.

For Austria, data refer to 2004 and 2013.

For Belgium, Canada, Denmark, Luxembourg and Sweden, data refer to 2013.

For Chile and New Zealand, data refer to 2007 and 2015.

For France, data refer to 2006 and 2013, for which data were partially available. For the year 2013, estimates based on 2012 breakdowns and 2013 totals were made to complete the series.

For Italy and the Netherlands, data refer to 2003 and 2014.

For Japan, firms with less than JPY 10 million in capital are excluded from the scope of R&D surveys. This leads to overstatement of the share of R&D accounted for large firms.

For Latvia, Poland, Portugal and Slovenia, data refer to 2014.

For Luxembourg, the 2013 SME's share of government-funded BERD is not available for confidentiality reasons.

For the Netherlands, firms with less than 10 employed persons are excluded from the scope of R&D surveys.

For Switzerland, data refer to 2004 and 2015.

For the United Kingdom, data refer to 2006 and 2014.

For the United States, figures reported refer to current expenditures, but include a depreciation component which may differ from the actual level of capital expenditure. In addition, the Business R&D and Innovation Survey does not include companies with fewer than five employees and excludes data for federally funded research and development centres.

R&D intensity by industry, 2015

R&D intensity has been calculated for each industry, where both R&D and Value Added (VA) data were available. These ratios are sensitive to the statistical units used in both frameworks. A broader discussion about coherence between the numerator and the denominator is available in Galindo-Rueda, F. and F. Verger (2016), "OECD Taxonomy of Economic Activities Based on R&D Intensity", *OECD Science, Technology and Industry Working Papers,* No. 2016/04, OECD Publishing, Paris. DOI: *http://dx.doi.org/10.1787/5jlv73sqqp8r-en*. In particular, national practices differ in respect to the treatment of large and complex multi-activity enterprises and those firms specialised in providing R&D services.

Figures are based on estimates of business R&D by industry reported on a main activity basis, in ISIC Rev.4.

The terms "ICT equipment" and "information services" refer to ISIC Rev.4 26 and 58-63, respectively.

For Australia, Austria, Belgium, Canada, France, Greece, Ireland, Korea and Sweden, data refer to 2013.

For Denmark, Finland, Germany, Hungary, Italy, the Netherlands, Poland, Portugal, Slovenia, Spain, the United Kingdom and the United States, data refer to 2014.

Value added is measured at basic prices except for Japan (purchasers' prices).

Data on value added come from the OECD STructural ANalysis (STAN) Database except for Chile, Hungary, Iceland, Ireland, Korea, New Zealand and Turkey (OECD National Accounts Statistics), Canada (national source) and Australia (OECD National Accounts Statistics and, estimates based on ABS Australian National Accounts: Input-Output Tables, 2013-14, for manufacturing industries).

4.2 Top R&D players

R&D investment per patent of top corporate R&D investors by headquarters' location, 2012-14

Data relate to countries featuring at least five companies' headquarters in the top 2 000 corporate R&D investors sample having filed for patents in 2012-14. R&D expenditures are presented in USD million. Patent data refer to IP5 patent families by first filing date owned by the top R&D companies.

Industries are defined according to ISIC Rev.4. The ICT sector covers ICT manufacturing industries (classes 2610, 2620, 2630, 2640 and 2680), ICT trade industries (4651 and 4652), ICT services industries (5820), Telecommunications (61), Computer programming (62), Data processing (631), and Repair of computers and communication equipment (951).

Industrial and technological specialisation of top R&D investors, 2012-14

Industry specialisation (concentration ratio – IS4) is the share of the top 4 industries of companies' affiliates in the total number of affiliates of top R&D investors performing in a given industry. Industries are defined according to ISIC Rev.4.

Technology specialisation (concentration ratio – TS4) is the share of companies' patent portfolio filed in the top 4 technology fields in which they patent in the total number of patents filed by top R&D companies performing in a given industry. Data refer to IP5 patent families by the first filing date owned by the top R&D companies. Patents are allocated to technology fields on the basis of their International Patent Classification (IPC) codes, following the concordance provided by WIPO (2013).

Data relate to industries featuring at least 10 companies' headquarters in the top 2 000 corporate R&D sample.

Net sales per trademark of top corporate R&D investors in the ICT sector, by headquarters' location, 2012-14

Data relate to countries featuring at least five companies' headquarters in the top 2 000 corporate R&D investors sample having filed for trademarks in 2012-14. Net sales are presented in USD million. Trademark data refer to new trademark applications filed at the EUIPO, the JPO and the USPTO, by filing date, owned by the top R&D companies.

Industries are defined according to ISIC Rev.4. The ICT sector covers ICT manufacturing industries (classes 2610, 2620, 2630, 2640 and 2680), ICT trade industries (4651 and 4652), ICT services industries (5820), Telecommunications (61), Computer programming (62), Data processing (631), and Repair of computers and communication equipment (951).

4.3 IP bundles

ICT-related patents, 2002-05 and 2012-15

Data refer to IP5 families, by filing date, according to the applicants' residence using fractional counts. Patents in ICT are identified using the list of IPC codes in Inaba and Squicciarini (2017). Only economies with more than 250 patents families in the periods considered are included. 2014 and 2015 figures are estimated based on available data for those years.

ICT-related trademarks, 2012-15

Data refer to trademarks filed at the European Union Intellectual Property Office (EUIPO), the Japan Patent Office (JPO) and the US Patent and Trademark Office (USPTO), by filing date, according to the applicants' residence using fractional counts. ICT-related trademarks refer to trademark applications designating classes 9, 28, 35, 38, 41 and/or 42 of the Nice Classification and containing ICT-related keywords in the goods and services description (complete list of keywords available on demand). Shares are calculated for countries with more than 250 trademarks filed at the EUIPO or the USPTO and more than 25 trademarks filed at the JPO during the period considered.

ICT-related designs, 2012-15

Data refer to design applications filed at the European Union Intellectual Property Office (EUIPO) and the Japan Patent Office (JPO), and design patents filed at the US Patent and Trademark Office (USPTO), by filing date, according to the applicants' residence using fractional counts. ICT-related designs refer to subclasses 14-01 to 14-04, 14-99, 16-01 to 16-06, 16-99, 18-01 to 18-04, 18-99 of the Locarno Classification. Shares are calculated for countries with more than 100 designs filed at the EUIPO or 100 design patents at the USPTO and more than 25 designs filed at the JPO during the period considered.

4.4 ICT and innovation

R&D expenditure by ICT equipment and information services industries, 2015

Figures are based on estimates of business R&D by industry reported on a main activity basis, in ISIC Rev.4.

These statistics are based upon OECD R&D Statistics (*http://oe.cd/rds*) and ANBERD (*http://oe.cd/anberd*) Databases. For more information on these data, including on issues such as breaks in series, please see those sources.

For Austria, Belgium, Greece and Ireland, data refer to 2013.

For Canada, Denmark, Finland, Hungary, Israel, Italy, the Netherlands, Poland, Portugal, Slovenia, the United Kingdom and the United States, data refer to 2014.

For Estonia, Germany and Japan, data refer to 2007 and 2015.

For France and Sweden, data refer to 2007 and 2013.

For Switzerland, data refer to 2004 and 2015.

Patents in ICT-related technologies and major players, 2012-15

Data refer to IP5 families, by filing date, according to the applicants' residence using fractional counts. Patents in ICT are identified using the list of IPC codes in Inaba and Squicciarini (2017). 2014 and 2015 figures are estimated based on available data for those years.

Innovative businesses in ICT manufacturing and information and communication services, 2012-14

International comparability may be limited due to differences in innovation survey methodologies and country-specific response patterns. European countries follow harmonised survey guidelines with the Community Innovation Survey. Please see *www.oecd.org/sti/inno-stats.htm* for more details.

ICT manufacturing refers to ISIC Rev.4 Division 26 (Manufacture of computer, electronic and optical products), while manufacturing refers to Section C. Information and communication services comprise the entire ISIC Rev.4 Division J, while services refer to Sections and Divisions B, C, D, E, G46, H, J, K and M71-72-73.

For countries following the Eurostat CIS 2014, data on innovative enterprises include product, process, organisational or marketing innovative firms (including ongoing or abandoned innovation activities). The Industry core coverage includes ISIC Rev.4 Sections and Divisions B, C, D, E, G46, H, J, K and M71-72-73. Only enterprises with 10 or more employees are covered.

For Australia, data come from the Business Characteristics Survey (BCS) and refer to the financial year 2014/15. Data on innovative enterprises include product, process, organisational or marketing innovative firms (including ongoing or abandoned innovation activities). The sectoral and size coverage of enterprises matches the CIS scope.

For Brazil, data come from the Brazil Innovation Survey 2014 (PINTEC) and refer to 2012-14. Data on innovative enterprises include product, process, organisational or marketing innovative firms (including ongoing or abandoned innovation activities). The industries surveyed differ from the CIS core coverage. ISIC Rev.4 Section E is not included and only a selection of services is covered (Divisions and groups: 592, 61, 62, 631, 71 and 72).

For Estonia, CIS-2014 data were the subject of a methodological review. This causes a break in series when comparing them to previous CIS editions.

For Japan, data come from the Japanese National Innovation Survey (J-NIS 2015). Data refer to the financial years 2012/13, 2013/14 and 2014/15. Data on innovative enterprises include product, process, organisational or marketing innovative firms (including ongoing or abandoned innovation activities). The sectoral and size coverage of enterprises matches the CIS scope.

For Korea, data come from the Korean Innovation Survey. The survey is carried out separately for manufacturing and services, but all data refer to the period 2013-15. Data on innovative enterprises include product, process, organisational or marketing innovative firms (including ongoing or abandoned innovation activities). The sectoral coverage is smaller than CIS for the industrial sector and includes ISIC Rev.4 Section C Manufacturing only. All services are covered except for Section (O) Public administration and defence; compulsory social security.

For New Zealand, data come from the Business Operation Survey (BOS) and refer to the financial years 2012/13 and 2013/14, and firms with six or more employees with an annual Goods and Services Tax (GST) turnover figure greater than NZD 30 000. Data on innovative enterprises refer to product, process, organisational and marketing innovating firms (including ongoing or abandoned innovation activities).

For Switzerland, data come from the Survey of Innovation Activities in the Swiss Economy, and refer to the period 2012-14. Data on innovative enterprises include product, process, organisational or marketing innovative firms (including ongoing or abandoned innovation activities).

4.5 Mixed modes of innovation

Innovation types, by business size, 2012-14

International comparability may be limited due to differences in innovation survey methodologies and country-specific response patterns. European countries follow harmonised survey guidelines with the Community Innovation Survey. Please see *www.oecd.org/sti/inno-stats.htm* for more details.

Size is calculated on the basis of numbers of persons employed. SMEs are defined as businesses with 10 to 249 employees and large firms as businesses with 250 employees or more.

For countries following the Eurostat CIS 2012, the data include ongoing or abandoned innovative activities. The Industry core coverage includes ISIC Rev.4 Sections and Divisions B, C, D, E, G46, H, J, K and M71-72-73. Only enterprises with 10 or more employees are covered.

For Australia, data come from the Business Characteristics Survey (BCS) and refer to financial year 2014/15. The data include ongoing or abandoned innovative activities. The sectoral and size coverage of enterprises matches the CIS scope.

For Brazil, data come from the Brazil Innovation Survey 2014 (PINTEC) and refer to 2012-14. The data do not include ongoing or abandoned innovative activities. The industries surveyed differ from the CIS core coverage. ISIC Rev.4 Section E is not included and only selected services are covered (Divisions and groups: 592, 61, 62, 631, 71 and 72).

For Chile, data come from the Chilean Innovation Survey 2015 and refer to 2013-14. The data do not include ongoing or abandoned innovative activities. The survey covers firms with more than UF 2 400 in annual revenue, no cut-off by size is applied. Sectoral coverage is larger for the industrial sector and besides CIS core activities includes: ISIC Rev.3 Sections A, Agriculture, hunting and forestry; B, Fishing and F, Construction. The services covered are ISIC Rev.3 (G, I, J and K).

For Estonia, CIS-2014 data were the subject of a methodological review. This causes a break in series when comparing them to previous CIS editions.

For Japan, data come from the Japanese National Innovation Survey (J-NIS 2015). Data refer to the financial years 2012/13, 2013/14 and 2014/15. The data include ongoing or abandoned innovative activities. The sectoral and size coverage of enterprises matches the CIS scope.

For Korea, data come from the Korean Innovation Survey. The survey is carried out separately for manufacturing and services, but both sets of data refer to 2013-15. Data do not include ongoing or abandoned innovative activities. The phrasing of the question on product innovation is slightly different from the guidelines given in the Oslo Manual. As a result, the introduction of new services by manufacturing firms or of new goods by service firms might be under reported. Sectoral coverage is smaller than CIS for the industrial sector and includes ISIC Rev.4 Section C Manufacturing only. All services are covered except for Section (O) Public administration and defence; compulsory social security.

For New Zealand, data come from the Business Operation Survey (BOS) and refer to the financial years 2012/13 and 2013/14, and firms with six or more employees with an annual Goods and Services Tax (GST) turnover figure greater than NZD 30 000. Data do not include ongoing or abandoned innovative activities. The sectoral and size coverage of enterprises matches the CIS scope.

For Switzerland, data come from the Survey of Innovation Activities in the Swiss Economy and refer to 2012-14. The data include ongoing or abandoned innovative activities. The sectoral and size coverage of enterprises matches the CIS scope.

New-to-market innovators, manufacturing and services, 2012-14

International comparability may be limited due to differences in innovation survey methodologies and country-specific response patterns. European countries follow harmonised survey guidelines with the Community Innovation Survey. Please see *www.oecd.org/sti/inno-stats.htm* for more details.

Manufacturing refers to ISIC Rev.4 Section C, while services refer to Sections and Divisions B, C, D, E, G46, H, J, K and M71-72-73.

For countries following the Eurostat CIS 2014, only enterprises with 10 or more employees are covered. The core coverage for services includes ISIC Rev.4 Sections and Divisions G46, H, J, K and M71-72-73.

For Australia, data come from the Business Characteristics Survey (BCS) and refer to financial year 2014/15. BCS does not have a single response for new to market, but combining New to Industry, New to Australia and New to World captures the same data (i.e. excludes new to firm only). The sectoral and size coverage of enterprises matches the CIS scope.

For Brazil, data come from the Brazil Innovation Survey 2014 (PINTEC) and refer to 2012-14. Data refer to product innovative enterprises with product innovation new to the national market. Only selected CIS core ISIC Rev.4 services are covered (Divisions and groups: 592, 61, 62, 631, 71 and 72).

For Chile, data come from the 9th Chilean Innovation Survey and refer to 2013-14. The survey covers firms with more than UF 2 400 in annual revenue, no cut-off by size is applied. The services covered are ISIC Rev.3 (G, I, J and K).

For Estonia, CIS-2014 data were the subject of a methodological review. This causes a break in series when comparing them to previous CIS editions.

For Japan, data come from the Japanese National Innovation Survey (J-NIS 2015). Data refer to the financial years 2012/13, 2013/14 and 2014/15. The sectoral and size coverage of enterprises matches the CIS scope.

For Korea, data come from the Korean Innovation Survey and refer to 2013-15. The phrasing of the question on product innovation is slightly different from the guidelines given in the Oslo Manual. As a result, the introduction of new services by manufacturing firms or of new goods by service firms might be under reported. Services coverage is larger than CIS core and includes all services except for Section (O) Public administration and defence; compulsory social security.

For New Zealand, data come from the Business Operation Survey (BOS) and refer to the financial years 2012/13 and 2013/14, and firms with six or more employees with an annual Goods and Services Tax (GST) turnover figure greater than NZD 30 000. BOS does not have a single response for new to market, but combining New to New Zealand and New to World captures the same data (i.e. excludes new to firm only).

For the Russian Federation, data refer to 2012-14 and firms with 15 or more employees. The industries surveyed differ from the CIS core coverage. ISIC Rev.3.1 Sections C, Mining and quarrying, D, Manufacturing, E, Electricity, gas and water supply and Divisions 64, 72, 73 and 74 for services are covered.

For Switzerland, data come from the Survey of Innovation Activities in the Swiss Economy, 2013. Data refer to 2010-12. The sectoral and size coverage of enterprises matches the CIS scope.

For the United States, data come from the Business R&D and Innovation Survey (BRDIS), 2014 and refer to 2012-14. The sectoral and size coverage of enterprises matches the CIS size and sectoral scope but item non response to new to the market product innovation question has been reported as non-new-to-market.

New-to-market innovators, by size, 2012-14

International comparability may be limited due to differences in innovation survey methodologies and country-specific response patterns. European countries follow harmonised survey guidelines with the Community Innovation Survey. Please see *www.oecd.org/sti/inno-stats.htm* for more details.

Size is calculated on the basis of numbers of persons employed. SMEs are defined as businesses with 10 to 249 employees and large firms as businesses with 250 employees or more.

For countries following the Eurostat CIS 2014, the Industry core coverage includes ISIC Rev.4 Sections and Divisions B, C, D, E, G46, H, J, K and M71-72-73. Only enterprises with 10 or more employees are covered.

For Australia, data come from the Business Characteristics Survey (BCS) and refer to financial year 2014/15. BCS does not have a single response for new to market, but combining New to Industry, New to Australia and New to World captures the same data (i.e. excludes new to firm only).

For Brazil, data come from the Brazil Innovation Survey 2015 (PINTEC) and refer to 2012-14. Data refer to product innovative enterprises with product innovation new to their national market. Only selected CIS core ISIC Rev.4 services are covered (Divisions and groups: 592, 61, 62, 631, 71 and 72).

For Chile, data come from the 9th Chilean Innovation Survey and refer to 2013-14. The survey covers firms with more than UF 2 400 in annual revenue, no cut-off by size is applied. Sectoral coverage is larger for the industrial sector and besides CIS core activities includes: ISIC Rev.3 Sections A, Agriculture, hunting and forestry; B, Fishing and F, Construction. The services covered are ISIC Rev.3 (G, I, J and K).

For Estonia, CIS-2014 data were the subject of a methodological review. This causes a break in series when comparing them to previous CIS editions.

For Japan, data come from the Japanese National Innovation Survey (J-NIS 2015). Data refer to the financial years 2012/13, 2013/14 and 2014/15. The sectoral and size coverage of enterprises matches the CIS scope.

For Korea, data come from the Korean Innovation Survey. The phrasing of the question on product innovation is slightly different from the guidelines given in the Oslo Manual. As a result, the introduction of new services by manufacturing firms or of new goods by service firms might be under reported. The survey is carried out separately for manufacturing and services, but both sets of data refer to 2013-15. Sectoral coverage is smaller than CIS for the industrial sector and includes ISIC Rev.4 Section C Manufacturing only. All services are covered except for Section (O) Public administration and defence; compulsory social security.

For New Zealand, data come from the Business Operation Survey (BOS) and refer to the financial years 2012/13 and 2013/14, and firms with six or more employees with an annual Goods and Services Tax (GST) turnover figure greater than NZD 30 000. BOS does not have a single response for new to market, but combining New to New Zealand and New to World captures the same data (i.e. excludes new to firm only).

For the Russian Federation, data refer to 2012-14 and firms with 15 or more employees. The industries surveyed differ from the CIS core coverage. ISIC Rev.3.1 Sections C, Mining and quarrying, D, Manufacturing, E, Electricity, gas and water supply and Divisions 64, 72, 73 and 74 for services are covered.

For Switzerland, data come from the Survey of Innovation Activities in the Swiss Economy. Data refer to 2012-14. The sectoral and size coverage of enterprises matches the CIS scope.

For the United States, data come from the Business R&D and Innovation Survey (BRDIS), 2014 and refer to 2012-14. The sectoral and size coverage of enterprises matches the CIS size and sectoral scope but item non response to new to the market product innovation question has been reported as non-new-to-market.

4.6 R&D tax incentives

Direct government funding and tax support for business R&D, 2015

For more information on R&D tax incentives, see *http://oe.cd/rdtax*, and for general notes and country-specific notes for this R&D tax incentive indicator, see *http://oe.cd/sb2017_notes_rdtax*.

Change in government support for business R&D through direct funding and tax incentives, 2006 and 2015

For more information on R&D tax incentives, see *http://oe.cd/rdtax*, and for general notes and country-specific notes for this R&D tax incentive indicator, see *http://oe.cd/sb2017_notes_rdtax*.

Tax subsidy rates on R&D expenditures, 2017

This is an experimental indicator based on quantitative and qualitative information representing a notional level of tax subsidy rate under different scenarios. It requires a number of assumptions and calculations specific to each country. International comparability may be limited.

For more information on R&D tax incentives, see *http://oe.cd/rdtax*, and for general notes and country-specific notes for this R&D tax incentive indicator, see *http://oe.cd/sb2017_notes_rdtax*.

4.7. Policy environment and demand for innovation

Venture capital investment, 2016

The early stage includes: for Australia, pre-seed, seed and start-up stage; for Canada and the United States, seed and early stage; for European countries, seed and start-up stage; for Israel, seed/start-up stage and early/expansion stage and for Japan, seed, early stage and expansion stage.

The later stage includes: for Australia, early expansion stage and for the United States, expansion and later stage.

Korea, New Zealand, the Russian Federation and South Africa do not provide breakdowns of venture capital by stage that would allow for meaningful international comparisons.

For Japan and Israel, data refer to 2014.

For the United States, data include venture capital investments done by other investors alongside venture capital firms, but exclude investment deals that are 100% financed by corporations and/or business angels.

Data providers are: InvestEurope (European countries), ABS (Australia), CVCA (Canada), KVCA (Korea), NVCA (United States), NZVCA (New Zealand), PwCMoneyTree (Israel), RVCA (the Russian Federation), SAVCA (South Africa) and VEC (Japan).

SMEs participating in international and public sector markets, by innovation status, 2012-14

International comparability may be limited due to differences in innovation survey methodologies and country-specific response patterns. Please see *www.oecd.org/sti/inno-stats.htm* for more details.

The international and public sector market participation of firms within the scope of innovation surveys is compared according to the innovation status of firms. Innovative firms are defined as those which have introduced a new product, process, organisational or marketing methods over the reference period.

Size is calculated on the basis of numbers of persons employed. SMEs are defined as businesses with 10 to 249 employees and large firms as businesses with 250 employees or more.

For countries following the Eurostat CIS 2014 the Industry core coverage includes ISIC Rev.4 Sections and Divisions B, C, D, E, G46, H, J, K, and M71-72-73. Only enterprises with 10 or more employees are covered.

For Australia, data come from the Business Characteristics Survey (BCS). Data refer to financial year 2014/15. The sectoral and size coverage of enterprises matches the CIS scope.

For Brazil, data come from the Brazil Innovation Survey 2015 (PINTEC) and refer to 2012-14. The industries surveyed differ from the CIS core coverage. ISIC Rev.4 Section E is not included and only selected services are covered (Divisions and groups: 592, 61, 62, 631, 71 and 72).

For Chile, data come from the 9th Chilean Innovation Survey and refer to 2013-14. The survey covers firms with more than UF 2 400 in annual revenue, no cut-off by size is applied. Sectoral coverage is larger than CIS core for the industrial sector and also includes: ISIC Rev. 3 Sections A, Agriculture, hunting and forestry; B, Fishing and F, Construction. The services covered are ISIC Rev.3 (G, I, J and K).

For Estonia, CIS-2014 data were the subject of a methodological review. This causes a break in series when comparing them to previous CIS editions.

For Japan, data come from the Japanese National Innovation Survey (J-NIS 2015). Data refer to the fiscal years 2012/14, 2010/11 and 2011/12. The sectoral and size coverage of enterprises matches the CIS scope.

For Korea, data come from the Korean Innovation Survey. The survey is carried out separately for manufacturing and services, but data refer to the same period 2013-15. Sectoral coverage is smaller than CIS for the industrial sector and includes ISIC Rev.4 Section C Manufacturing only. All services are covered except for Section (O) Public administration and defence; compulsory social security.

For Switzerland, data come from the Survey of Innovation Activities in the Swiss Economy. Data refer to 2012-14. The sectoral and size coverage of enterprises matches the CIS scope.

Businesses receiving public support for innovation, by size, 2012-14

International comparability may be limited due to differences in innovation survey methodologies and country-specific response patterns. European countries follow harmonised survey guidelines with the Community Innovation Survey. Please see *www.oecd.org/sti/inno-stats.htm* and chapter notes for more details.

Size is calculated on the basis of numbers of persons employed. SMEs are defined as businesses with 10 to 249 employees and large firms as businesses with 250 employees or more.

For countries following the Eurostat CIS 2014 the data on public support for innovation include product or process innovative firms (including ongoing or abandoned innovation activities). The Industry core coverage includes ISIC Rev.4 Sections and Divisions B, C, D, E, G46, H, J, K and M71-72-73. Only enterprises with 10 or more employees are covered.

For Australia, data come from the Business Characteristics Survey (BCS) and refer to financial year 2014/15 and 2012/13. Data on public support for innovation include product, process, marketing and organisational innovative firms (including ongoing or abandoned innovation activities). The BCS asks a yes/no question as to whether government financial assistance has been received. The sectoral and size coverage of enterprises matches the CIS scope.

For Brazil, data come from the Brazil Innovation Survey 2015 (PINTEC) and refer to 2012-14 and 2009-11. Data on public support for innovation include product or process innovative firms (including ongoing or abandoned innovation activities). The industries surveyed differ from the CIS core coverage. ISIC Rev.4 Section E is not included and only selected services are covered (Divisions and groups: 592, 61, 62, 631, 71 and 72).

For Chile, data come from the 9th Chilean Innovation Survey and refer to 2013-14 and 2009-11. Data on public support for innovation include product, process, organisational and marketing innovative firms (ongoing or abandoned innovative activities are not identified). The survey covers firms with more than UF 2 400 in annual revenue, no cut-off by size is applied. The sectoral coverage is larger for the industrial sector and besides CIS core activities includes: ISIC Rev.3 Sections A, Agriculture, hunting and forestry; B, Fishing and F, Construction. The services covered are ISIC Rev.3 (G, I, J and K).

For Estonia, CIS-2014 data were the subject of a methodological review. This causes a break in series when comparing them to previous CIS editions.

For Japan, data come from the Japanese National Innovation Survey (J-NIS 2015 and J-NIS 2012). Data refer to the financial years 2012/13, 2013/14 and 2014/15 and to 2009/10, 2010/11 and 2011/12. Data on public support for innovation include product or process innovative firms (including ongoing or abandoned innovation activities). The sectoral and size coverage of enterprises matches the CIS scope.

For Korea, data come from the Korean Innovation Survey. The survey is carried out separately for manufacturing and services, but both sets of data refer to 2013-15 and 2011-13. Data on public support for innovation include product, process, organisational and marketing innovative firms (including ongoing or abandoned innovation activities). Sectoral coverage is smaller than CIS for the industrial sector and includes ISIC Rev.4 Section C Manufacturing only. All services are covered except for Section (O) Public administration and defence; compulsory social security.

For the Russian Federation, data refer to 2012-14 and 2009-11 and firms with 15 or more employees. Data on public support for innovation include product or process innovative firms (including ongoing or abandoned innovation activities). The industries surveyed differ from the CIS core coverage. ISIC Rev.3.1 Sections C, Mining and quarrying; D, Manufacturing; E, Electricity, gas and water supply and Divisions 64, 72, 73 and 74 for services, are covered.

For Switzerland, data come from the Survey of Innovation Activities in the Swiss Economy. Data refer to 2012-14 and 2010-12. The sectoral and size coverage of enterprises matches the CIS scope.

References

Appelt, S. and F. Galindo-Rueda (2016), "Measuring the link between public procurement and innovation", *OECD Science, Technology and Industry Working Papers*, No. 2016/03, OECD Publishing, Paris, *http://dx.doi.org/10.1787/5jlvc7sl1w7h-en*.

Inaba, T. and M. Squicciarini (2017), "ICT: A new taxonomy based on the international patent classification", *OECD Science, Technology and Industry Working Papers*, No. 2017/01, OECD Publishing, Paris, *http://dx.doi.org/10.1787/ab16c396-en*.

OECD (2017a), *Entrepreneurship at a Glance*. OECD Publishing, Paris, *http://dx.doi.org/10.1787/entrepreneur_aag-2015-en*.

OECD (2017b), *Financing SMEs and Entrepreneurs 2017: An OECD Scoreboard*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/fin_sme_ent-2017-en*.

OECD (2015), *Frascati Manual 2015: Guidelines for Collecting and Reporting Data on Research and Experimental Development*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/9789264239012-en*.

OECD (2010), *Tax Expenditures in OECD Countries*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/9789264076907-en*.

OECD/Eurostat (2005), *Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data, 3rd Edition*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/9789264013100-en*.

Warda, J. (2001), "Measuring the value of R&D tax treatment in OECD countries", *STI Review*, No. 27: Special Issue on New Science and Technology Indicators, OECD Publishing, Paris, *www.oecd.org/sti/37124998.pdf*.

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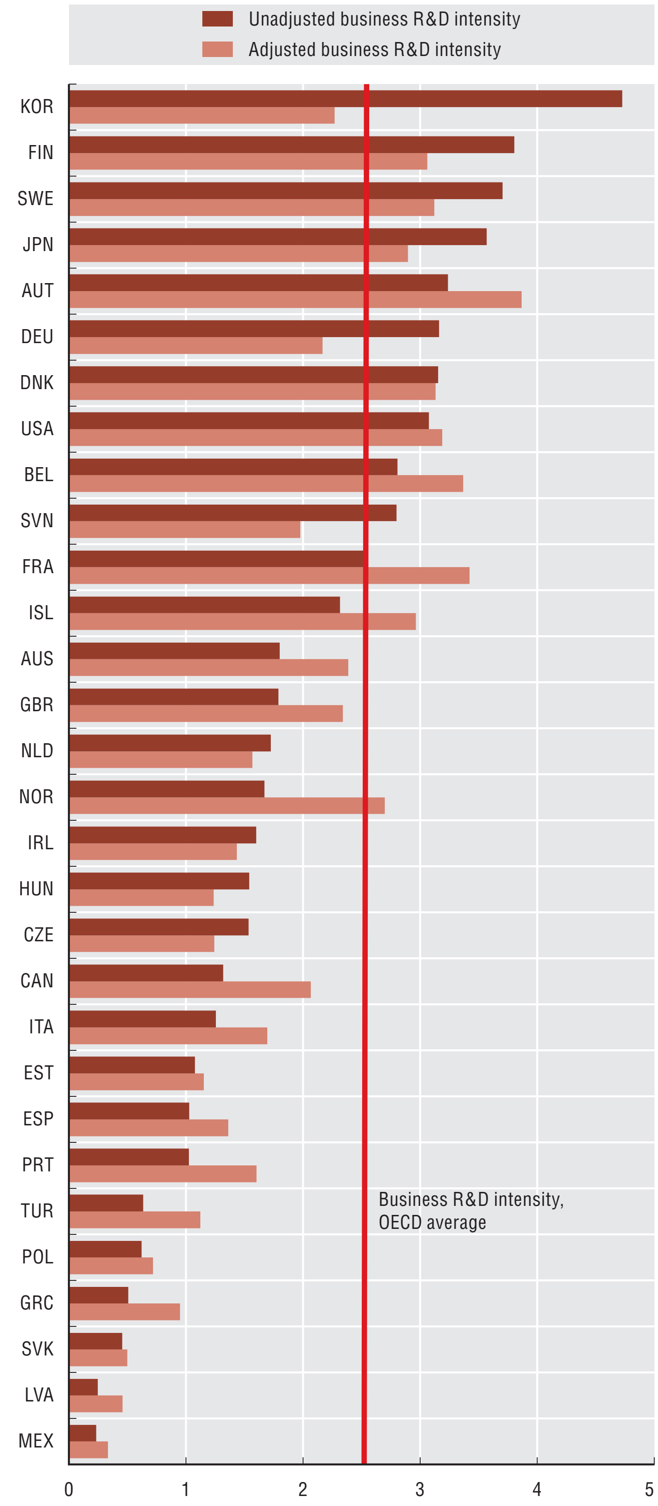
5. Leadership and competitiveness

1. R&D specialisation

Business R&D intensity adjusted for industrial structure, 2015

As a percentage of value added in industry



Source: OECD calculations based on the ANBERD Database, *http://oe.cd/anberd*, the National Accounts (SNA) Database, the Structural Analysis (STAN) Database, *http://oe.cd/stan*, Main Science and Technology Indicators Database, *http://oe.cd/msti*, and Research and Development Statistics Database, *http://oe.cd/rds*, June 2017. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933619524

Did you know?

Manufacturing industries account for over 85% of all business R&D carried out in China, Germany, Japan and Korea, while the OECD average is 54%.

When comparing countries' business R&D intensity (business R&D expenditure relative to value added), their relative specialisation in different industries with varying R&D intensities can impact the analysis. Comparison is facilitated by calculating the notional value of a country's business R&D intensity assuming it had an "OECD average industrial structure". If this were the case – and assuming countries retained their own R&D intensities within industries – adjusted business R&D intensity for Germany and Korea would be below the OECD average of 2.5%, because these economies are relatively specialised in R&D intensive industries. For Belgium and France, business R&D intensity would shift above the OECD average, because they are more specialised in less R&D-intensive industries, while Canada, Norway and the United Kingdom would converge towards the OECD average. For most Southern and Eastern European countries, the change would not greatly alter overall R&D intensity. The United States' industrial structure already closely resembles the OECD average.

R&D-intensive industries typically account for the largest share of business enterprise expenditure on R&D (BERD) in manufacturing. In most OECD countries, more than one-third of BERD is performed within service industries. This share has increased over the last decade, boosted in part by the role of information and communication service industries. Cross-country comparisons of the sectoral distribution of BERD should be made with care, however, as varying business structures and statistical practices can affect the extent to which R&D performers (including some involved in manufacturing-related R&D) are recorded in the specific R&D services industry – which may account for over half of all R&D in services industries.

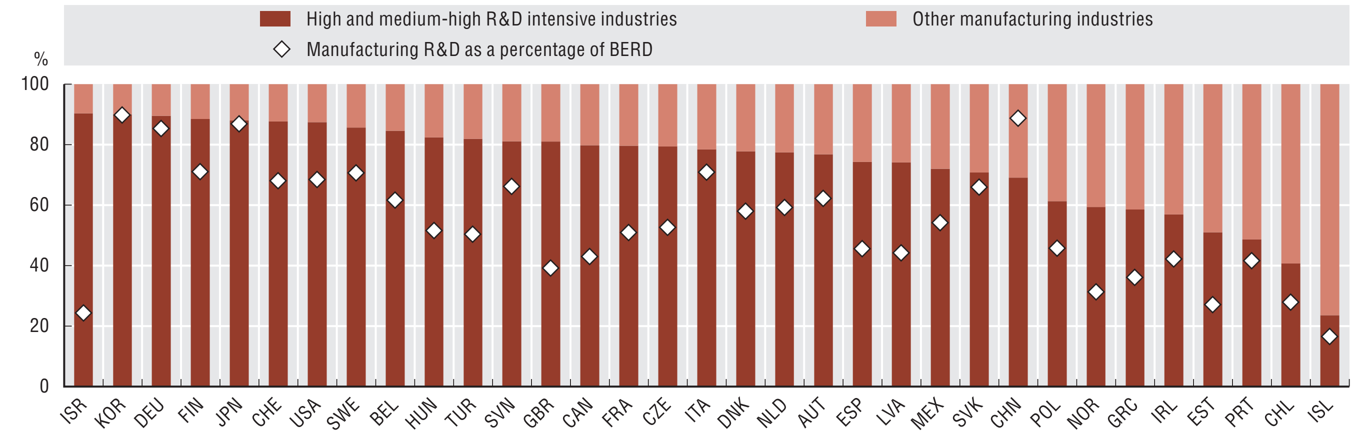
Definitions

R&D intensity adjusted for industry structure is a weighted average of the R&D intensities of a country's industrial sectors, using the OECD industrial structure's sector value added shares as weights instead of the actual shares used in the unadjusted measure of R&D intensity. Calculations are based on the ISIC Rev.4 classification.

The R&D intensity groups are defined in Galindo-Rueda and Verger (2016). High and medium-high R&D intensive manufacturing includes "chemicals and pharmaceutical products" (ISIC Rev.4 20 and 21) and "computer, electronic and optical products, electrical equipment, machinery, motor vehicles and other transport equipment" (ISIC Rev.4 26 to 30). R&D services correspond to ISIC Rev.4 Division 72.

Business R&D in manufacturing, by R&D intensity group, 2015

As a percentage of manufacturing R&D

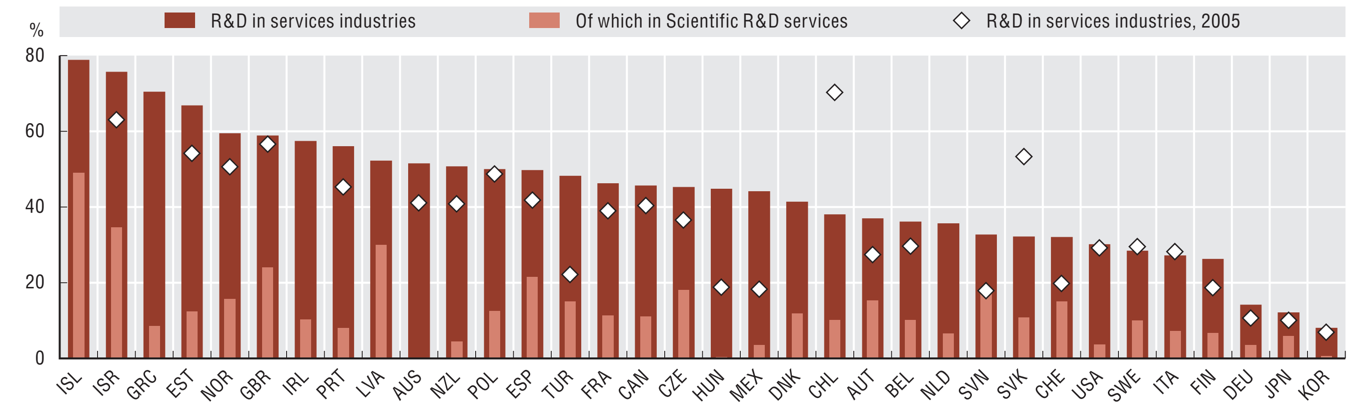


Source: OECD, ANBERD Database, *http://oe.cd/anberd*; Research and Development Statistics Database, *http://oe.cd/rds*, June 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933619543

R&D in services industries, 2015

As a percentage of business expenditure on R&D



Source: OECD, ANBERD Database, *http://oe.cd/anberd*; Research and Development Statistics Database, *http://oe.cd/rds*, June 2017. StatLink contains more data. See chapter notes.

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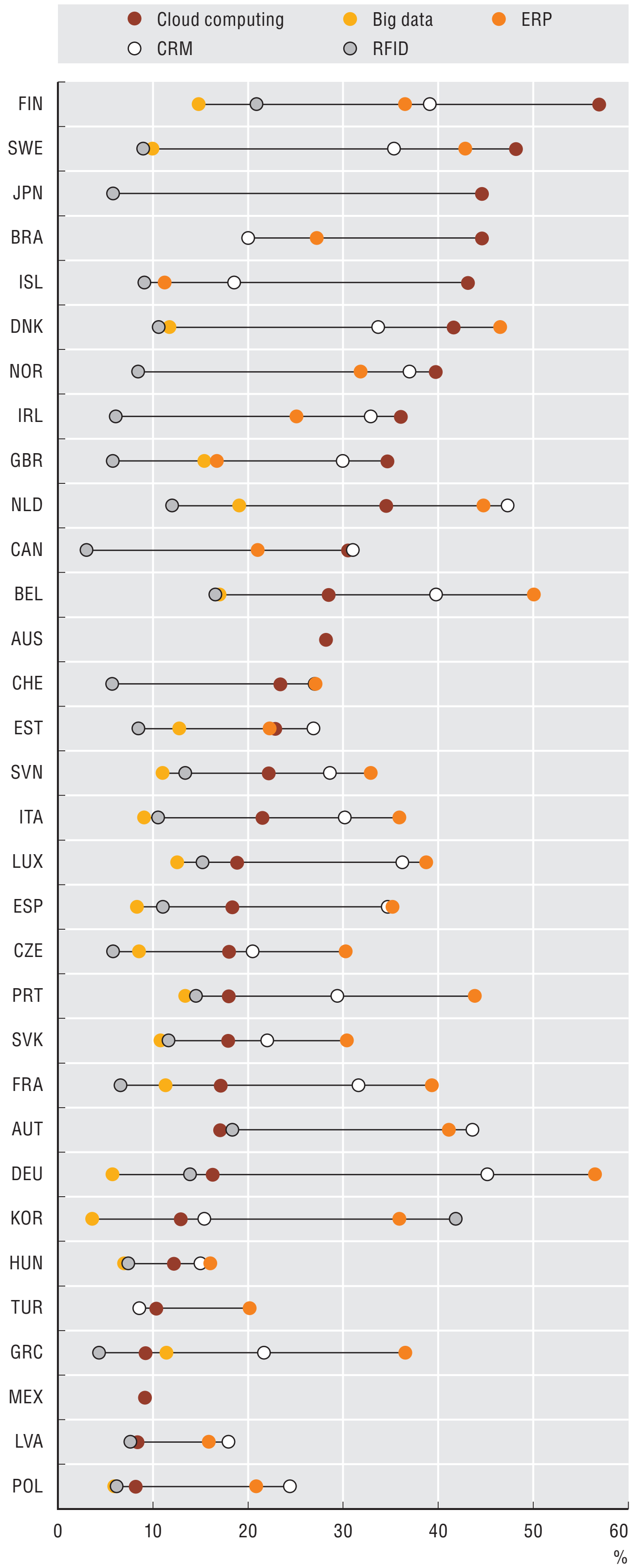
Measurability

Distributing R&D to industries presents several challenges. In most countries, R&D expenditure is assigned to a firm's principal industrial activity based on value-added ("main activity" approach). However, in some, allocation is based on the main R&D activity of the firm or the content of the R&D itself ("industry-orientation" approach). The Frascati Manual 2015 recommends classifying statistical units by their main activity and suggests that their R&D activities be classified both on that basis and by industry orientation. In practice, some countries use a combination of the two approaches. The methodology used to adjust R&D intensity for industrial structure is also sensitive to the industrial classification used. Other impacting factors are the level of aggregation at which the sectoral weights are calculated and the countries included in the benchmark. Countries where the disaggregation level for R&D is too low and where there are no comparable SNA data on Value Added by industry have been excluded.

2. E-business uptake

Diffusion of selected ICT tools and activities in enterprises, by technology, 2016

As percentage of enterprises with ten or more persons employed



Source: OECD, ICT Access and Usage by Businesses Database, *http://oe.cd/bus*, July 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933619581

Did you know?

In 2015-16, 95% of firms in reporting OECD countries had a broadband connection, but only 22% made sales via e-commerce.

Almost no business today is run without ICTs, but the extent to which countries integrate ICT tools into their business processes tends to vary across countries in line with firm and industry composition. Finland had the largest proportion of enterprises using cloud computing in 2016 (57%), but uptake of big data analytics was lower than in the Netherlands (19%) and Belgium (17%). Similarly, use of cloud services in Germany (16%) is lower than in the average OECD country (25%), but German enterprises account for the highest uptake of electronic resource planning (ERP, 57%) and the second highest usage of customer relationship management (CRM, 45%). Korea has the highest proportion of enterprises using radio frequency identification (RFID, 42%), but the lowest uptake of big data analytics (4%).

On average, 22% of OECD enterprises made sales via e-commerce in 2015, representing an increase of 3 percentage points only since 2009. Differences among countries remain large. In New Zealand, over half of enterprises reported making sales via e-commerce, compared to less than one in ten firms in Korea and Mexico.

Non-harmonised definitions of e-sales may explain some of these differences however the main cause seems to be the weight of smaller firms in economies. On average, 40% of larger firms engaged in e-sales in 2015, compared to only 20% of small enterprises.

Definitions

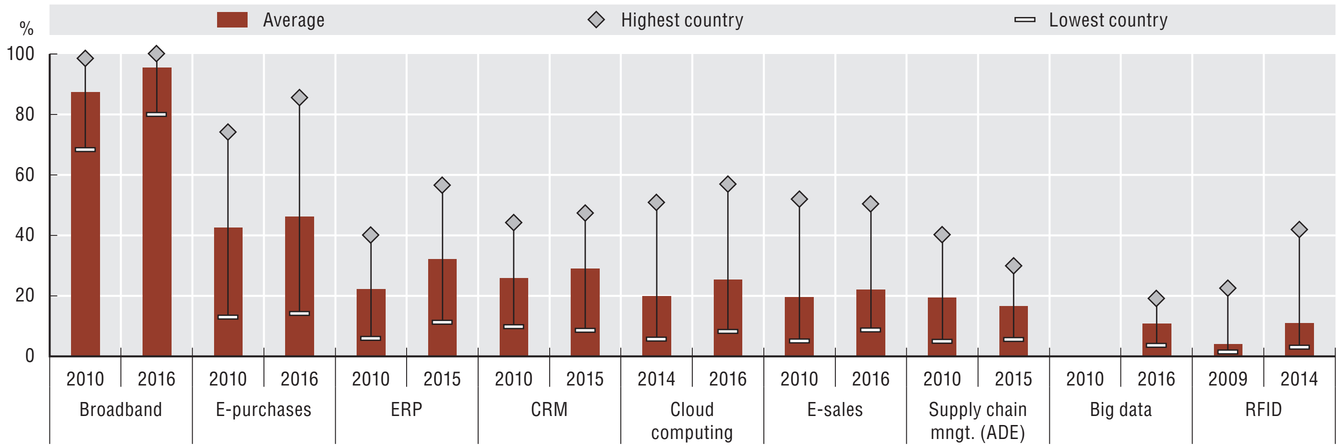
Broadband includes both fixed and mobile connections with an advertised download rate of at least 256 kbps. *Supply chain management* refers to the use of automated data exchange (ADE) applications. *Enterprise resource planning* (ERP) systems are software-based tools for managing internal information flows. *Customer relationship management* (CRM) is software for managing a company's interactions with customers, employees and suppliers. *Cloud computing* refers to ICT services over the Internet to access server, storage, network components and software applications. *Big data* refers to the analysis of vast amounts of data generated by activities carried out electronically and through machine-to-machine communications.

Size classes are defined as small (10-49 employees), medium (50-249 employees) and large (250 employees or more).

E-sales refer to the sale of goods or services conducted over computer networks by methods specifically designed for the purpose of receiving or placing orders (i.e. webpages, extranet or EDI), but not orders made by telephone, fax or manually typed e-mail.

Diffusion of selected ICT tools and activities in enterprises, OECD countries, 2010 and 2016

As a percentage of enterprises with ten or more persons employed



Source: OECD, ICT Access and Usage by Businesses Database, *http://oe.cd/bus*, July 2017. StatLink contains more data. See chapter notes.

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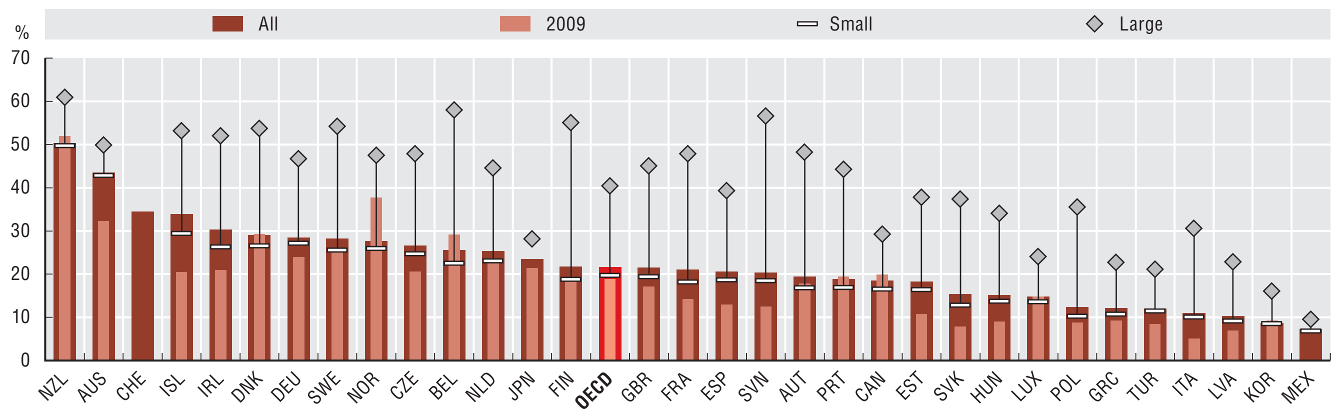
Enterprises engaged in sales via e-commerce, by size, 2015

As a percentage of enterprises in each employment size class



Source: OECD, ICT Access and Usage by Businesses Database, *http://oe.cd/bus*, July 2017. StatLink contains more data. See chapter notes.

StatLink *http://dx.doi.org/10.1787/888933619619*

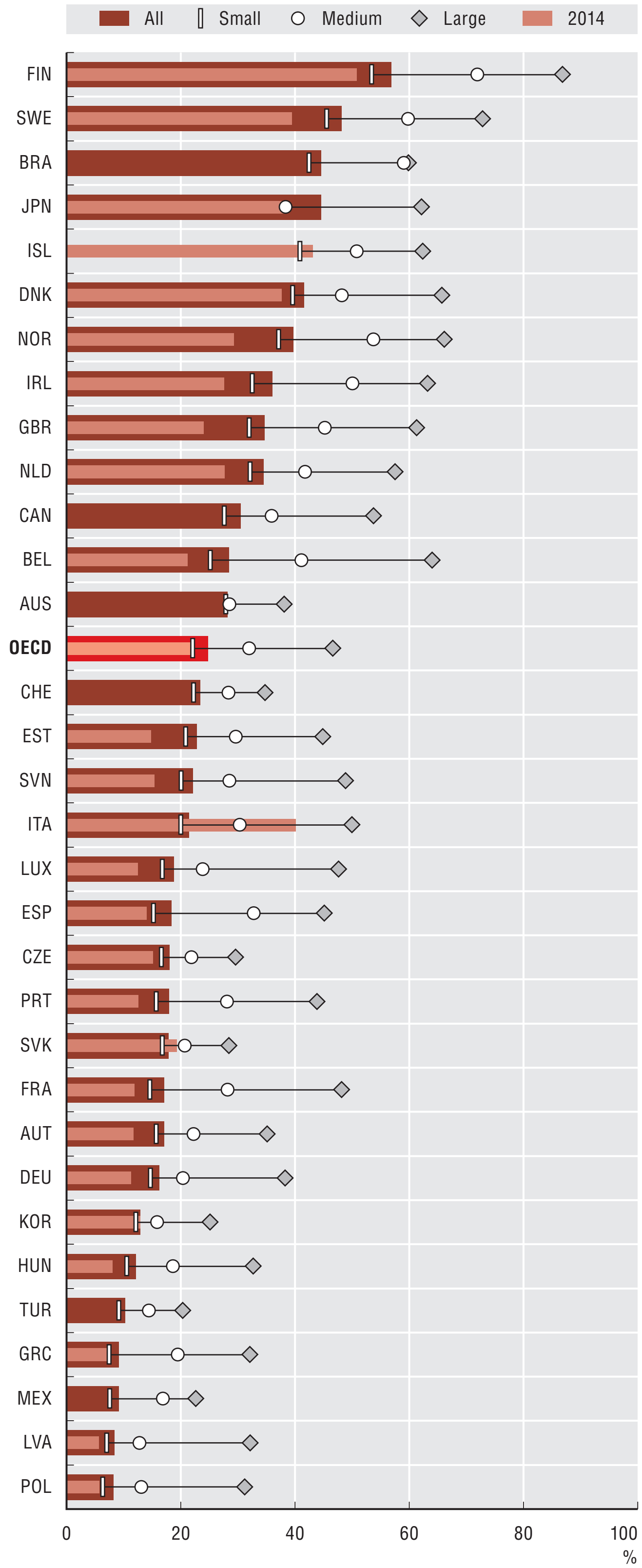
Measurability

Measurement of e-commerce presents several methodological challenges that can affect international comparability, such as the adoption of different practices for data collection and estimations, as well as the treatment of outliers and the extent of e-commerce carried out by multinationals. Other issues include differences in sectoral coverage of surveys and lack of measures concerning the actors involved (B2B, B2C, etc.). Convergence of technologies brings additional challenges for the treatment (and surveying) of emerging transactions, notably over mobile phones, via SMS or through the use of devices that enable near-field communication. Not all OECD countries undertake specific surveys on ICT usage by businesses. Aside from differences in the survey vehicle, the majority of indicators correspond to generic definitions, which can only proxy the functionalities and potential uses of ICT tools. For example, various software tools with different functionalities fall under the same ERP heading, and there are substantial differences in the sophistication of ERP systems and their degree of implementation. Cloud computing services and big data raise similar issues.

3. E-business across applications and sectors

Enterprises using cloud computing services, by size, 2016

As a percentage of enterprises in each employment size class



Source: OECD, ICT Access and Usage by Businesses Database, *http://oe.cd/bus*, July 2017. StatLink contains more data. See chapter notes.

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Did you know?

Over 25% of OECD businesses reported using cloud services in 2016, ranging from 57% in Finland to 8% in Poland.

Electronic business (e-business) can help drive business growth by expanding market reach, saving on costs and meeting customised demand. Cloud computing, in particular, is opening up an array of new business processes, as it allows firms, particularly young ones, to use and pay for on-demand computing services. Over 25% of businesses in the OECD reported using such services in 2016, up from 22% in 2014.

Intensity of use of cloud computing varies largely among countries and sectors, as well as between small and large firms. On average, only 22% of small firms in the OECD area use cloud services, against 32% in medium firms and 47% in large ones.

Differences across sectors and among countries for a given sector are large as well. The sector with the highest uptake by far is information and communication services where, on average, 51% of OECD firms use cloud services. Professional, scientific and technical activities are the second highest sector in terms of cloud uptake, with 38% of OECD firms using cloud services. The lowest share of firms using cloud services are, on average, retail trade (20%) and accommodation and food services (17%).

Diffusion of other ICT tools tends to vary among sectors. In 2016, sectoral differences regarding uptake among firms were largest for social media (46 percentage points) and customer relationship management (45), and smallest for broadband (8). Construction and accommodation and food services appear to be the sectors with the lowest diffusion of ICT tools and activities.

Definitions

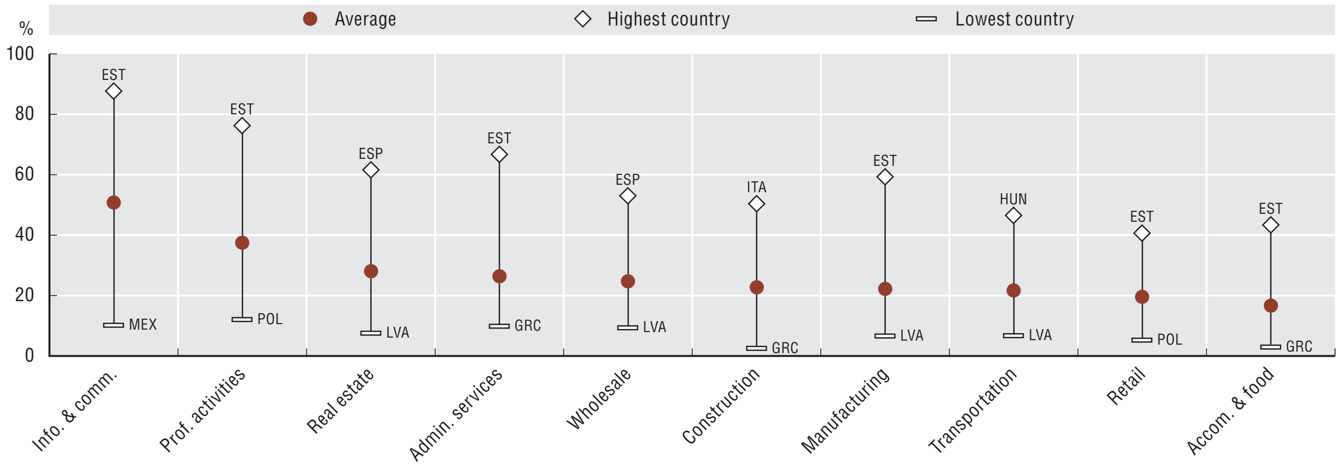
Cloud computing refers to ICT services over the Internet to access server, storage, network components and software applications.

Size classes are defined as small (10 to 49 persons employed), medium (50 to 249) and large (250 and more).

Broadband includes both fixed and mobile connections with an advertised download rate of at least 256 kbps. *Supply chain management* refers to the use of automated data exchange (ADE) applications. *Enterprise resource planning* (ERP) systems are software-based tools for managing internal information flows. *Customer relationship management* (CRM) refers to software for managing a company's interactions with customers, employees and suppliers. *Big data* refers to the analysis of huge amounts of data generated by activities carried out electronically and from machine-to-machine communications. *E-sales* refer to the sale of goods or services conducted over computer networks by methods specifically designed for the purpose of receiving or placing orders.

Uptake of cloud services in industries, OECD, 2016

As a percentage of enterprises with ten or more persons employed



Source: OECD, ICT Access and Usage by Businesses Database, *http://oe.cd/bus*, July 2017. StatLink contains more data. See chapter notes.

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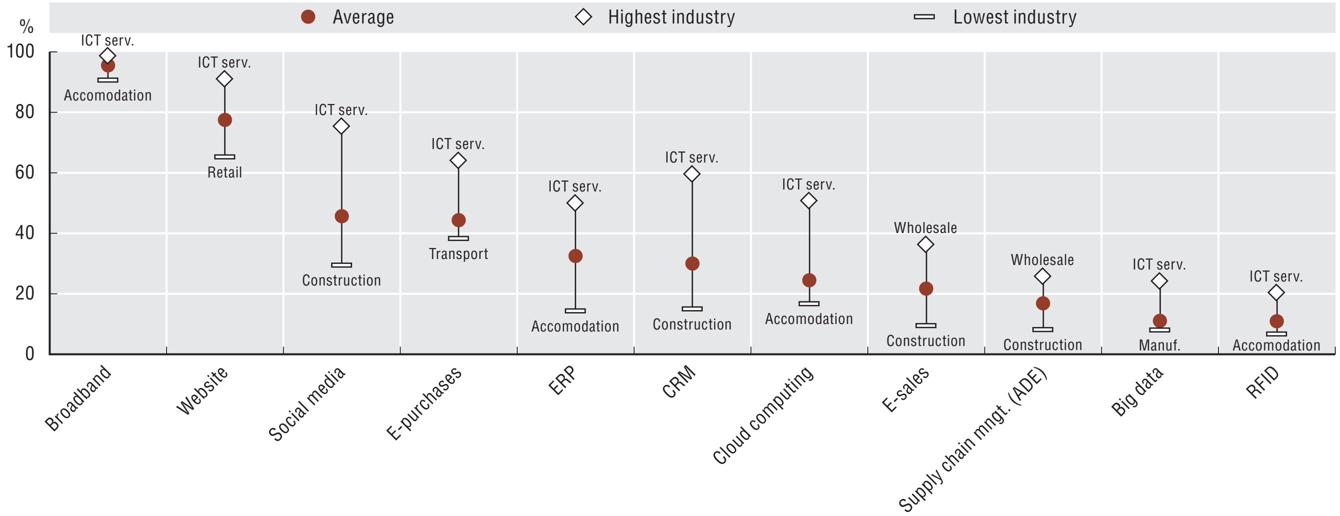
Diffusion of selected ICT tools and activities in industries, OECD, 2016

As a percentage of enterprises with ten or more persons employed



Source: OECD, ICT Access and Usage by Businesses Database, *http://oe.cd/bus*, July 2017. See chapter notes.

StatLink *http://dx.doi.org/10.1787/888933619676*

Measurability

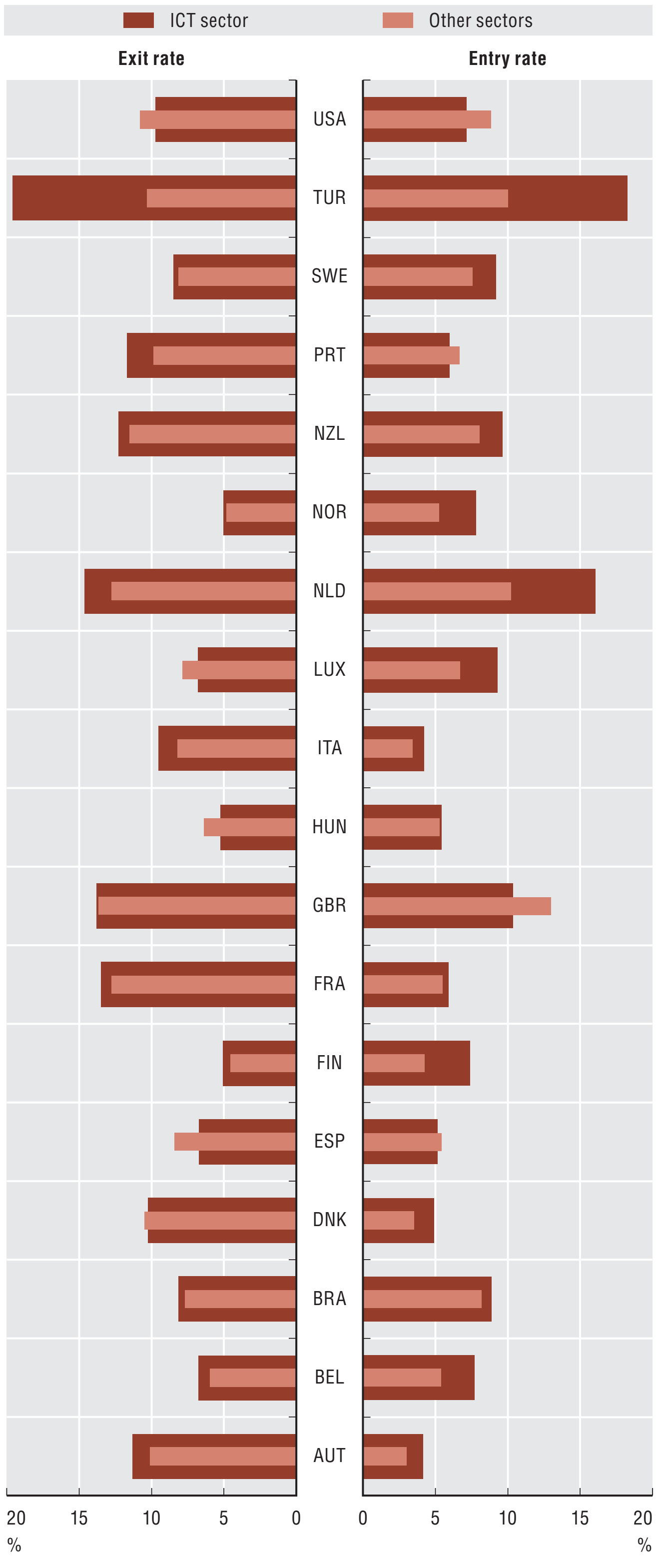
Not all OECD countries undertake specific surveys on ICT usage by businesses. Aside from differences in the survey vehicle, the majority of indicators correspond to generic definitions, which can only proxy ICT tools' functionalities and potential uses. For example, various software tools with different functionalities fall under the same electronic resource planning (ERP) heading, and there are substantial differences in the sophistication of ERP systems and their degree of implementation. Cloud services are a relatively new phenomenon compared to Web applications for customer relationship management (CMR) or ERP. One of the main challenges faced when measuring usage is the ability to make a clear distinction between cloud computing and other online services

Other issues include differences in sectoral coverage of surveys. Convergence of technologies brings additional challenges for the treatment (and surveying) of emerging transactions, notably over mobile phones, via SMS or using devices that enable near-field communication.

4. Start-up dynamics

Entry and exit rates in ICT and other business sectors, 2013-15

Number of entering/exiting units as a percentage of number of entering/exiting and incumbent units



Source: OECD calculations based on the DynEmp v.2 and v.3 Databases, preliminary data, *http://oe.cld/dynemp*, July 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933619695

Did you know?

In most countries, the ICT sector is more dynamic than other sectors, with a higher share of small and young businesses that also often grow faster.

The ICT sector exhibits higher entry and exit rates than other sectors in most of the countries covered in the OECD's DynEmp project. This is particularly driven by entry and exit in ICT services sectors (IT and other information services and telecommunications). High entry and exit rates may be associated with higher productivity-enhancing reallocation within those sectors.

The ICT sector tends to have a higher share of young micro and small incumbents when compared with other sectors of the economy. This result holds when ICT services are compared with other non-financial market services. More heterogeneous dynamics characterise the manufacturing sector, where differences between ICT and non-ICT manufacturing are small for many countries. As in the case of entry rates, however, this trend is reversed in the United Kingdom and the United States.

In all countries, young small firms grow faster than their older counterparts. In most cases, the difference in average employment growth between young small firms and old small firms is higher in the ICT sector than in other sectors of the economy. This confirms the widespread perception of higher dynamism in the ICT sector.

Definitions

The *ICT sector* includes ISIC Rev.4 Divisions 26, 61 and 62-63 (Computer and electronics, Telecommunications, and IT and other information services). Other sectors cover manufacturing and the non-financial business services sector excluding the ICT sector, Coke and refined petroleum products, and Real estate activities.

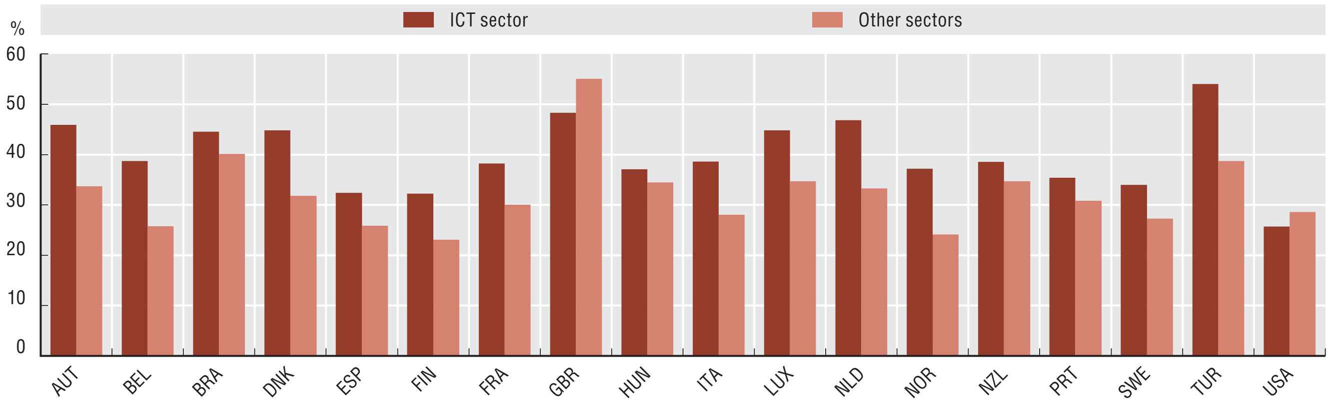
Entry rates are defined as the number of entering units over the sum of entering and incumbent units, that is units active in the current year. *Exit rates* are defined as the number of exiting units over the sum of exiting and incumbent units, that is units active in the previous year.

The *share of young micro and small incumbents* is calculated as the number of incumbents operational for less than 6 years and with under 50 employees over the total number of incumbents.

Young small units include units operational for less than 6 years and with 10-49 employees. *Old small* units include units operational for 6 years or more and with 10-49 employees. Employment growth is defined as the average of unit-level employment growth rates, $GR_{it} = \frac{Employment_t - Employment_{t-1}}{0.5 * Employment_t + (Employment_{t-1})}$ in the country-sector group of units. It is scale neutral and bounded between -200% and 200%.

Share of young micro and small existing firms in ICT and other sectors, 2013-15

As a percentage of total existing firms

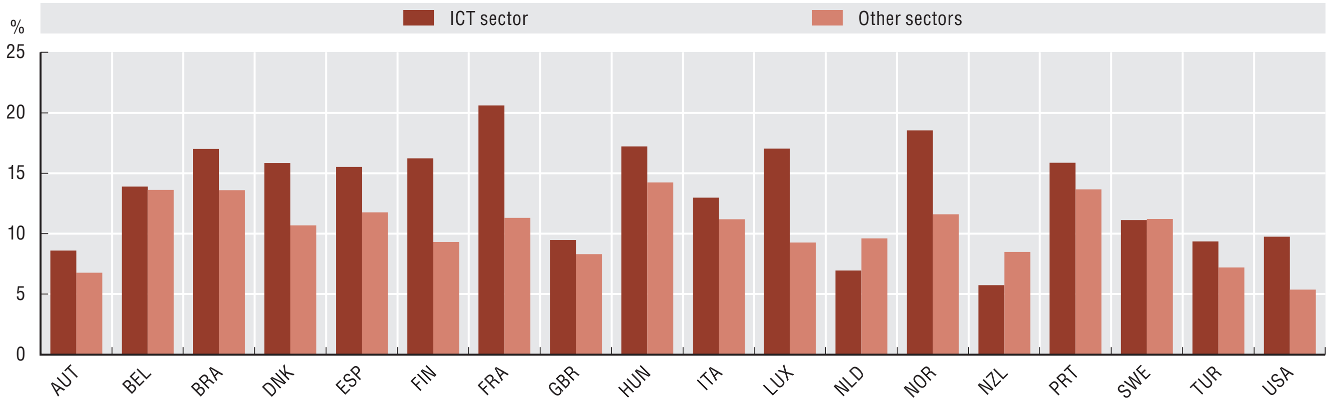


Source: OECD calculations based on the DynEmp v.2 and v.3 Databases, preliminary data, *http://oe.cd/dynemp*, July 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933619714

Differences in employment growth between young small and old small firms in ICT and other sectors, 2013-15

Percentage growth rates



Source: OECD calculations based on the DynEmp v.2 and v.3 Databases, preliminary data, *http://oe.cd/dynemp*, July 2017. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933619733

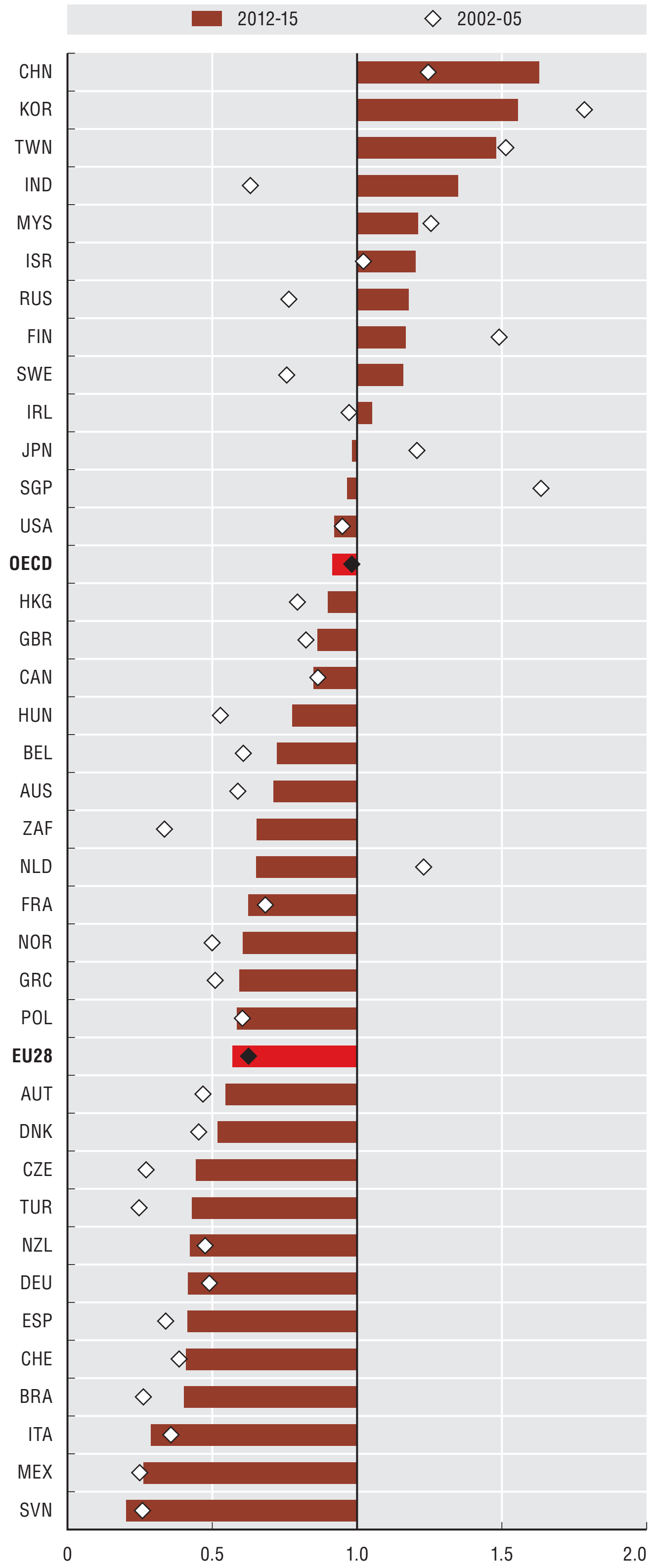
Measurability

The OECD DynEmp project is based on a distributed data collection process designed to create a harmonised micro-aggregated database on employment dynamics. The main sources of data are business registers. The project is supported by national experts who run common statistical routines developed by the OECD on confidential micro-data to which they have access. They also implement country-specific disclosure procedures to ensure confidentiality is respected. Belgium, Brazil, Finland, Hungary, Norway, Spain, Sweden and Turkey are sourced from DynEmp version 3; other countries are sourced from DynEmp version 2. Figures from DynEmp version 3 exclude units in the 0-1 size class. The two versions of DynEmp apply a different adjustment to the birth year when it occurs within the sample period. Concerning the United Kingdom, this work contains statistical data from the Office of National Statistics (ONS) which is Crown Copyright. The use of ONS statistical data in this work does not imply the endorsement of the ONS in relation to the interpretation or analysis of the statistical data. This work uses research datasets which may not exactly reproduce National Statistics aggregates.

5. Technological advantage

Revealed technology advantage in ICT, 2002-05 and 2012-15

Index based on IP5 patent families



Source: OECD, STI Micro-data Lab: Intellectual Property Database, *http://oe.cd/ipstats* , June 2017. StatLink contains more data. See chapter notes.

StatLink *http://dx.doi.org/10.1787/888933619752*

Did you know?

Specialisation in ICT patents more than doubled in India during 2002-15 and increased by more than 50% in China.

Innovations in enabling technologies such as information and communication technologies (ICT) and technologies addressing societal needs related to health and the environment have the potential to benefit people worldwide. Information contained in patent documents helps to shed light on the relative specialisation of countries with regard to these technologies.

Between 2002 and 2015, a number of economies, especially China and India, increased their relative specialisation in ICT, as measured by the index of revealed technology advantage (RTA). The average decrease in specialisation of OECD countries (-7% on average) between 2002-05 and 2012-15 conceals a diverse picture. For example, Korea and Finland decreased their specialisation in ICT-patented technologies by more than 20%, while specialisation increased in Israel and Sweden by approximately 20% or more.

While OECD countries, overall, did not increase their specialisation in health or environmental applications, fairly heterogeneous patterns emerge. Health-related technologies saw many OECD countries further increase their RTA over the period considered. Among them, the Netherlands more than doubled its RTA in health technologies and Korea substantially reduced the relative lack of specialisation exhibited the previous decade. Conversely, China despecialised over the same period.

Somewhat similar patterns can be observed in the case of environmental technologies, which saw OECD economies such as Denmark and New Zealand increase their RTA by more than 50%. Conversely, BRIICS countries appear to have despecialised by more than 20%, overall.

Definitions

The revealed technological advantage (RTA) index measures the share of an economy's patents in a specific technology relative to the share of total patents owned. The index is calculated on the basis of patent families within the Five IP Offices (IP5), by location of the inventor(s).

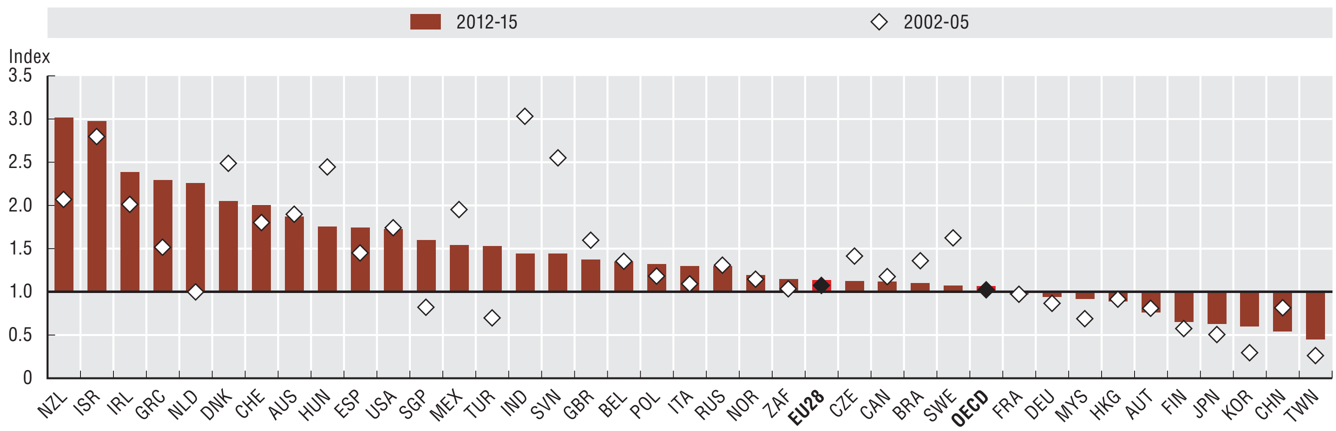
Patents in ICT rely on the International Patent Classification (IPC) codes detailed in Inaba and Squicciarini (2017), and reflect recent developments in ICT, notably in networks, mobile communication, security, data analysis and human interfaces.

Health-related patents are identified using the WIPO IPC-technology concordance (2013), and cover pharmaceutical and medical technology patents.

Environmental technology patents are identified using refined search strategies based on the IPC and the Cooperative Patent Classification (CPC), and draw upon the expertise of patent examiners at the European Patent Office (EPO), as described in Haščič and Migotto (2015).

Revealed technology advantage in health-related technologies, 2002-05 and 2012-15

Index based on IP5 patent families

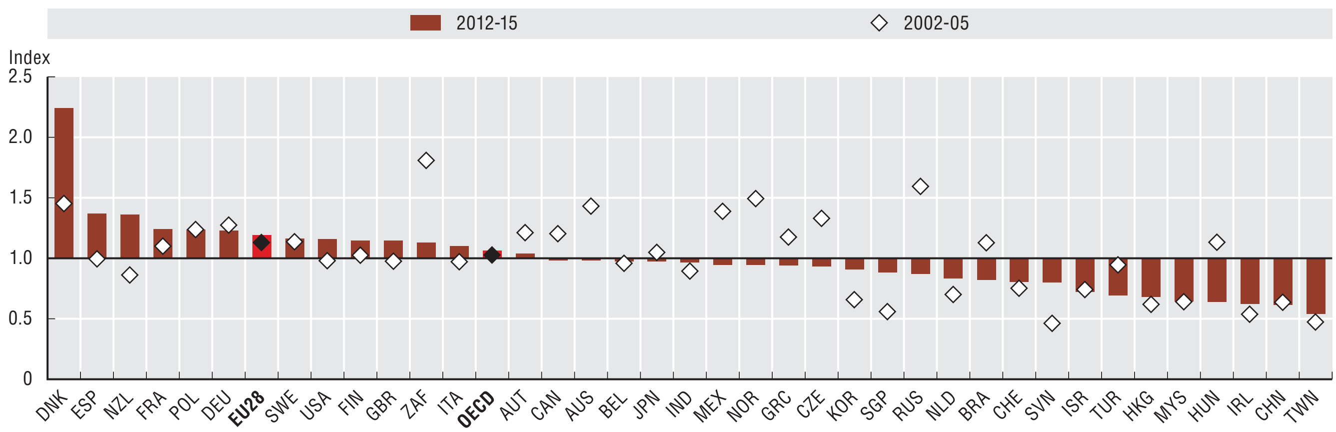


Source: OECD, STI Micro-data Lab: Intellectual Property Database, *http://oe.cd/ipstats* , June 2017. StatLink contains more data. See chapter notes.

StatLink *http://dx.doi.org/10.1787/888933619771*

Revealed technology advantage in environment-related technologies, 2002-05 and 2012-15

Index based on IP5 patent families



Source: OECD, STI Micro-data Lab: Intellectual Property Database, *http://oe.cd/ipstats* , June 2017. StatLink contains more data. See chapter notes.

StatLink *http://dx.doi.org/10.1787/888933619790*

Measurability

The RTA index is equal to zero when the economy has no patents in a given field, equals 1 when the economy's share in the technology field is equivalent to its share in all fields (no specialisation), and rises above 1 when specialisation is observed. Given the way the RTA is compiled, economies with relatively low levels of patenting may appear highly specialised in certain technologies, as their activities are more likely to be concentrated in only a few fields.

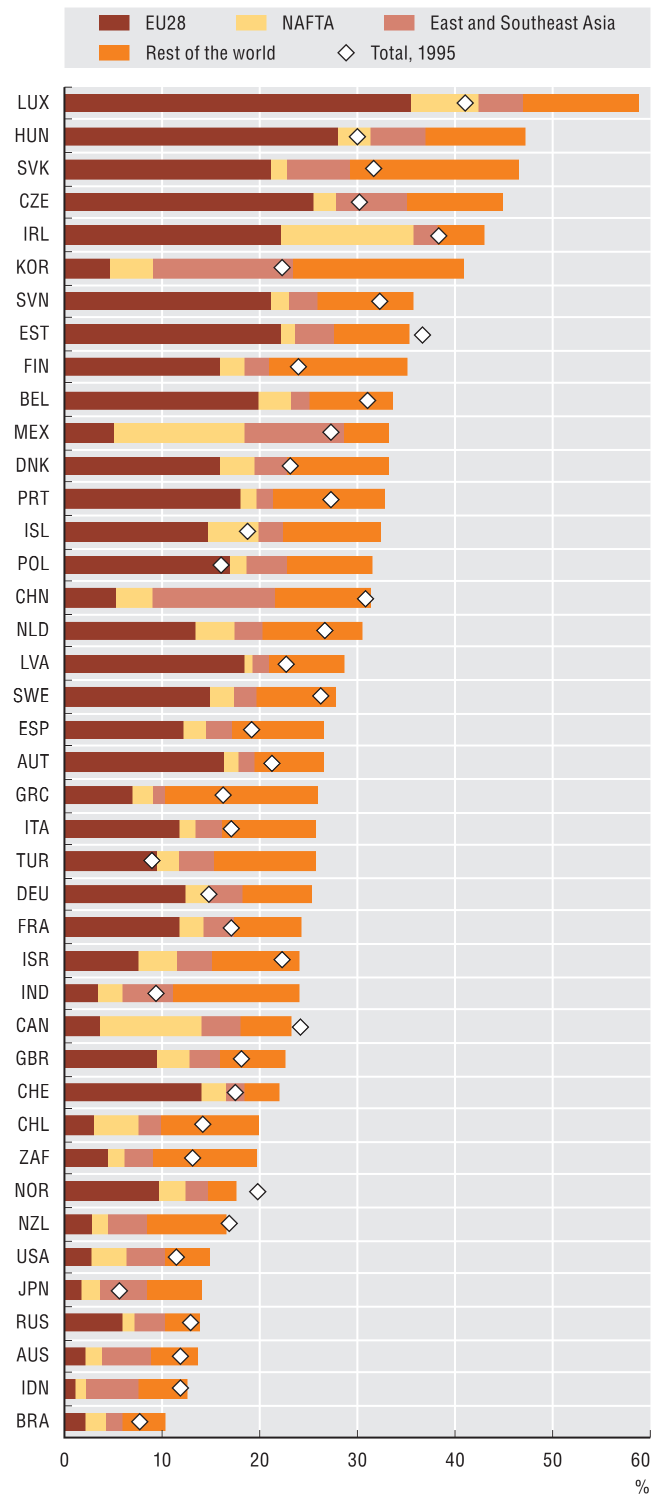
International Patent Classification codes attributed by patent examiners during the examination process indicate the technological domains to which inventions belong. IPC classifications are revised periodically to account for the emergence of new technologies and the evolution of existing ones. This may lead to the reclassification of patents into different classes.

The use of data from other patent offices may change the patterns observed, as companies within and across technology fields may behave differently and pursue different innovative strategies in different markets.

6. Participation in global value chains

Regional origin of foreign value added embodied in gross exports, 2014

As a percentage of domestic gross exports



Source: OECD estimates based on Trade in Value Added (TiVA) Database, *http://oe.cd/tiva*, Inter-Country Input-Output (ICIO) Database, *http://oe.cd/icio*, Bilateral Trade Database by Industry and End-use (BTDIxE), *http://oe.cd/btd*, Annual National Accounts Database, *www.oecd.org/std/na*, and most recent national Supply and Use Tables and Input Output Tables, April 2017. StatLink contains more data. See chapter notes.

StatLink *http://dx.doi.org/10.1787/888933619809*

Did you know?

OECD countries remain firmly integrated in global production systems with foreign content of exports ranging from about 15% in Japan and the United States to over 40% in smaller EU countries.

Integration of countries into global value chains (GVCs) can be measured by tracking the origins of value added embodied in exports. Estimates of foreign value added in exports highlight the importance of imports for export performance, while domestic value added embodied in the exports of partner countries shows how industries within a country reach consumers abroad even when no direct trading relationship exists.

For most countries, a large share of foreign value added in exports originates from the same region, reflecting the importance of geographic proximity and regional trade agreements. Between 1995 and 2014, many countries experienced notable increases in the share of foreign value added in exports as global value chains became well established. The highest increases were evident in Japan, India, Korea, Poland and Turkey.

For many countries, the share of domestic value added embodied in partners' exports ("forward linkages in GVCs") increased significantly between 1995 and 2014, particularly for countries such as Australia, Brazil, Canada, Chile, Norway and South Africa, reflecting growing demand for mineral products in global value chains.

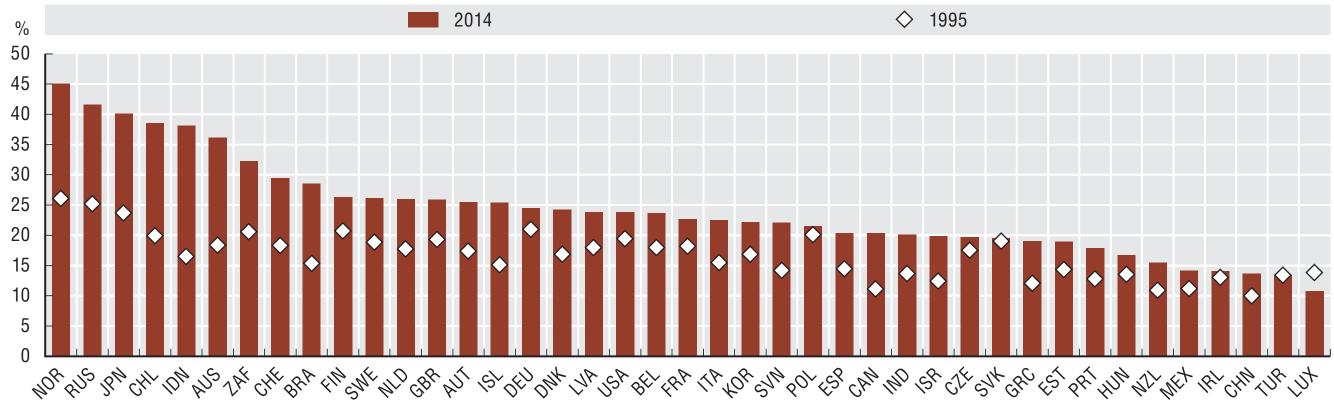
Analysis of the sectoral origins of domestic value added in gross exports reveals the important contribution of domestic services which, in 2014, accounted for more than half the value-added content of total exports in countries such as France, Israel, Switzerland and the United Kingdom. While direct exports of service products have risen in recent years, a significant share of domestic service activity continues to be driven by foreign demand for exports of raw materials and manufactured goods. Domestic manufacturing activities have continued to be a major source of value added in total exports (over 30%) for Chile, China, Germany, Japan and Korea.

Definitions

The Trade in Value Added (TiVA) database provides indicators on the domestic and foreign origins of value added embodied in exports and in final demand. They are derived from OECD's Inter-Country Input-Output (ICIO) database which provides estimates of the flows of goods and services between 63 countries and 34 industries from 1995 to 2011. Tracing global flows of value added provides insights for the analysis of GVCs that are not always evident from conventional trade statistics. Estimates for 2014 are projections based on the latest ICIO extended using more recent time series drawn from annual national accounts and merchandise trade statistics.

Domestic value added embodied in partner countries' exports, 2014

As a percentage of domestic gross exports

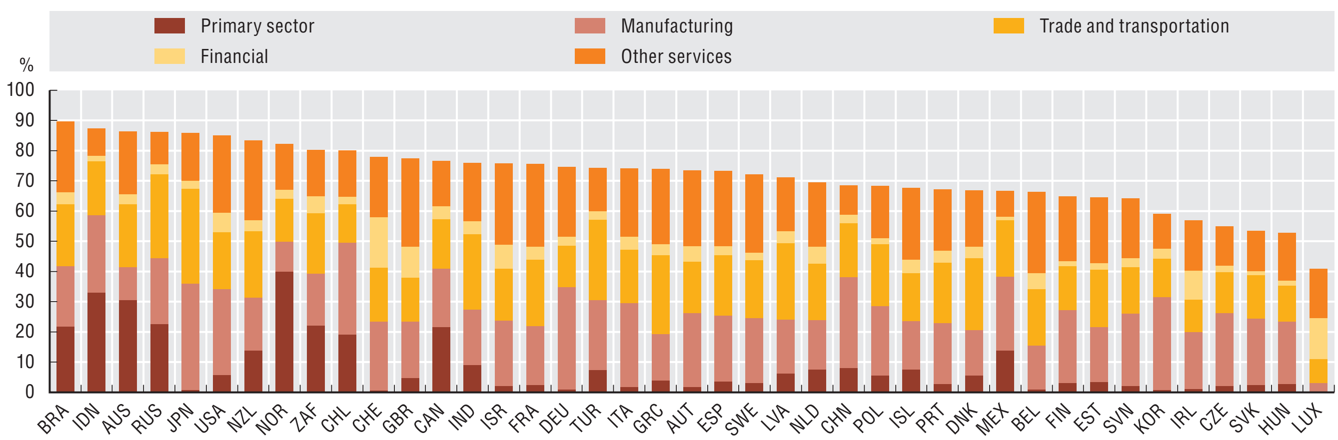


Source: OECD estimates based on Trade in Value Added (TiVA) Database, *http://oe.cd/tiva*, Inter-Country Input-Output (ICIO) Database, *http://oe.cd/icio*, Bilateral Trade Database by Industry and End-use (BTDIxE), *http://oe.cd/btd*, Annual National Accounts Database, *www.oecd.org/std/na*, and most recent national Supply and Use Tables and Input Output Tables, April 2017. StatLink contains more data.

StatLink http://dx.doi.org/10.1787/888933619828

Sectoral origin of the domestic value added created by gross exports, 2014

As a percentage of domestic gross exports



Source: OECD estimates based on Trade in Value Added (TiVA) Database, *http://oe.cd/tiva*, Inter-Country Input-Output (ICIO) Database, *http://oe.cd/icio*, Bilateral Trade Database by Industry and End-use (BTDIxE), *http://oe.cd/btd*, Annual National Accounts Database, *www.oecd.org/std/na*, and most recent national Supply and Use Tables and Input Output Tables, April 2017. StatLink contains more data.

StatLink http://dx.doi.org/10.1787/888933619847

Measurability

Estimates of foreign value added content of exports are often referred to as backward linkages in GVCs, while domestic value added content in partner countries' exports (calculated as the sum of domestic value added in exports of intermediates that are then embodied in other countries' exports) are referred to as forward linkages. Both are used to provide an indication of GVC participation and, given the different perspectives (foreign versus domestic value added), are best analysed separately.

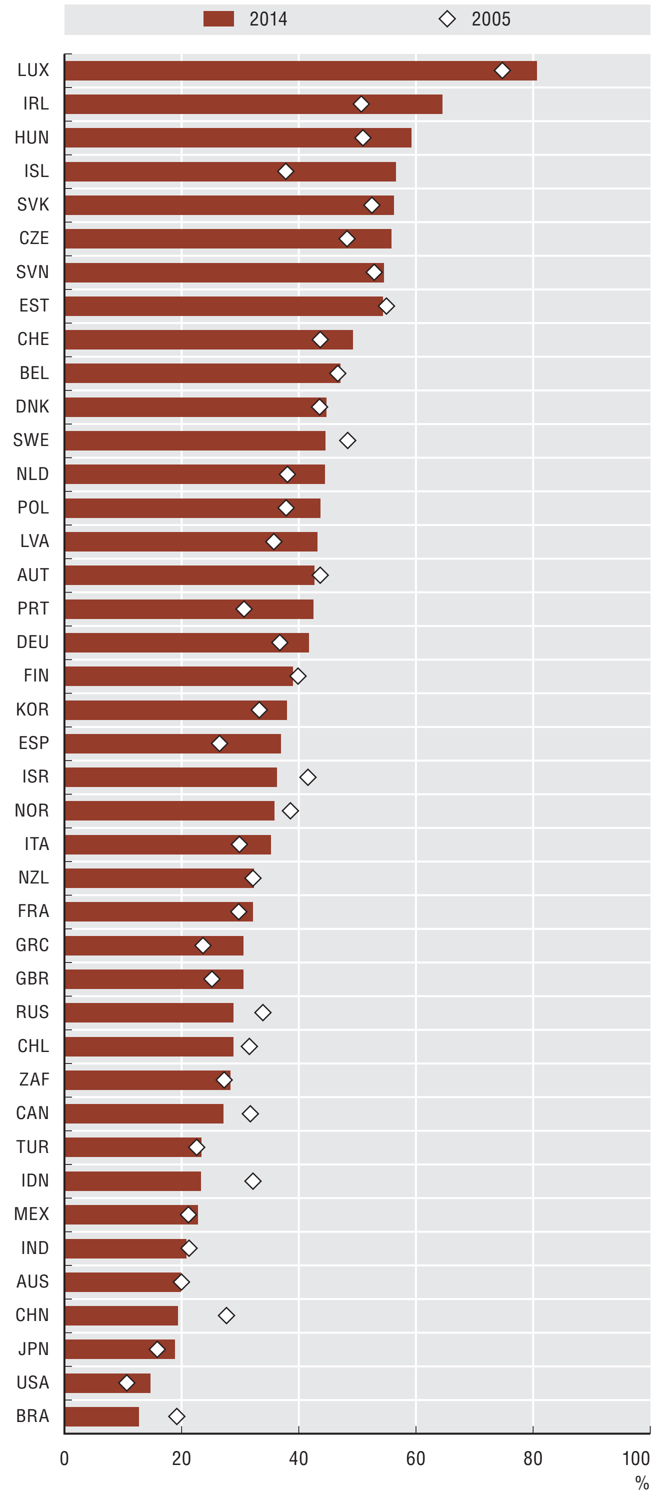
Changes in participation in GVCs not only reflect changes in specialisation towards activities at the beginning or end of value chains, but also changes in commodity prices. For example, a surge in oil prices could result in an increase in the import content of exports for many countries. The same domestic value added can be included in many other countries' exports, if it moves along multi-country production chains. Thus, care should be taken when interpreting measures of GVC participation over time.

Non-resident final expenditures (e.g. by tourists) are allocated to the consumer's country of residence (i.e. treated as exports of the country in which the goods and services are purchased).

7. Trade and jobs

Jobs in the business sector sustained by foreign final demand, 2005 and 2014

As a percentage of total business sector employment



Source: OECD calculations based on Inter-Country Input-Output (ICIO) Database, *http://oe.cd/icio*, Annual National Accounts Database, *www.oecd.org/std/na*, Structural Analysis (STAN) Database, *http://oe.cd/stan*, Trade in Employment (TiM), *http://oe.cd/io-empn*; World Input-Output Database (WIOD) and national sources, June 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933619866

Did you know?

In most European countries, 30-60% of business sector jobs were sustained by consumers in foreign markets in 2014. In the United States, only 15% but amounting to 13 million jobs.

Estimates of jobs embodied in foreign final demand can reveal the extent to which a country is integrated into the global economy. As the number of firms specialising in particular stages of global production increases, dependencies between economies deepen. The ability of economies to meet foreign final demand increasingly determines the evolution of job markets. Traditional statistics are unable to reveal the full nature of these interdependencies – notably, how consumers in one country may drive production and sustain jobs in countries further up the value chain. New indicators, based on OECD's Inter-Country Input-Output (ICIO) database, can shed light on these relationships.

For example, in most European countries between 30% and 60% of jobs in the business sector were sustained by consumers in foreign markets in 2014. In Japan and the United States, shares are lower, reflecting their relatively large size and lower dependency on exports/imports. In spite of this, OECD estimates suggest that in 2014 the number of jobs sustained by foreign demand was about 13 million in the United States and over 8 million in Japan.

In countries such as China, India, Israel and Mexico, the share of jobs in information and communication industries meeting foreign demand was notably higher than in other industries in 2014. Between 2005 and 2014, China experienced a huge increase in its share (64%).

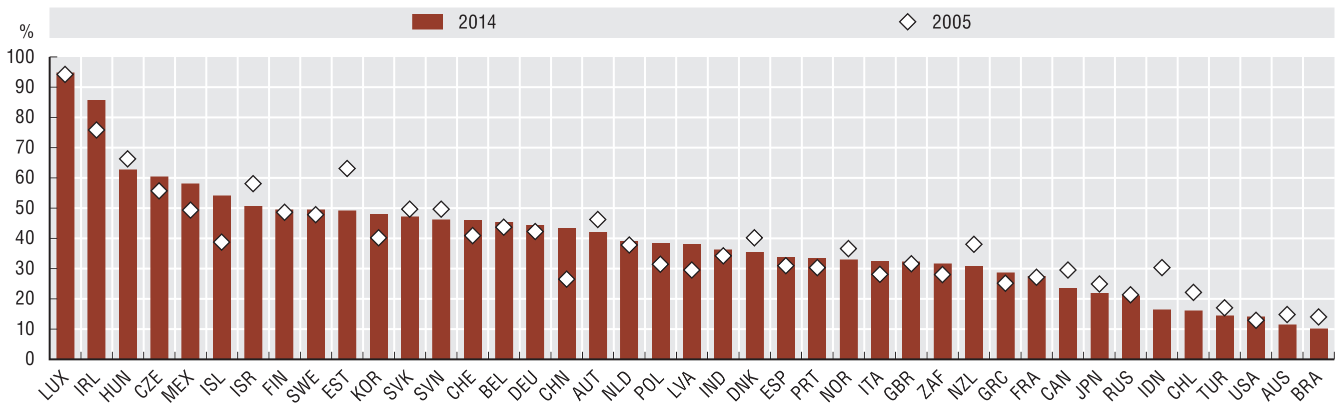
Another perspective on the impact of GVCs on labour markets can be provided by comparing labour shares (the share of value added devoted to compensation of employees) to produce output to meet domestic demand with that to meet foreign final demand. Tentative estimates suggest that for most OECD countries, industries in the business sector more oriented towards meeting foreign final demand (including upstream non-exporting domestic suppliers of intermediate goods and services as well as direct exporters) have higher labour shares than industries more oriented towards domestic demand.

Definitions

Jobs refer to the total number of persons engaged in production (headcounts). *Labour costs* refer to the labour compensation of employees as defined by the System of National Accounts. *Information and communication industries* correspond to ISIC Rev.3 Divisions 30, 32, 33, 64 and 72.

Jobs in information and communication industries sustained by foreign final demand, 2005 and 2014

As a percentage of total jobs in information and communication industries

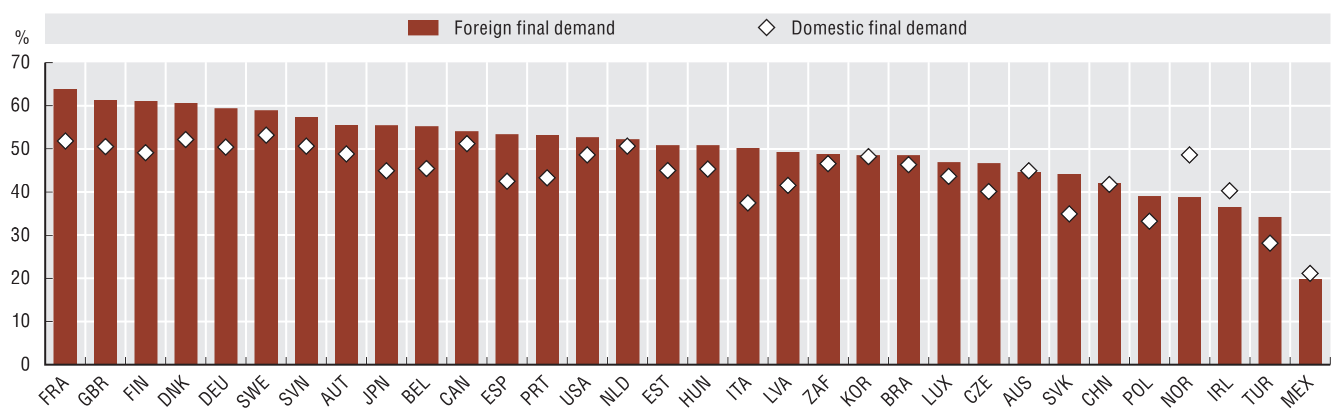


Source: OECD calculations based on Inter-Country Input-Output (ICIO) Database, *http://oe.cd/icio*, Annual National Accounts Database, *www.oecd/std/na*, Structural Analysis (STAN) Database, *http://oe.cd/stan*, Trade in Employment (TiM), *http://oe.cd/io-empn*; World Input-Output Database (WIOD) and national sources, June 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933619885

Share of compensation of employees in the business sector sustained by domestic and foreign final demand, 2014

As a percentage of value added in the business sector



Source: OECD calculations based on Inter-Country Input-Output (ICIO) Database, *http://oe.cd/icio*, Annual National Accounts Database, *www.oecd.org/std/na*, Structural Analysis (STAN) Database, *http://oe.cd/stan*, Trade in Employment (TiM), *http://oe.cd/io-empn* and national sources, June 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933619904

Measurability

Input-output accounting frameworks are sensitive to certain assumptions such as: exporting firms have the same labour productivity and, the same share of imports, in relation to output, as firms serving domestic markets. However, evidence suggests that exporting firms may have higher labour productivity and a higher share of imports for a given output, indicating that the results presented may be biased upwards. Also, the jobs estimates are not full-time equivalent measures and, the results relate to jobs *sustained* rather than *created*, as the jobs may have previously existed to serve domestic consumers.

For most countries, at the detailed level of industry used in ICIO, labour shares of value added are the same regardless of whether the output is destined for domestic or foreign consumption. This is a consequence of the assumptions used in the construction of ICIO (exceptions are China and Mexico where "processing exporters" and "global manufacturers", respectively, are distinguished from other firms). The differences in the labour shares for the aggregate business sector thus reflect the differences in weights of underlying industries meeting domestic demand and foreign demand.

Notes and references

Cyprus

The following note is included at the request of Turkey:

"The information in this document with reference to 'Cyprus' relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognizes the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Turkey shall preserve its position concerning the 'Cyprus issue'."

The following note is included at the request of all of the European Union Member States of the OECD and the European Union:

"The Republic of Cyprus is recognized by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus."

Israel

"The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities or third party. 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.

"It should be noted that statistical data on Israeli patents and trademarks are supplied by the patent and trademark offices of the relevant countries."

5.1. R&D specialisation

Business R&D intensity adjusted for industrial structure, 2015

A country's industrial structure-adjusted indicator of R&D intensity is a weighted average of its sectoral R&D intensities (ratio of R&D to value added), using the OECD industrial structure – sectoral share in OECD value added for 2015 – as adjusted, common weights across all countries. The unadjusted measure of BERD intensity is by definition an average based on each country's actual sector shares.

R&D series are presented as a percentage of value added in industry estimated as the value added in all activities except: Real estate activities (ISIC Rev.4 68); Public administration and defence; Compulsory social security and education (ISIC Rev.4 84-85); Human health and social work activities (ISIC Rev.4 86-88); and Activities of households as employers (ISIC Rev.4 97-98). R&D performed in these sectors across the OECD is reported to be negligible.

Figures are based on estimates of business R&D by industry reported on a main activity basis, in ISIC Rev.4.

For Australia, Austria, Belgium, Canada, France, Greece, Ireland, Korea and Sweden, data refer to 2013.

For Denmark, Finland, Hungary, Italy, the Netherlands, Poland, Portugal, Slovenia, the United Kingdom and the United States, data refer to 2014.

Value added is measured at basic prices except for Japan (purchasers' prices).

Data on value added come from the OECD STructural ANalysis (STAN) Database except for Hungary, Iceland, Ireland, Korea and Turkey (OECD National Accounts Statistics), Canada (national source) and Australia (OECD National Accounts Statistics and estimates based on ABS Australian National Accounts: Input-Output Tables, 2013-14, for manufacturing industries).

Business R&D in manufacturing, by R&D intensity group, 2015

The R&D intensity groups are defined according to the OECD R&D intensity classification at a two-digit level. See Galindo-Rueda and Verger (2016), "OECD Taxonomy of Economic Activities Based on R&D Intensity", OECD Science, Technology and Industry Working Papers, No. 2016/04, OECD Publishing, Paris. DOI: *http://dx.doi.org/10.1787/5jlv73sqqp8r-en*.

High and medium-high R&D intensive manufacturing includes "Chemicals and pharmaceutical products" (ISIC Rev.4 Divisions 20 and 21) and "Computer, electronic and optical products, electrical equipment, machinery, motor vehicles and other transport equipment" (ISIC Rev.4 Divisions 26 to 30).

Figures are based on estimates of business R&D by industry reported on a main activity basis, in ISIC Rev.4.

For Austria, Belgium, France, Greece, Ireland and Sweden, data refer to 2013.

For Canada, Denmark, Finland, Hungary, Israel, Italy, the Netherlands, Poland, Portugal, Slovenia, the United Kingdom and the United States, data refer to 2014.

For Denmark, Israel, Sweden and Switzerland, "Chemicals and chemical products" (ISIC Rev.4 Division 20) are included in "Other manufacturing industries".

R&D in services industries, 2015

Figures are based on estimates of business R&D by industry reported on a main activity basis, in ISIC Rev.4.

These statistics are based on OECD R&D Statistics (*http://oe.cd/rds*) and ANBERD (*http://oe.cd/anberd*) Databases. For more information on these data, including on issues such as breaks in series, please see those sources.

For Australia, Austria, Belgium, Ireland and New Zealand, data refer to 2013.

For Canada, Denmark, Finland, Hungary, Israel, Italy, the Netherlands, Poland, Portugal, Slovenia and the United States, data refer to 2014.

For Chile, data refer to 2007 and 2015.

For France and Sweden, data refer to 2007 and 2013.

For Greece, the 2015 estimate for R&D services industry is based on 2013 data.

For Switzerland, data refer to 2004 and 2015.

For the United Kingdom, data refer to 2007 and 2014.

5.2. E-business uptake

Diffusion of selected ICT tools and activities in enterprises, by technology, 2016

Unless otherwise stated, only enterprises with ten or more employees are considered.

Data for ERP relate to 2015 for all countries except Canada (2013), Iceland (2014) and Sweden (2014).

Data for CRM relate to 2015.

Data for RFID relate to 2014.

Cloud computing: For Canada, data refer to 2012 and to enterprises that have made expenditures on "software as a service" (e.g. cloud computing). For Mexico, data refer to 2012.

"For countries in the European Statistical System, data on e-purchases and e-sales refer to 2015.

For Australia, data refer to the fiscal year 2014/15 ending on 30 June.

For Canada, data refer to 2013 except cloud computing (2012).

For Iceland, data refer to 2014.

For Japan, data refer to 2015 and include businesses with 100 or more employees instead of ten or more.

For Korea, data refer to 2015 except cloud computing (2013).

For Switzerland, data refer 2015 and to businesses with five or more employees instead of ten or more.

Diffusion of selected ICT tools and activities in enterprises, OECD countries, 2010 and 2016

E-purchases and e-sales refer to the purchase and sales of goods or services conducted over computer networks by methods specifically designed for the purpose of receiving or placing orders (i.e. webpages, extranet or electronic data interchange (EDI), but not orders by telephone, fax or manually typed e-mails). Payment and delivery methods are not considered.

Enterprise resource planning (ERP) systems are software-based tools that can integrate the management of internal and external information flows from material and human resources to finance, accounting and customer relations. Here, only sharing of information within the firm is considered. For ERP, data refer to 2015.

Cloud computing refers to ICT services over the Internet to access server, storage, network components and software applications.

Supply chain management (SCM) refers to the use of automated data exchange (ADE) applications. For SCM, data refer to 2015.

Customer/supplier relationship management software (CRM) is a software package used for managing a company's interactions with customers, clients, sales prospects, partners, employees and suppliers. For CRM, data refer to 2015.

Social media refers to applications based on Internet technology or communication platforms for connecting, creating and exchanging content online with customers, suppliers or partners, or within the enterprise. Social media might include social networks (other than paid adverts), blogs, file sharing and wiki-type knowledge-sharing tools.

Radio frequency identification (RFID) is a technology that enables contactless transmission of information via radio waves. RFID can be used for a wide range of purposes, including personal identification or access control, logistics, retail trade and process monitoring in manufacturing. For RFID, data refer to 2014.

Enterprises engaged in sales via e-commerce, by size, 2015

Unless otherwise stated, only enterprises with ten or more employees are considered. Small firms have 10-49 employees and large firms have 250 or more employees.

For Australia, data refer to the fiscal years 2010/11 ending on 30 June and 2014/15.

For Canada, data refer to 2012 and 2013. Large firms have 300 or more employees. Sales online over the Internet may include EDI sales over the Internet as well as website sales, but do not include sales via manually typed e-mail or leads.

For Iceland, data refer to 2013 instead of 2015.

For Japan, data refer to 2010 instead of 2009 and to businesses with 100 or more employees instead of ten or more. Large firms have 300 or more employees.

For Korea, data refer to 2010 instead of 2009.

For Mexico, data refer to 2012 and to businesses receiving orders via the Internet instead of over computer networks.

For New Zealand, data refer to the fiscal years 2010/11 ending on 30 June and 2015/16.

For Switzerland, data refer to 2011.

5.3. E-business across applications and sectors

Enterprises using cloud computing services, by size, 2016

Unless otherwise stated, only enterprises with ten or more persons employed are considered. Size classes are defined as: small (from 10 to 49 persons employed), medium (50 to 249) and large (250 and more).

For Australia, data refer to the fiscal year 2014/2015 ending on 30 June.

For Brazil, data refer to 2015.

For Canada, data refer to 2012 and to enterprises that have made expenditures on "software as a service" (e.g. cloud computing). Medium-sized enterprises have 50-299 employees. Large enterprises have 300 or more employees.

For Iceland, data refer to 2014.

For Italy, there is a break in series between 2014 and 2016.

For Japan, data refer to 2015 instead of 2016 and to businesses with 100 or more employees. Medium-sized enterprises have 100-299 employees. Large enterprises have 300 or more employees.

For Korea, data refer to 2015 instead of 2016.

For Mexico, data refer to 2012.

For Switzerland, data refer to 2015 and to firms with five or more employees.

Uptake of cloud services in industries, OECD, 2016

Data refer to 2016 or most recent year available.

Unless otherwise stated, data refer to enterprises with ten or more persons employed.

The following industries were considered: Manufacturing; Construction; Wholesale trade, except of motor vehicles and motorcycles; Retail trade, except of motor vehicles and motorcycles; Transportation and storage; Accommodation and Food and beverage service activities; Information and communication; Real estate activities; Professional, scientific and technical activities; Administrative and support service activities. For each of those industries, the following indicators are reported: (i) the OECD simple average based on the OECD countries available; and (ii) the countries with respectively the maximal and minimal value.

Diffusion of selected ICT tools and activities in industries, OECD, 2016

Data refer to 2016 or most recent year available.

For each ICT tool or activity, the following industries were considered: Manufacturing; Construction; Wholesale trade, except of motor vehicles and motorcycles; Retail trade, except of motor vehicles and motorcycles; Transportation and storage; Accommodation and Food and beverage service activities; Information and communication; Real estate activities; Professional, scientific and technical activities; Administrative and support service activities. For each ICT tool or activity: (i) an OECD simple average was calculated for each of the industries based on data available for the OECD countries; (ii) the OECD simple average by industry was ranked by decreasing order of the value by industry, and the maximum and minimum value with the respective industries have been reported in the figure. For each ICT tool or activity, the value of the average reported in the figure correspond to the OECD average calculated for all available OECD countries for all industries and may differ slightly from the average value reported in Figure 5.2.2.

E-purchases and e-sales refer to the purchase and sales of goods or services conducted over computer networks by methods specifically designed for the purpose of receiving or placing orders (i.e. web pages, extranet or electronic data interchange [EDI], but not orders by telephone, fax or manually typed e-mails). Payment and delivery methods are not considered.

Enterprise resource planning (ERP) systems are software-based tools that can integrate the management of internal and external information flows from material and human resources to finance, accounting and customer relations. Here, only sharing of information within the firm is considered. For ERP, data refer to 2015.

Supply chain management (SCM) refers to the use of automated data exchange (ADE) applications. For SCM, data refer to 2015.

Customer/supplier relationship management software (CRM) is a software package used for managing a company's interactions with customers, clients, sales prospects, partners, employees and suppliers. For CRM, data refer to 2015.

Social media refers to applications based on Internet technology or communication platforms for connecting, creating and exchanging content online with customers, suppliers or partners, or within the enterprise. Social media might include social networks (other than paid adverts), blogs, file sharing and wiki-type knowledge-sharing tools.

Radio frequency identification (RFID) is a technology that enables contactless transmission of information via radio waves. RFID can be used for a wide range of purposes, including personal identification or access control, logistics, retail trade and process monitoring in manufacturing. For RFID, data refer to 2014.

5.4. Start-up dynamics

Entry and exit rates in ICT and other business sectors, 2013-15

Figures report averages over the three most recent available years, conditional on the availability of data.

The ICT sector includes the ISIC Rev.4 sectors 26, 61 and 62-63: Computer and electronics; Telecommunications and IT and other information services.

Other sectors cover manufacturing and the non-financial business services sector excluding the ICT sector, Coke and refined petroleum products and Real estate activities.

Figures from DynEmp v.3 exclude units in the 0-1 size class.

DynEmp v.2 and v.3 apply a different adjustment to the year of birth when this occurs within the sample period.

Data for some countries are still preliminary.

Owing to methodological differences, figures may deviate from officially published national statistics.

For Italy and the United Kingdom, data refer to 2008-10.

For France and New Zealand, data refer to 2009-11.

For Austria, Denmark, Luxembourg, the Netherlands and Portugal, data refer to 2010-12.

For Belgium and the United States, data refer to 2011-13.

For Norway, data refer to 2010-11 and 2014.

Concerning the United Kingdom, this work contains statistical data from the Office for National Statistics (ONS) which is Crown Copyright. The use of ONS statistical data in this work does not imply the endorsement of the ONS in relation to the interpretation or analysis of the statistical data. This work uses research datasets which may not exactly reproduce National Statistics aggregates.

Share of young micro and small existing firms in ICT and other sectors, 2013-15

The graph reports the share of young (less than 6 years old) micro and small (less than 50 employees) incumbent units.

Figures report averages over the three most recent available years, conditional on the availability of data.

The ICT sector includes the ISIC Rev.4 sectors 26, 61 and 62-63: Computer and electronics; Telecommunications and IT and other information services.

Other sectors cover manufacturing and the non-financial business services sector excluding the ICT sector, Coke and refined petroleum products and Real estate activities.

Figures from DynEmp v.3 exclude units in the 0-1 size class.

DynEmp v.2 and v.3 apply a different adjustment to the year of birth when this occurs within the sample period.

Data for some countries are still preliminary.

Owing to methodological differences, figures may deviate from officially published national statistics.

For Italy and the United Kingdom, data refer to 2008-10.

For France and New Zealand, data refer to 2009-11.

For Austria, Denmark, Luxembourg, the Netherlands and Portugal, data refer to 2010-12.

For Belgium and the United States, data refer to 2011-13.

For Norway, data refer to 2010-11 and 2014.

Concerning the United Kingdom, this work contains statistical data from the Office for National Statistics (ONS) which is Crown Copyright. The use of ONS statistical data in this work does not imply the endorsement of the ONS in relation to the interpretation or analysis of the statistical data. This work uses research datasets which may not exactly reproduce National Statistics aggregates.

Differences in employment growth between young small and old small firms in ICT and other sectors, 2013-15

The graph shows the difference between the average employment growth rate of small (10-49 employees) young (less than 6 years old) units and the average employment growth rate of small (10-49 employees) old (6+ years old) units.

Micro (less than 10 employees) units are excluded from the computations.

Figures report averages over the three most recent available years, conditional on the availability of data.

The ICT sector includes the ISIC Rev.4 sectors 26, 61 and 62-63: Computer and electronics; Telecommunications and IT and other information services.

Other sectors cover manufacturing and the non-financial business services sector excluding the ICT sector, Coke and refined petroleum products and Real estate activities.

Data for some countries are still preliminary.

Owing to methodological differences, figures may deviate from officially published national statistics.

For Italy and the United Kingdom, data refer to 2008-10.

For France and New Zealand, data refer to 2009-11.

For Austria, Denmark, Luxembourg, the Netherlands and Portugal, data refer to 2010-12.

For Belgium and the United States, data refer to 2011-13.

For Norway, data refer to 2010-11 and 2014.

Concerning the United Kingdom, this work contains statistical data from the Office for National Statistics (ONS) which is Crown Copyright. The use of ONS statistical data in this work does not imply the endorsement of the ONS in relation to the interpretation or analysis of the statistical data. This work uses research datasets which may not exactly reproduce National Statistics aggregates.

5.5. Technological advantage

Revealed technology advantage in ICT, 2002-05 and 2012-15

The revealed technological advantage index is calculated as the share of patents of an economy in a particular technology area relative to the share of total patents belonging to the economy. Data refer to IP5 families, by filing date, according to the inventors' residence using fractional counts. Patents in ICT are identified using the list of IPC codes in Inaba and Squicciarini (2017). Only economies with more than 250 patents families in the periods considered are included. 2014 and 2015 figures are estimated based on available data for those years.

Revealed technology advantage in health-related technologies, 2002-05 and 2012-15

The revealed technological advantage index is calculated as the share of patents of an economy in a particular technology area relative to the share of total patents belonging to the economy. Data refer to IP5 families, by filing date, according to the inventor's residence using fractional counts. Patents are allocated to health-related fields on the basis of the International Patent Classification (IPC) codes, following the concordance provided by WIPO (2013). Only economies with more than 250 patents families in the periods considered are included. 2014 and 2015 figures are estimated based on available data for those years.

Revealed technology advantage in environment-related technologies, 2002-05 and 2012-15

The revealed technological advantage index is calculated as the share of patents of an economy in a particular technology area relative to the share of total patents belonging to the economy. Data refer to IP5 families by filing date according to the inventor's residence using fractional counts. Environment-related patents are defined on the basis of their International Patent Classification (IPC) codes or Cooperative Patent Classification (CPC) codes, as described in Haščič and Migotto (2015). Only economies with more than 250 patents families in the periods considered are included. 2014 and 2015 figures are estimated based on available data for those years.

5.6. Participation in global value chains

Regional origin of the foreign value added embodied in gross exports, 2014

East and Southeast Asia comprises Brunei Darussalam, Cambodia, China, Hong Kong (China), Indonesia, Japan, Korea, Malaysia, Philippines, Singapore, Thailand, Chinese Taipei and Viet Nam.

5.7. Trade and jobs

Jobs in the business sector sustained by foreign final demand, 2005 and 2014

The business sector corresponds to ISIC Rev.3 Divisions 10 to 74, i.e. total economy excluding Agriculture, forestry and fishing (Divisions 01-05), Public administration (75), Education (80), Health (85) and Other community, social and personal services (90-95).

Jobs in information and communication industries sustained by foreign final demand, 2005 and 2014

The information and communication industries correspond to ISIC Rev.3 Divisions 30, 32, 33, 64 and 72.

Share of compensation of employees in the business sector sustained by domestic and foreign final demand, 2014

The business sector corresponds to ISIC Rev.3 Divisions 10 to 74, i.e. total economy excluding Agriculture, forestry and fishing (Divisions 01-05), Public administration (75), Education (80), Health (85) and Other community, social and personal services (90-95).

An industry's output can be driven by both domestic and foreign final demand. Using an ICIO/TiVA framework, value added generated to meet foreign demand can be separated from value added generated to meet domestic demand. The same distinction can be made for labour costs. Here, labour costs embodied in domestic demand as a share of value added embodied in domestic demand is compared with labour costs embodied in foreign demand as a share of value added embodied in foreign demand. Note that at the most detailed level of industry, for most countries, labour shares of value added are the same whether the output is destined for domestic or foreign consumption. This is a consequence of assumptions in the construction of ICIO (exceptions are China and Mexico, where processing exporters are distinguished from other firms). The differences in the labour shares for the aggregate business sector mainly reflect the differences in weights of underlying industries meeting domestic demand and foreign demand.

References

Haščič, I. and M. Migotto (2015), "Measuring environmental innovation using patent data", *OECD Environment Working Papers*, No. 89, OECD Publishing, Paris, *http://dx.doi.org/10.1787/5js009kf48xw-en*.

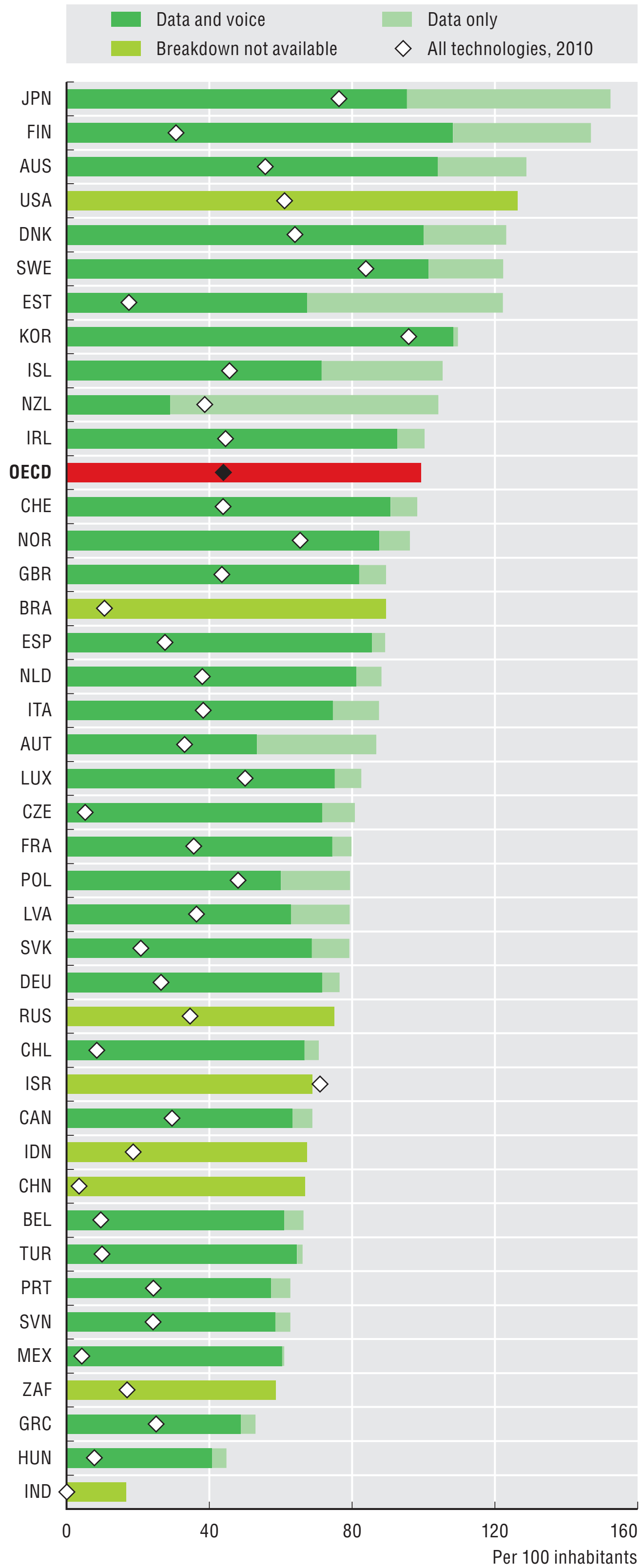
Inaba, T. and M. Squicciarini (2017), "ICT: A new taxonomy based on the international patent classification", *OECD Science, Technology and Industry Working Papers*, No. 2017/01, OECD Publishing, Paris, *http://dx.doi.org/10.1787/ab16c396-en*.

WIPO (2013), IPC – Technology Concordance Table, *www.wipo.int/ipstats/en/statistics/technology_concordance.html* (accessed 1 June 2017).

6. Society and the digital transformation

1. Connectivity

Mobile broadband penetration, by technology
December 2016
Per 100 inhabitants



Source: OECD, Broadband Portal, *www.oecd.org/sti/broadband/oecdbroadbandportal.htm*, July 2017. StatLink contains more data. See chapter notes.
StatLink http://dx.doi.org/10.1787/888933619923

Did you know?

The number of mobile broadband subscriptions in the OECD area more than doubled between 2010 and 2016, reaching about 1.3 billion – almost one subscription per inhabitant.

Broadband communication networks and the services provided over them support existing economic and social activities and hold potential for tremendous innovation. Broadband diffusion remains uneven across OECD economies but continues to increase everywhere. Fixed broadband subscriptions in the OECD area reached 387 million as of December 2016, with an average penetration rate of 30%, up from 25% at the end of 2010. Switzerland had the highest penetration rate (50%) followed by Denmark, the Netherlands and France (all above 40%).

Progress has been particularly swift in mobile broadband. Mobile broadband penetration for the OECD area reached 99% in December 2016, up from 44% in 2010 – almost one subscription per inhabitant. Over the same period, total mobile broadband subscriptions increased from 544 million to 1.275 billion and represent 77% of all broadband access paths in the OECD area. Penetration rates in OECD countries increased spectacularly between 2010 and 2016, particularly in the Czech Republic (by 16 times) and Mexico (14 times).

Broadband connections in households are an indicator of people's access to information and services. Disparities in broadband access are partly explained by urban-rural divides within countries. Gaps in broadband access are largest in Greece (21 percentage points), Chile (19) and Portugal (15).

Higher broadband penetration has narrowed the gap between medium and small firms. Nevertheless, the gap remains substantial in Mexico (17 percentage points), Greece (14), Poland (7) and the United Kingdom (6).

Definitions

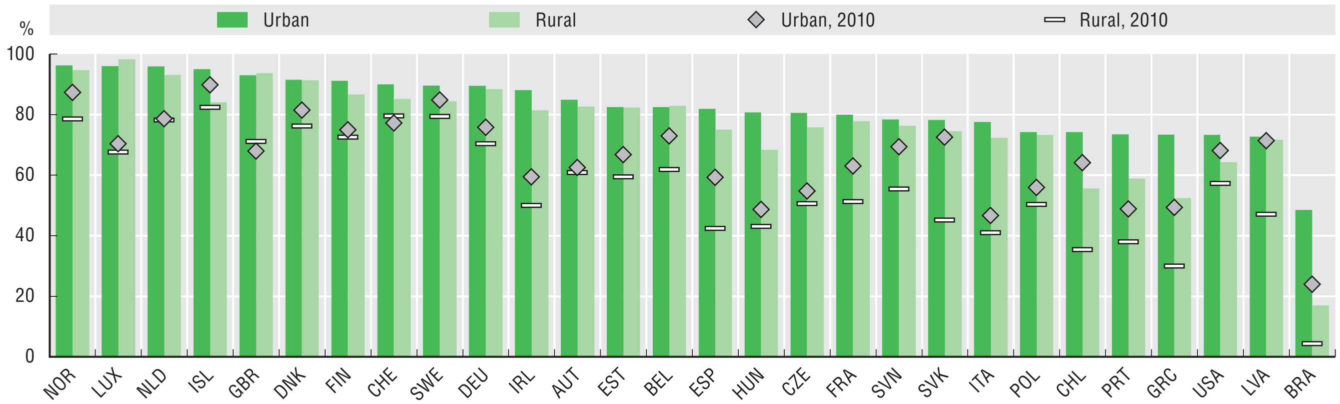
Broadband penetration is defined as the number of subscriptions to fixed and mobile broadband services, i.e. with advertised data speeds of 256 kbps or more, divided by the number of residents in each country. Fixed broadband comprises DSL, cable, fibre-to-the-home (FTTH) and fibre-to-the-building (FTTB), satellite, terrestrial fixed wireless and other fixed-wired technologies. Mobile broadband comprises data and voice and data only subscriptions.

According to the *OECD Regional Typology*, a region is classified as *rural* (*urban*) if the share of the population living in local units with a population density below 150 inhabitants per square kilometre is above 50% (below 15%). In Japan and Korea, the threshold is 500 inhabitants, as national population density exceeds 300 inhabitants per square kilometre.

Firms' size classes are defined as *small* (10 to 49 persons employed), *medium* (50 to 249) and *large* (above 250).

Households with broadband connections, urban and rural, 2010 and 2016

As a percentage of households in each category

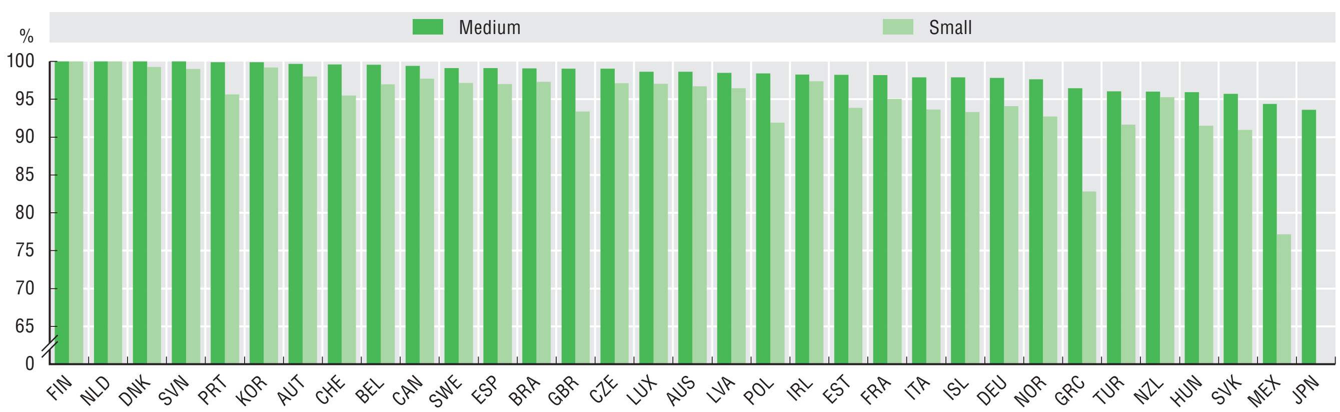


Source: OECD, ICT Access and Usage by Households and Individuals Database, *http://oe.cd/hhind*, June 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933619942

Small and medium enterprises with broadband access, fixed or mobile, 2016

As a percentage of enterprises in each employment size class



Source: OECD, ICT Access and Usage by Businesses Database, *http://oe.cd/bus*, July 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933619961

Measurability

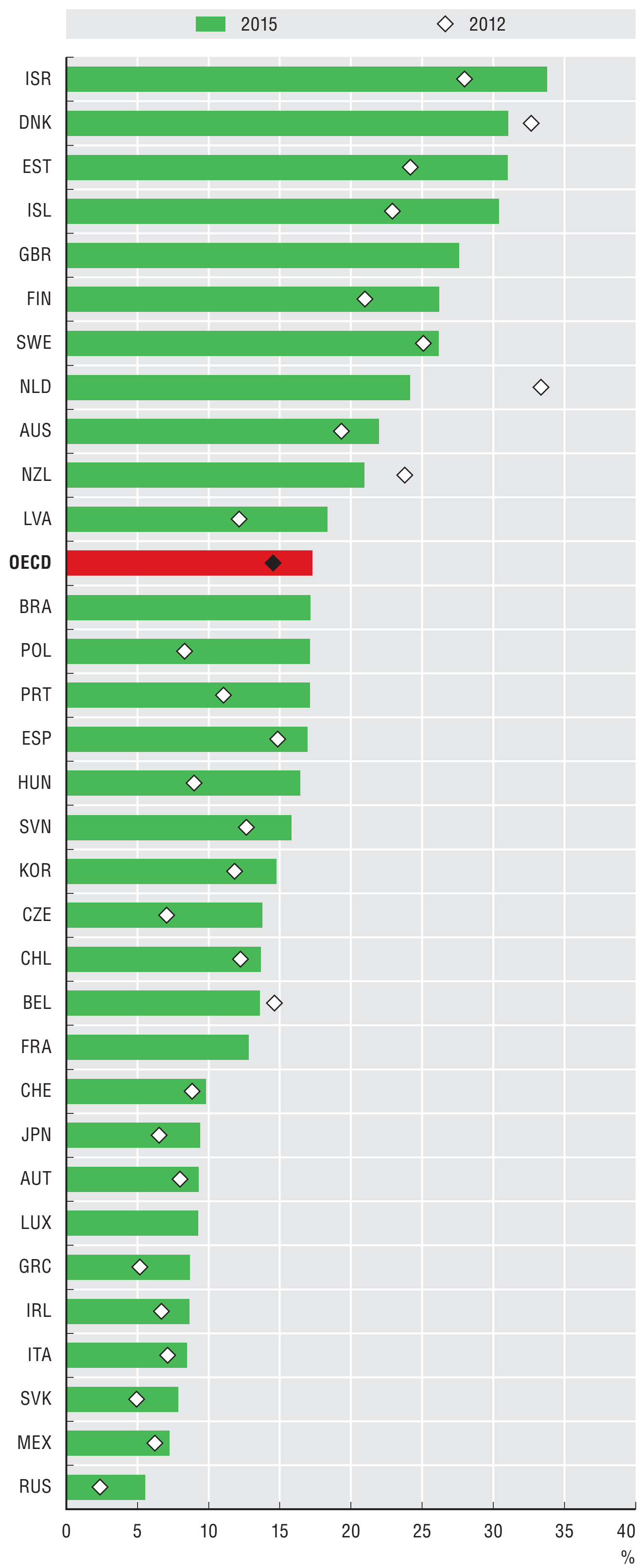
Fixed (wired) and mobile wireless broadband subscriptions for OECD countries are collected according to common definitions and are highly comparable (OECD, 2015a). Data for wireless broadband subscriptions have improved greatly in recent years, especially with regard to measurement of Data and voice mobile and Data only mobile data subscriptions. In the case of Data and voice mobile subscriptions, these need to be active during the last three months before the date of measurement, which can pose difficulties. Data respecting these standards are now available for most OECD countries.

The OECD Regional Typology can help explain regional differences in economic and labour market performance. However, as it is based on population density, it cannot discriminate between regions close to a large populated centre and remote regions. In order to account for these differences, the OECD Regional Typology has been extended to include an additional criterion based on the driving time needed for 50% of the population of a region to reach a populated centre (Brezzi et al., 2011). For the time being, the extended typology has only been computed for regions in North America (Canada, Mexico and the United States) and Europe.

2. Digital natives

Students who first accessed the Internet at the age of 6 or before, 2012 and 2015

As a percentage of 15 year-old students



Source: OECD calculations based on OECD PISA 2015 Database, July 2017. StatLink contains more data.

StatLink http://dx.doi.org/10.1787/888933619980

Did you know?

On average, 56% of 15-year-old boys in OECD play online games daily or almost daily against only 13% of girls, who themselves have a higher propensity to chat online.

The Internet permeates every aspect of the economy and society, and is also becoming an essential element of young people's lives. Increasingly, policy makers require evidence of the impact of ICTs on students' school performance. However, current research presents a rather mixed picture and underlines the need for additional metrics.

According to the results of the 2015 OECD Programme for International Student Assessment (PISA), 17% of students in the OECD area first accessed the Internet at the age of 6 or before. For countries where data are available, less than 0.3% of 15-year-olds reported never having accessed the Internet.

The age of first access to the Internet varies across countries. Over 30% of students started using the Internet at the age of 6 or before in Denmark, Estonia, Iceland and Israel. The most common age of first access to the Internet is between 7 and 9 years in about two-thirds of the countries surveyed by PISA, and 10 years and over in the remaining third.

In 2015, 43% of 15-year-olds in the OECD area spent between 2 and 6 hours a day online outside school – a sizeable increase from less than 30% in 2012. Brazil and Chile were the countries with the largest proportion of students (over 30%) spending more than 6 hours a day on the Internet outside school.

Today, 62% of 15-year-olds in the OECD area chat online and 73% participate in a social network daily or almost daily. Gender differences are particularly notable in activities such as playing online games (most popular among boys) and uploading personally created content for sharing online (most popular among girls).

Definitions

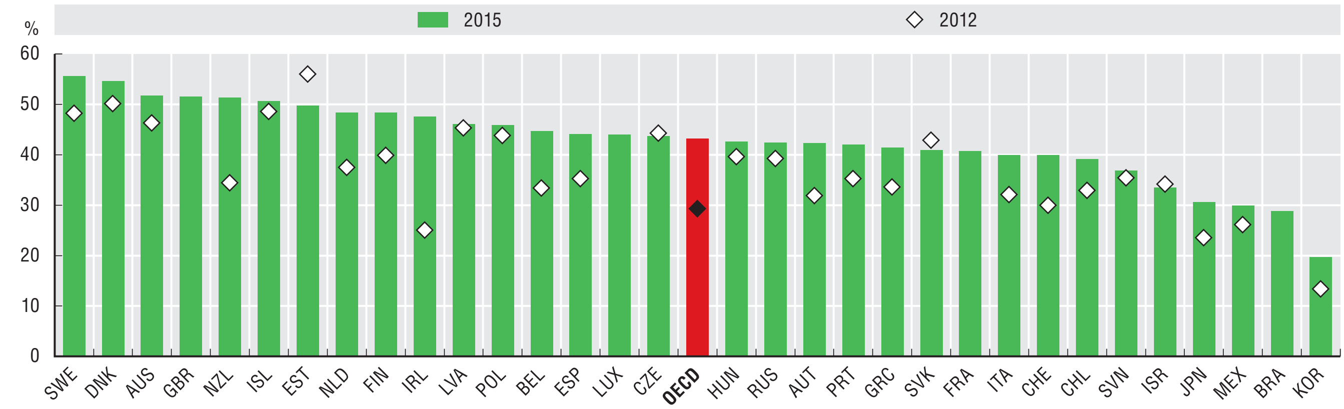
Students assessed by PISA are between the ages of 15 years, 3 months and 16 years, 2 months. They must be enrolled in school and have completed at least six years of formal schooling, regardless of the type of institution, programme followed or whether the education is full-time or part-time.

Online games include one-player or collaborative online games.

All PISA shares are reported as a percentage of respondents. Results are based on students' self-reports.

Time spent on the Internet by students outside school, 2012 and 2015

Percentage of 15 year-old students spending 2 to 6 hours on the Internet during a typical weekday

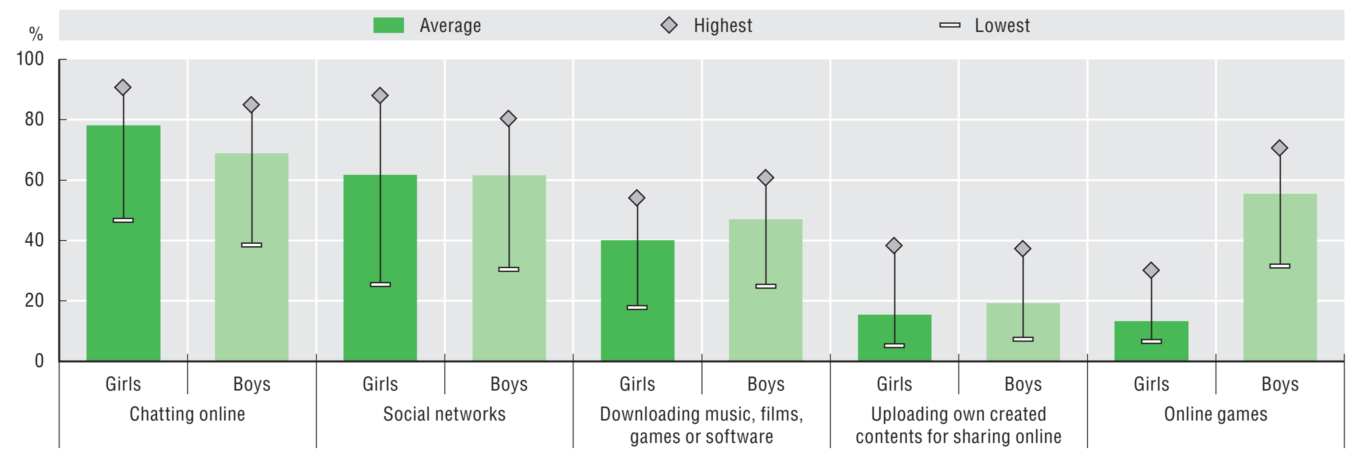


Source: OECD calculations based on OECD PISA 2015 Database, July 2017. StatLink contains more data.

StatLink http://dx.doi.org/10.1787/888933619999

Diffusion of selected online activities among students in OECD countries, by gender, 2015

Percentage of 15 year-old students performing each activity daily or almost daily



Source: OECD calculations based on OECD PISA 2015 Database, July 2017. StatLink contains more data.

StatLink http://dx.doi.org/10.1787/888933620018

Measurability

PISA 2015 assessed the skills of 15-year-olds in 72 economies. Over half a million students between the ages of 15 years, 3 months and 16 years, 2 months, representing 28 million 15-year-olds globally, took the internationally agreed 2-hour test.

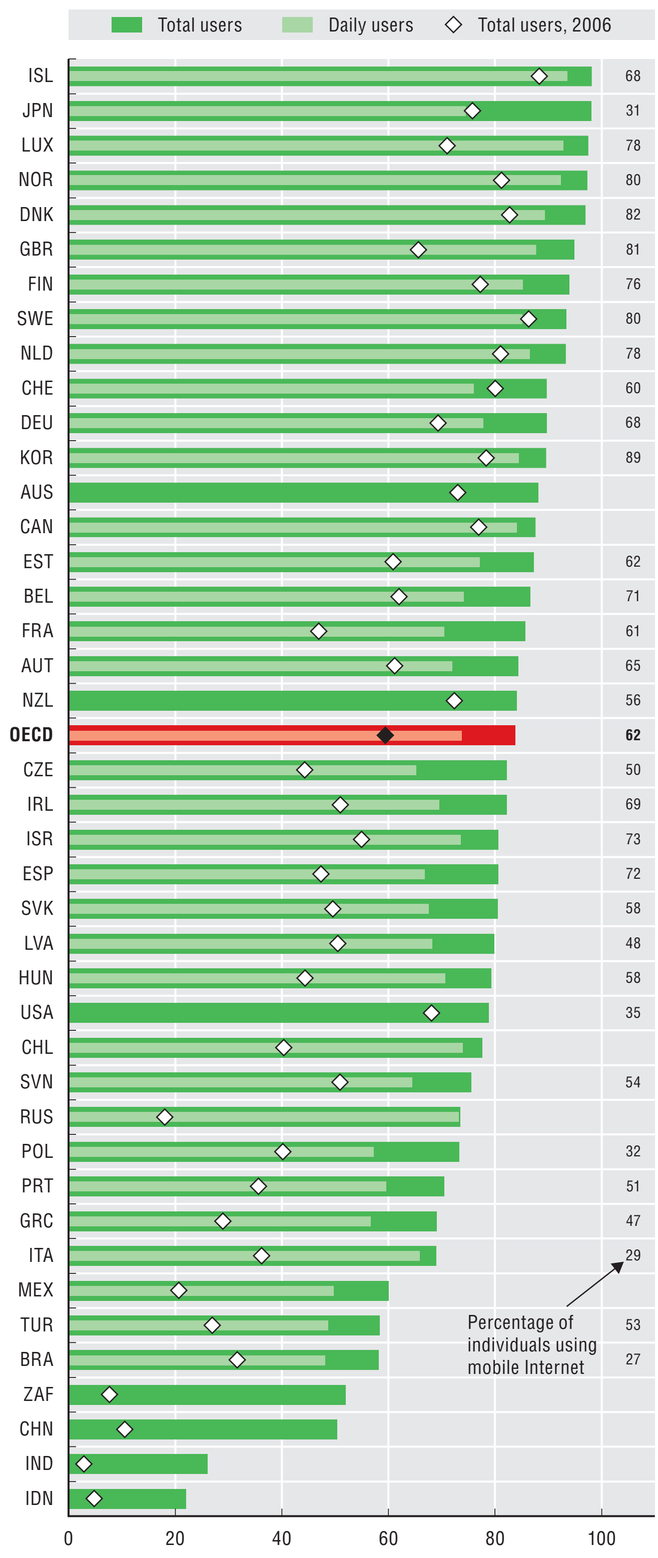
The ICT familiarity questionnaire is an optional module and consists of questions on the availability of ICTs at home and school, the frequency of use of different devices and technologies, students' ability to carry out computer tasks and their attitudes towards computer use. In 2015, 47 out of 72 economies participating in PISA ran this specific module. Despite the valuable information gained as a result of implementation, the ICT questionnaire was not administered in 2015 in several OECD countries (Canada, Norway, Turkey and the United States) due largely to the high costs generated by the inclusion of these additional questions in the survey.

Increasing availability of data from multiple PISA waves allows the assessment of student use of ICTs both at school and outside school over time, as well as investigation of the impact on school performance, which is a key concern for education policy makers.

3. Internet users

Total, daily and mobile Internet users, 2016

As a percentage of 16-74 year olds



Source: OECD, ICT Access and Usage by Households and Individuals Database, *http://oe.cd/hhind*; ITU, World Telecommunication/ICT Indicators Database and national sources, June 2017. StatLink contains more data. See chapter notes.

StatLink *http://dx.doi.org/10.1787/888933620037*

Did you know?

Over 60% of the OECD adult populations use a mobile or smartphone to connect to the Internet.

For most people, the Internet is now part of everyday life. Between 2006 and 2016, total usage rates across the OECD increased by 25 percentage points from 59% to 84%. On average, 74% of individuals in OECD countries for which data are available connect to the Internet on a daily basis, while 62% of the OECD adult population used a mobile or smartphone to connect.

Internet usage varies widely across OECD countries and among social groups. In 2016, no less than 97% of the adult population accessed the Internet in Denmark, Iceland, Japan, Luxembourg and Norway. However, Internet usage was substantially lower in Mexico at only 60% and even lower (58%) in Turkey. Among non-OECD countries, this share varied between 58% in Brazil and 22% in Indonesia.

Differences in Internet uptake are linked primarily to age and education, often intertwined with income levels. In all OECD countries except the United States, the proportion of Internet users with tertiary education was above 90% in 2016, but there were wide differences among less educated people. The share of Internet users among individuals with low or no education ranges between over 90% in Denmark, Iceland, Luxembourg and Norway and less than 40% in Chile and Greece. In Mexico and Turkey, the difference in Internet uptake between high and low-education individuals was 35 percentage points and above. People with lower education are therefore a potential focus for strategies to foster digital inclusion.

In 2016, Internet usage among women in OECD countries (83%) was still slightly lower than among men (85%). This difference was more pronounced in Turkey, where Internet usage among women was 18 percentage points below that of men, Austria (-7) and Italy (-6). Overall, there are large differences in the total share of Internet users between young (96%) and elderly women (61%) across the OECD.

Definitions

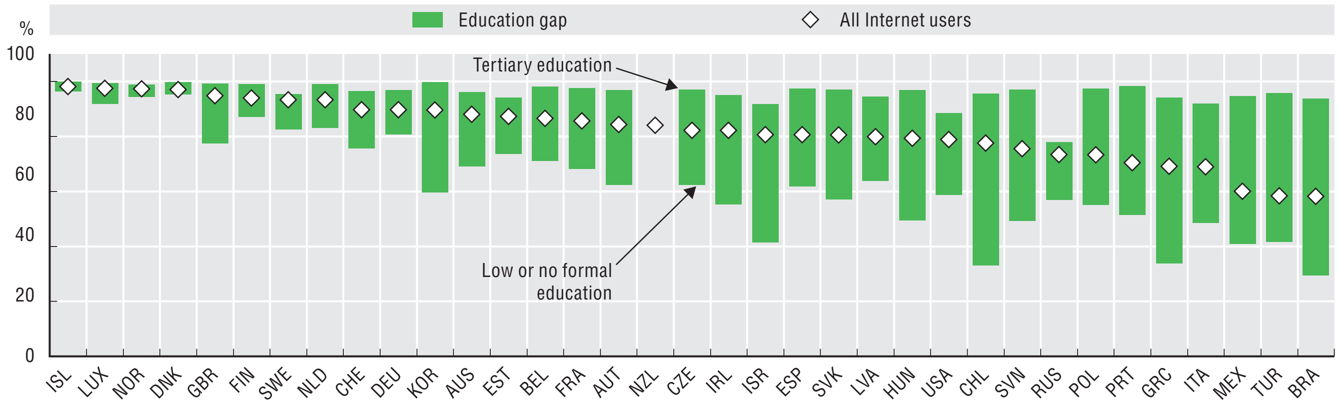
Users include individuals who accessed the Internet within the last three months prior to surveying. Different recall periods have been used for some countries (see chapter notes).

Daily users consist of individuals accessing the Internet approximately every day on a typical week (i.e. excluding holidays, etc.).

Mobile Internet usage is defined as using the Internet away from home or work on a portable computer or handheld device. Figures on individuals using the Internet via mobile or smartphones include connection via mobile or wireless networks for countries in the European Statistical System; for other countries see chapter notes.

Gap in Internet use by educational attainment, 2016

As a percentage of the population in each category



Source: OECD, ICT Access and Usage by Households and Individuals Database, *http://oe.cd/hhind* and ITU, World Telecommunication/ICT Indicators Database, June 2017. StatLink contains more data. See chapter notes.

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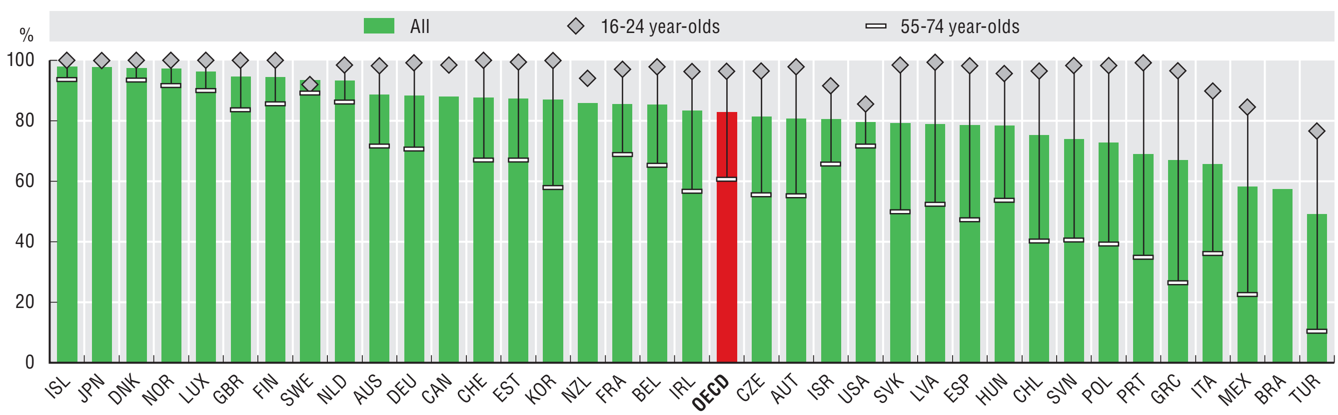
Women Internet users, by age, 2016

As a percentage of the population in each age group



Source: OECD, ICT Access and Usage by Households and Individuals Database, *http://oe.cd/hhind* and ITU, World Telecommunication/ICT Indicators Database, June 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933620075

Measurability

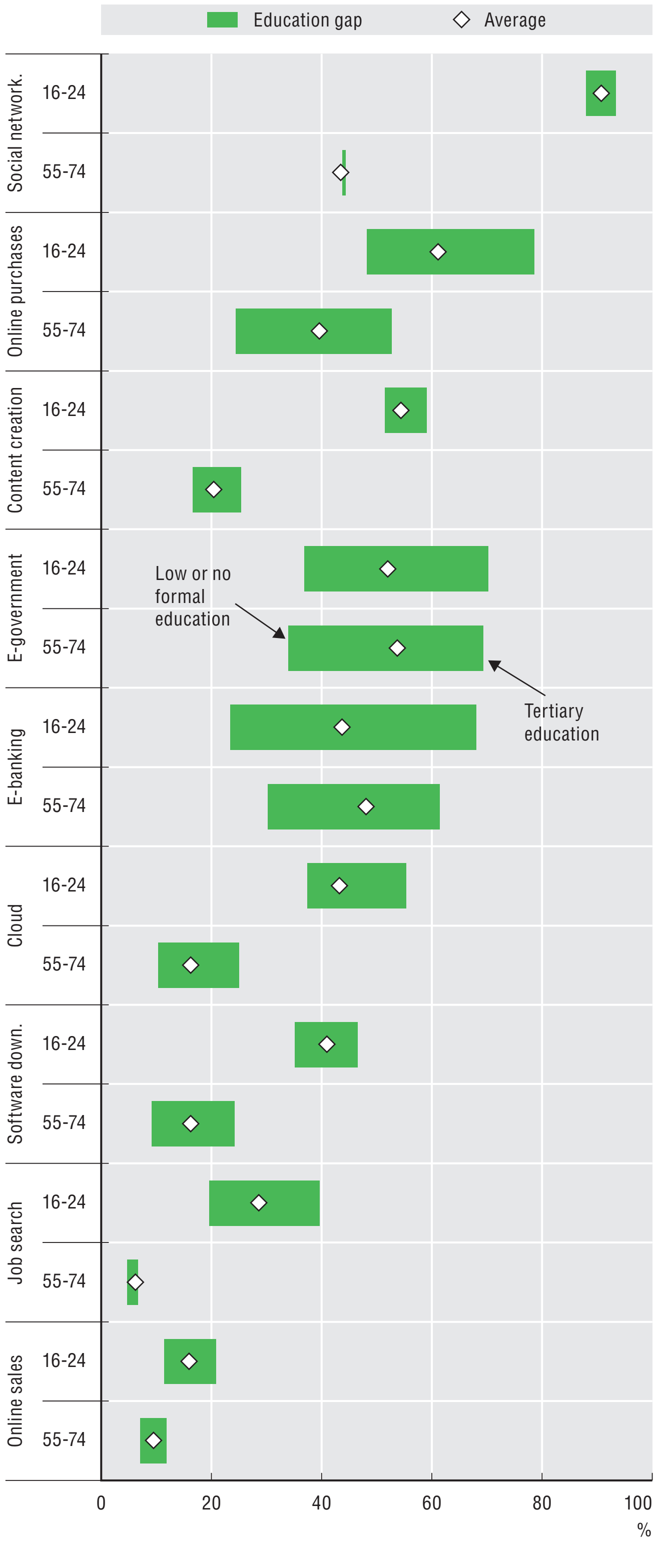
Not all OECD countries survey ICT usage by households and individuals. Data availability for specific indicators also varies (see chapter notes). Surveys in Australia, Canada, Chile, Israel and New Zealand are undertaken on a multi-year or occasional basis, but take place annually in other countries. In the European Union, the survey is compulsory in only eight countries. Breakdown of indicators by age or educational attainment groups may also raise issues about the robustness of information, especially for smaller countries, owing to sample size and survey design.

The OECD is actively engaged in work to facilitate the collection of comparable information in this field through its Model Survey on ICT Access and Usage by Households and Individuals (OECD, 2015b), and its encouragement of coordinated collection of statistics on ICT usage in general.

4. Users' sophistication

Diffusion of selected online activities among Internet users in OECD countries, by age and educational attainment, 2016

Internet users performing each activity as a percentage of the respective group



Source: OECD, ICT Access and Usage by Households and Individuals Database, *http://oe.cd/hhind*, June 2017. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933620094

Did you know?

In 2016, 70% of Internet users in the OECD were active on social networks, irrespective of their educational attainment.

The types of activities carried out over the Internet vary widely across countries, as a result of different institutional, cultural or economic factors. The breadth of activities performed by each Internet user provides an indicator of user sophistication.

Age and education are among the main factors that explain differences in uptake within countries. Most activities enjoy higher uptake among young people, except e-government and e-banking where the share of elderly users is larger. Education interacts with age in different ways depending on the type of activity undertaken online. Differences in uptake between high and low-education individuals are larger for the elderly for activities such as downloading software and, to a smaller extent, creating online content. However, education differences are more important for young people in all other activities, including e-banking, e-government, cloud services and social networking, selling and purchasing or searching for a job online.

In nearly all countries, the share of online purchasers in 2016 was higher than in 2010. In some countries starting with a lower level of uptake, such as Estonia and Mexico, shares more than doubled. In 2016, 60% of all OECD Internet users made a purchase online, but the proportion of online purchasers among users aged 16-24 was, on average, over 20 percentage points higher than among users aged 55-74.

Over the last few years, ICTs have increasingly contributed to a wider array of learning opportunities through the development of online courses such as massive open online courses (MOOCs). In 2016, over 14% of Internet users aged 16-24 years in the OECD followed an online course, compared with 13% in 2009. However, this proportion varies from less than 3% in the Slovak Republic to 77% in Canada.

Definitions

Internet users are individuals who have accessed the Internet within the last three months prior to surveying. Different recall periods have been used for some countries (see chapter notes).

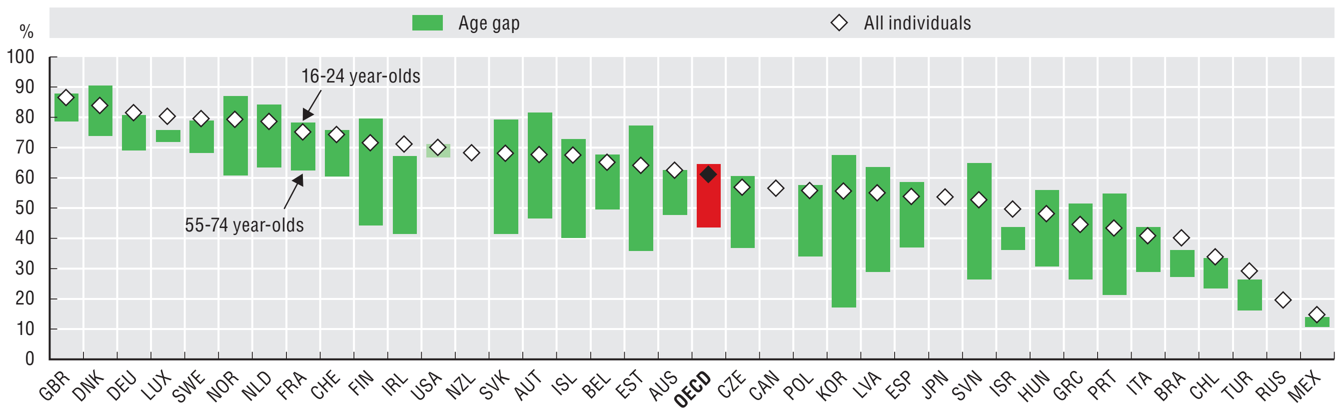
Tertiary education refers to ISCED levels 5 or 6 and above. *Low or no formal education* refers to ISCED levels 0 to 2.

An *e-commerce* transaction describes the sale or purchase of goods or services conducted over computer networks by methods specifically designed for the purpose of receiving or placing orders (OECD, 2011).

An *online course* is a course in which some content is delivered electronically via the Internet or other computer-based methods, and/or some teaching is conducted from a remote location through online or electronic tools.

Individuals who purchased online in the last 12 months, by age, 2016

As a percentage of Internet users in each age group



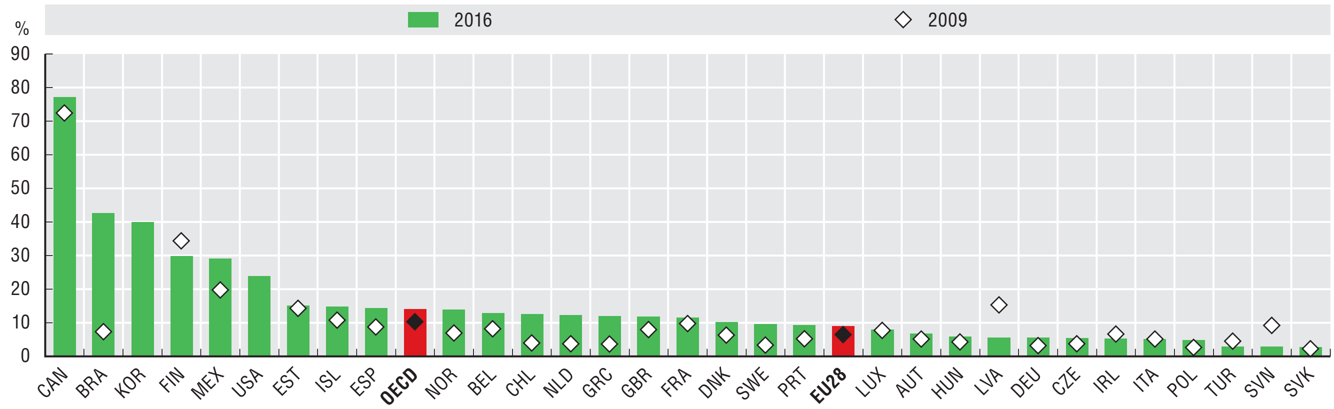
Note: For the United States, the age gap shown in lighter green is reversed. Individuals aged 55-74 have a slightly higher propensity to purchase online than individuals aged 16-24.

Source: OECD, ICT Access and Usage by Households and Individuals Database, *http://oe.cd/hhind* and ITU, World Telecommunication/ICT Indicators Database, June 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933620113

Individuals aged 16-24 who attended an online course, 2009 and 2016

As a percentage of individuals aged 16-24



Source: OECD, ICT Access and Usage by Households and Individuals Database, *http://oe.cd/hhind*, June 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933620132

Measurability

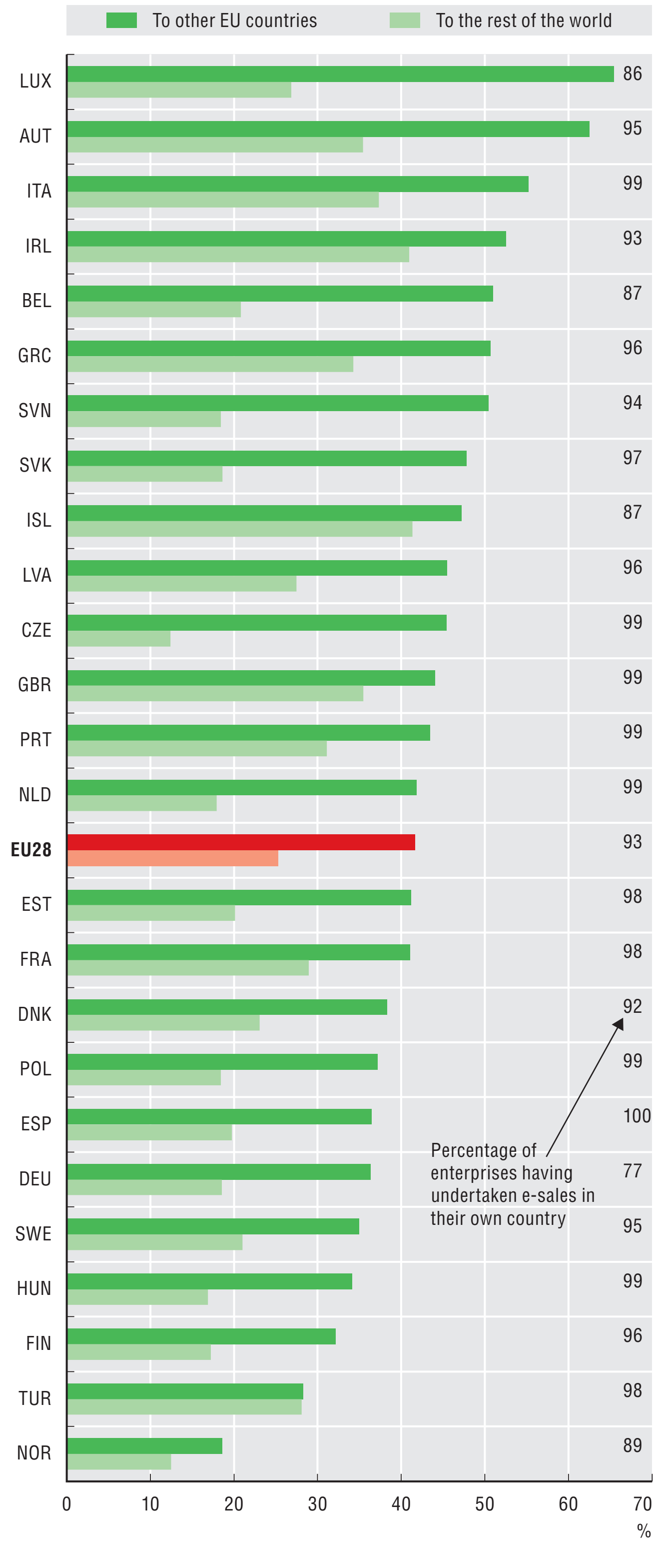
Data collection on ICT usage by individuals is uneven across OECD countries, due to differences in frequency and the nature of surveys. In particular, data on the type of activities performed – which are potentially wide and increasing – are often restricted to basic information.

For online purchases, issues of comparability may be linked to several factors. Differences in age limits play a role – data for Japan and the United States refer to all individuals aged 6 and over instead of 16-74 year olds, which might reduce overall rates. Differences in reference periods are also significant – the recall period for Israel is 3 months instead of 12, while no recall period is specified for Chile and the United States. Differences also exist in the definition itself – for New Zealand, only e-purchases accompanied by an online payment are considered). Finally, there are differences in survey methodology (e.g. techniques, time of year, etc.).

5. E-consumers across borders

Enterprises having undertaken cross-border e-commerce sales, 2014

As a percentage of all enterprises having undertaken e-commerce sales



Source: OECD, based on Eurostat, Digital Economy and Society Statistics, Comprehensive Database, July 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933620151

Did you know?

In 2016, 20% of online purchasers in Europe ordered from a seller in a non-European country.

The Internet has facilitated access to global markets, creating new opportunities for consumers and businesses. Key factors that affect the uptake of cross-border e-commerce include IT infrastructure, regulatory frameworks and economic integration.

In 2014, 42% of European enterprises selling online made cross-border sales to other European countries and 25% to non-European ones. The proportion of cross-border sellers to other European countries was the highest in Luxembourg (65%) and Austria (62%). Iceland and Ireland had the highest share (41%) of cross-border sellers to non-European countries.

Consumers in both Canada and Europe prefer buying online from national rather than foreign sellers. Small open economies, such as Austria and Luxembourg, are the only exceptions to this pattern. In all countries except Iceland, consumers prefer buying from partner countries when ordering goods or services online from a foreign seller. In 2016, 90% of online purchasers in Luxembourg ordered from a seller located in a partner country as opposed to 7% in Turkey.

In the United States, turnover from business to consumer e-commerce represented just over 7% of retail turnover, similar to the average for European countries (8.7%). The European average, though, hides large variations across countries, ranging from 20% in Sweden and 15% in Denmark to below 3% in Portugal in 2015. Diffusion of e-commerce in retail does not seem to be linked to the size of the sector, as countries with the largest revenue share of retail in total business sector are also those with the lowest share of e-retail transactions.

Definitions

An *e-commerce transaction* describes the sale or purchase of goods or services conducted over computer networks by methods specifically designed for the purpose of receiving or placing orders (OECD, 2011). For individuals, whether sellers or purchasers, such transactions typically occur over the Internet. For enterprises, e-commerce sales include all transactions carried out over webpages, extranet or Electronic Data Interchange (EDI) systems.

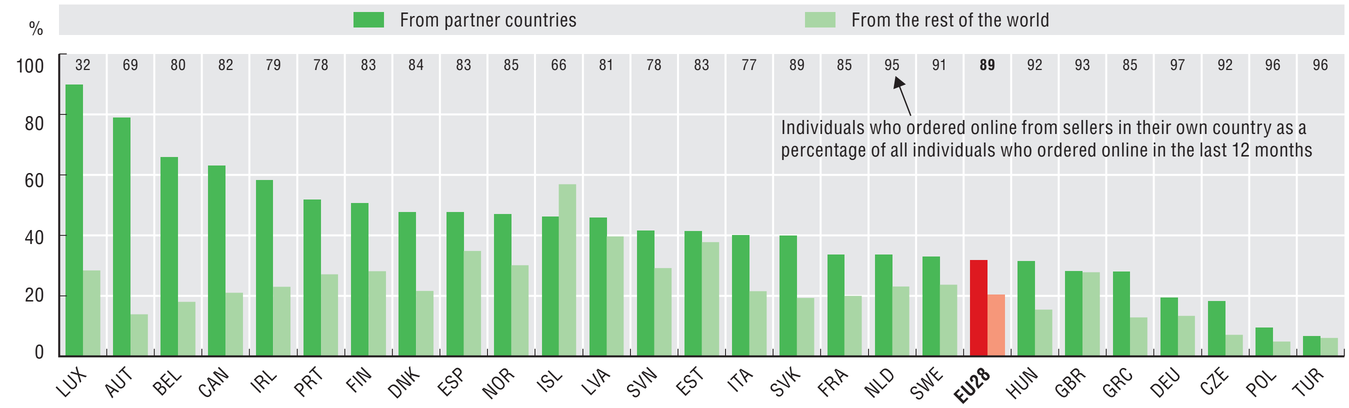
Business-to-consumer (B2C) consists of sales by exclusively e-commerce enterprises to consumers, and traditional bricks-and-mortar retail or manufacturing firms that have added an online sales channel. The products sold may be physical goods or digital products and services.

Size classes are defined as: small (10 to 49 persons employed), medium (50 to 249) and large (250 and more).

Partner countries refer to EU member states for countries in the European Statistical System and to the United States for Canada.

Individuals purchasing online from domestic and foreign markets, 2016

As a percentage of individuals who ordered goods or services over the Internet in the last 12 months

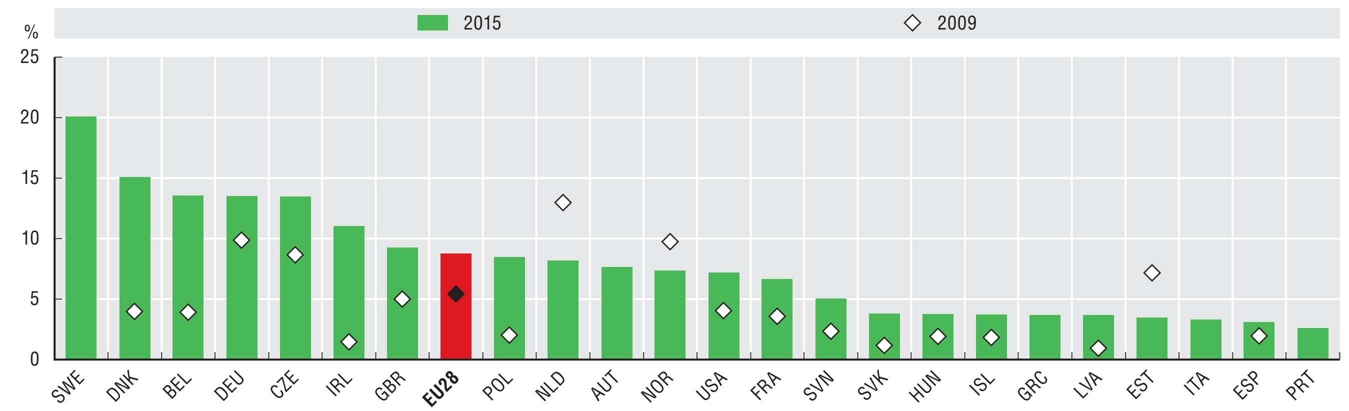


Source: OECD, based on Eurostat, Digital Economy and Society Statistics, Comprehensive Database and national sources, July 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933620170

Business to consumer transactions (B2C), 2009 and 2015

Turnover from retail e-commerce as a percentage of total turnover in the retail sector



Source: OECD, based on Eurostat, Digital Economy and Society Statistics, Comprehensive Database and US Census Bureau, Quarterly Retail E-Commerce Sales, 1st Quarter 2017, July 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933620189

Measurability

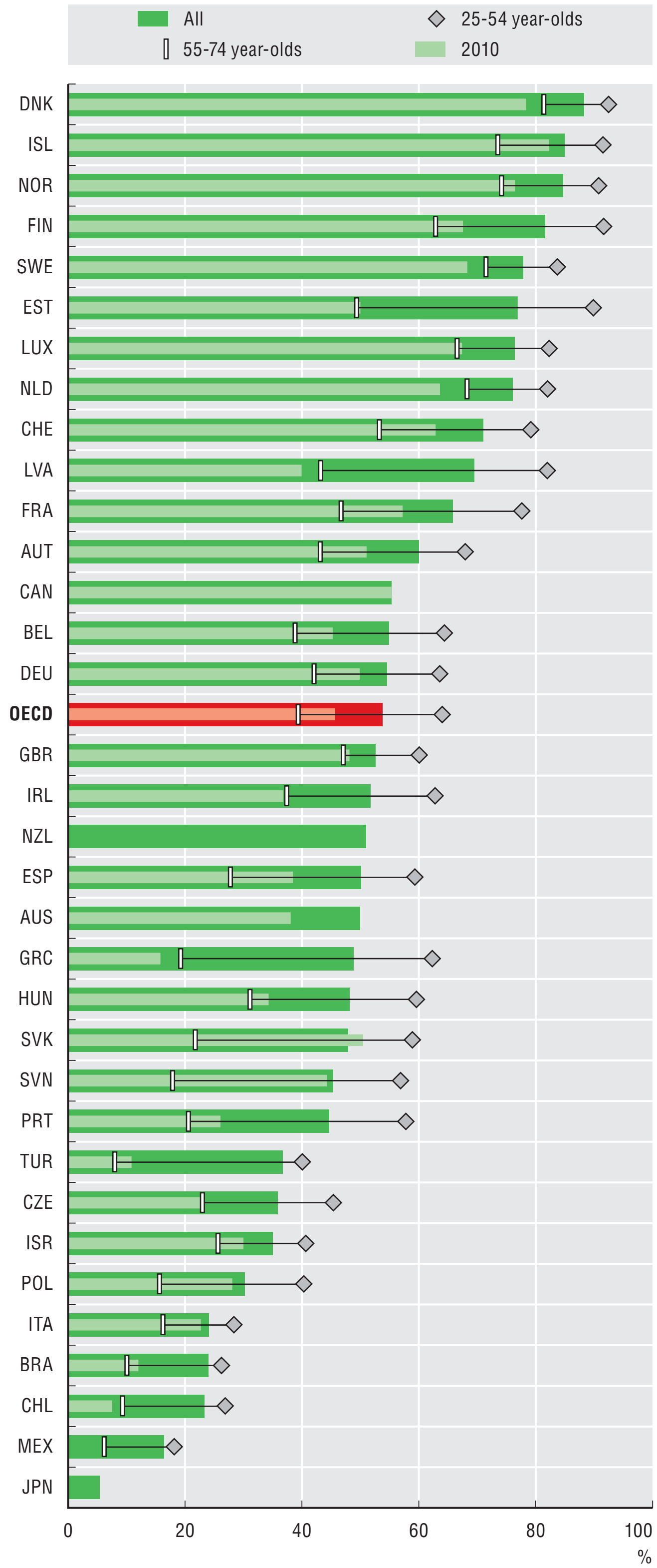
Measurement of e-commerce presents methodological challenges that can affect the comparability of estimates. These include the adoption of different practices for data collection and estimations, the treatment of outliers and the extent of e-commerce carried out by multinationals, the imputation of values from ranges recorded in surveys, and differences in sectoral coverage. In the case of demand-side surveys, consumers generally have poor recall with regard to specific types of questions, such as countries purchased from. A significant proportion of users are not necessarily aware of the origin of websites they use for shopping or may not recall the amounts spent. In addition, because B2C includes the purchase of digital products, which are increasingly downloaded or streamed over the Internet, it is difficult for the consumer to identify the country of origin.

Cross-border e-commerce transactions are captured by ICT usage surveys, both for firms and individuals, in countries that follow the European Statistical System, and for individuals only in Canada. Other countries have plans to collect comparable data in line with the growing impact of the digital economy on society.

6. E-government

Individuals using the Internet to interact with public authorities, by age, 2016

As a percentage of population in each age group



Source: OECD, ICT access and use database, (households and individuals), *http://oe.cd/hhind* (accessed in June 2017). StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933620208

Did you know?

Over 50% of individuals interact with governments online in OECD countries. However, this proportion can vary widely, ranging from 80% in the Nordic countries to below 10% in Japan.

The share of individuals using the Internet to interact with public authorities in OECD countries has increased in recent years, from 46% in 2010 to 54% in 2016. Cross-country differences remain large, however, ranging from over 80% in Denmark, Iceland, Norway and Finland to 5% in Japan. Use by individuals in the 55-74-years-old bracket remains significantly lower than average in all countries.

Cross-country differences may reflect differences in Internet usage rates, the supply of e-government services and the propensity of users to perform administrative procedures online, as well as limited data comparability. On average, less than 4% of EU citizens who had to submit a completed form to public authorities in 2016 reported not submitting online because the service was not available. The share was much higher in Germany (13%).

Concerns about protection and security of personal data are also reported as a frequent reason for not submitting official forms online. In 2016, 21% of Europeans chose not to submit completed forms to public authorities and, on average, 22% among those cited privacy and security concerns as a reason for not doing so. This was particularly the case in Germany (38%), Portugal (34%) and Hungary (33%).

Use of the Internet to send documents to public authorities is more common among firms than individuals, as enterprises undertake administrative procedures more frequently. In some cases, use of online tools is mandatory by law. In 2015, 36% of EU firms sent an invoice online to public authorities, although this share ranges from 70% in Denmark to 17% in the Czech Republic. In all EU countries except Denmark, use of the Internet for this purpose is higher among large firms than small ones.

Definitions

Individuals' online interactions with public authorities range from the simple collection of information on government websites to interactive procedures where completed forms are sent via the Internet – excluding interaction via e-mail (for businesses) or manually typed e-mails (for individuals).

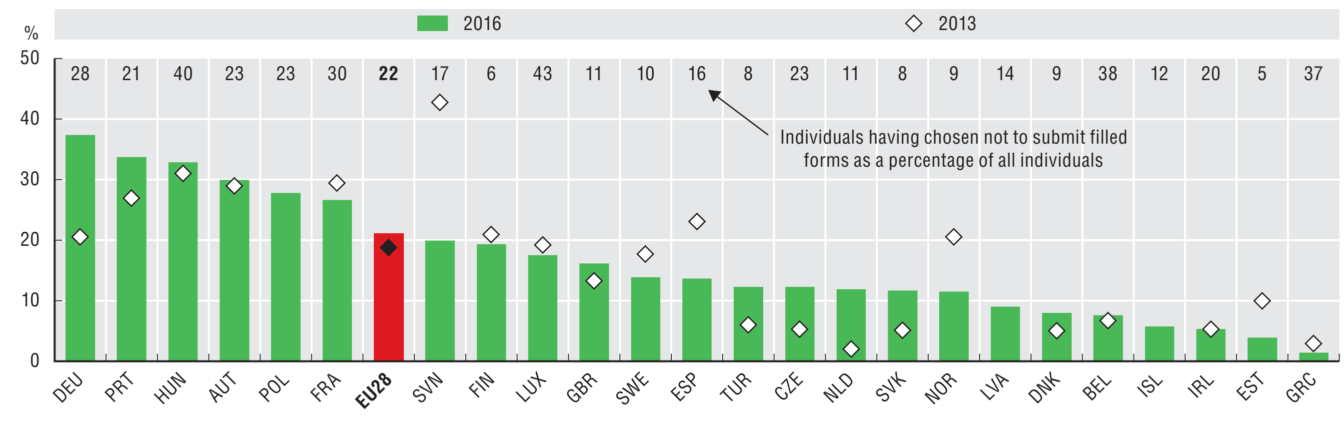
Public authorities refer to both public services and administration activities. These may be authorities at the local, regional or national level.

Electronic signatures and electronic ID/certificates are intended to provide users with a secure and accurate identification method for the submission of online forms.

Size classes are defined as: small (from 10 to 49 persons employed) and large (250 and more).

Individuals not submitting official forms online due to privacy and security concerns, 2016

As a percentage of individuals having chosen not to submit online

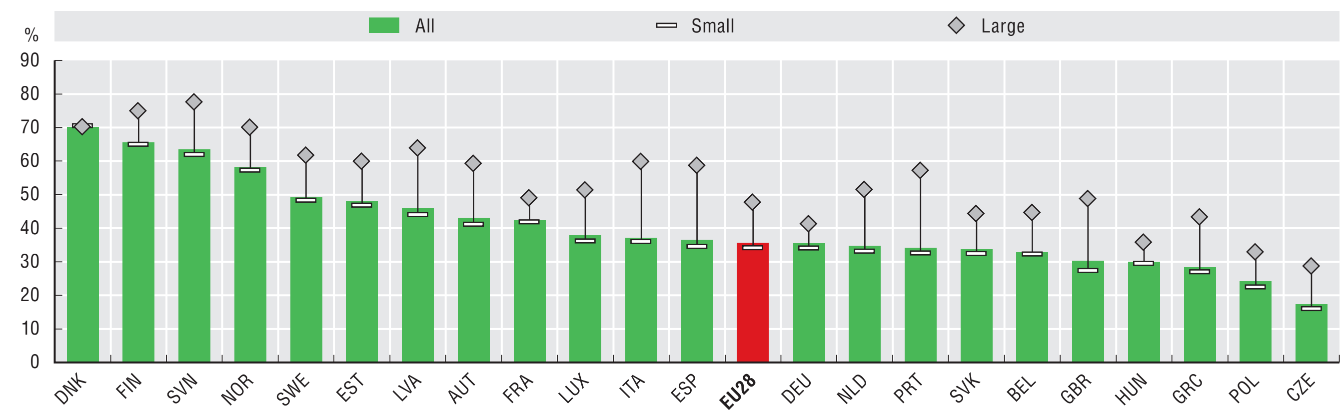


Source: OECD, based on Eurostat, Digital Economy and Society Statistics, Comprehensive Database, July 2017. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933620227

Businesses using the Internet to send invoices to the public authorities, by size, 2015

As a percentage of businesses in each employment size class



Source: OECD, based on Eurostat, Digital Economy and Society Statistics, Comprehensive Database, July 2017. StatLink contains more data. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933620246

Measurability

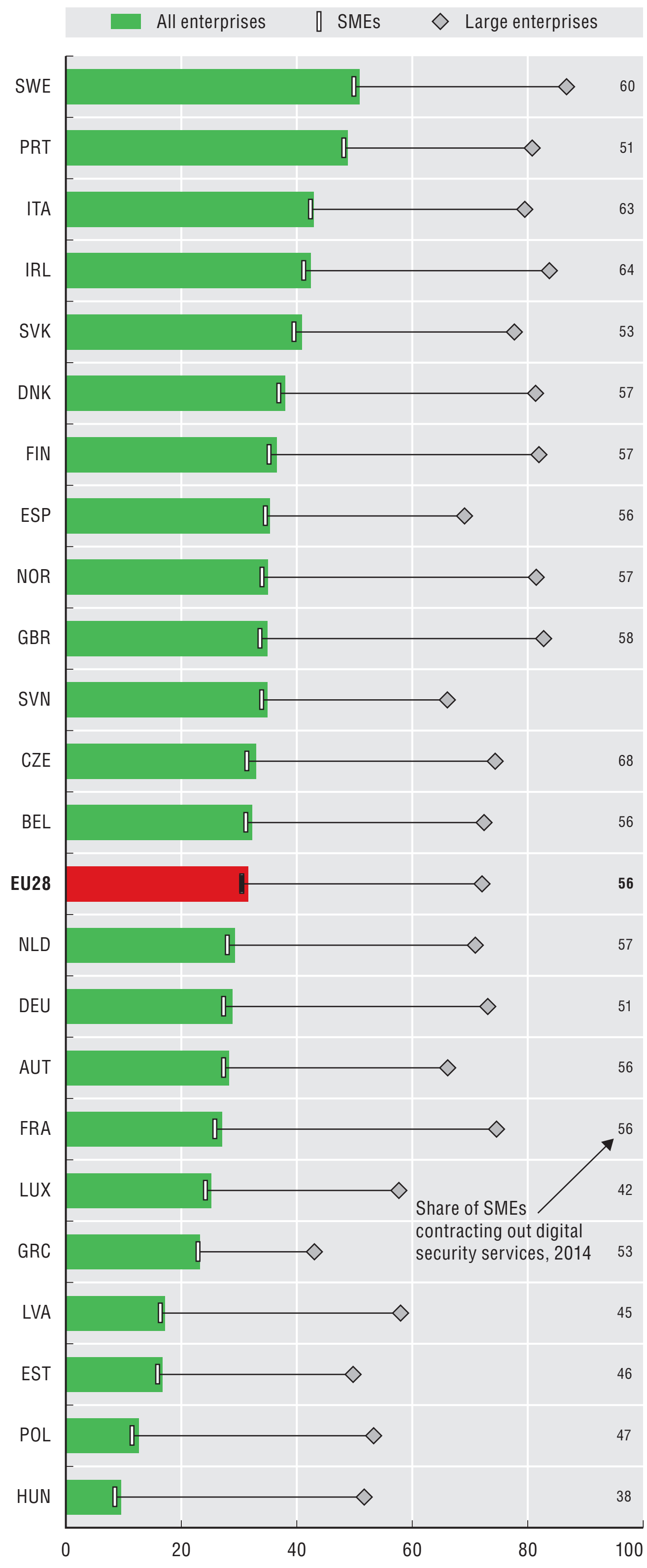
E-government can be measured by collecting information on electronic services offered by government entities (supply-side approach) or on the use of these services by businesses and individuals (demand-side approach). In recognition of the statistical difficulties of the supply-side approach, the OECD and other international organisations have adopted a demand-side approach. Such an approach is not without difficulties, however. As the same services (e.g. transport, education, health) are provided by government in some countries and by public or private sector businesses in others, the scope for e-government service use by individuals and firms will differ among countries. These structural differences are likely to affect not only international comparability, but also comparability over time within countries.

The OECD is actively engaged in the collection of comparable and more detailed information in this field, by means of its Model Surveys on ICT usage by households/individuals (OECD, 2015b) and by businesses (OECD, 2015c). Other complementary ways to collect information are also being explored, including by means of information on public administration web-portals.

7. Trust

Enterprises having a formally defined security policy, by size, 2015

As percentage of enterprises in each employment size class



Source: OECD, based on Eurostat, Digital Economy and Society Statistics, Comprehensive Database, July 2017. See chapter notes.

StatLink http://dx.doi.org/10.1787/888933620265

Did you know?

In 2015, 70% of large enterprises in Europe had a formal security policy but only 30% of SMEs.

The digitisation of information and network connectivity are creating new challenges for the protection of sensitive data and network communications. Having a formal ICT security policy is a sign that an enterprise has experienced or is aware of digital risks.

In 2015, about 32% of European enterprises had a formally defined ICT security policy. However, this proportion varied widely across countries and by firm size. While 30% of European SMEs had a formal ICT security policy in 2015, in the United States this proportion was 23% (US National Cyber Security Alliance and Symantec, 2011).

SMEs also tend to rely more on external workers to ensure their digital security and data protection, probably due to limited access to financial resources and specialised skills. In 2015, digital security and data protection was performed internally in over 64% of large enterprises as opposed to 14% in SMEs.

In 2016, more than 70% of Internet users in Europe provided some kind of personal information online, with many performing actions to control access to this data on the Internet. 46% of all Internet users in Europe refused to allow the use of personal information for advertising and 40% limited access to their profile or content on social networking sites. More than one-third of Internet users read privacy policy statements before providing personal information and restricted access to their geographical location.

Young people show a higher propensity to share personal information online, but also undertake actions to control access to the information more often. Men tend to be more willing to share private information online than women in over two-thirds of the countries surveyed.

Definitions

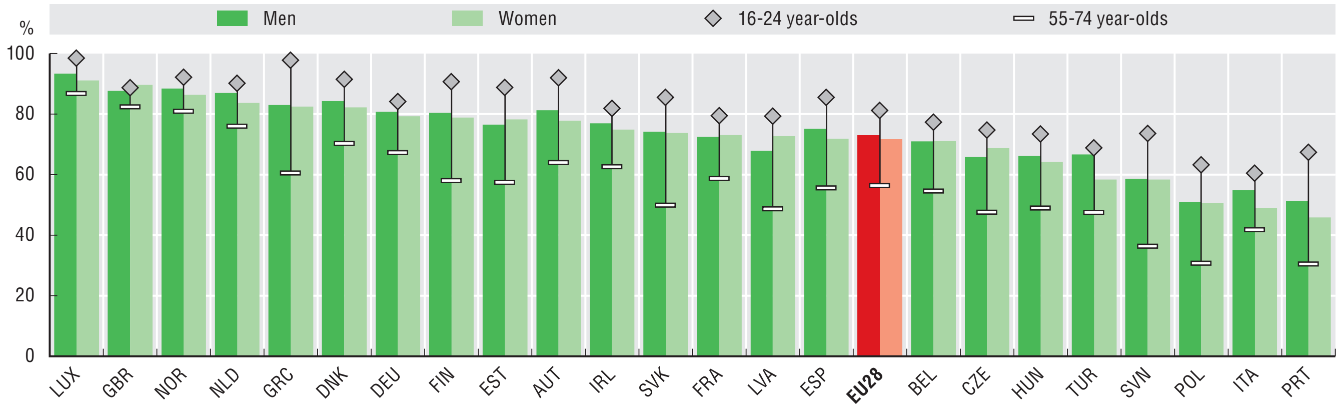
ICT security policies include measures, controls and procedures applied to ICT systems to ensure the integrity, authenticity, availability and confidentiality of data and systems. In particular, such policies are designed to address the following security risks: destruction or corruption of data due to hardware or software failures; unavailability of ICT services due to outside attacks; and disclosure of confidential data due to intrusion, pharming or phishing attacks.

Size classes are defined as SMEs (10 to 249 person employed) and large (250 and more).

Personal information refers to information that the user considers private and would not necessarily disclose to the public, such as personal, contact and payment details or other personal information.

Individuals who provided personal information over the Internet in the last 12 months, by gender and age, 2016

As a percentage of Internet users in each group

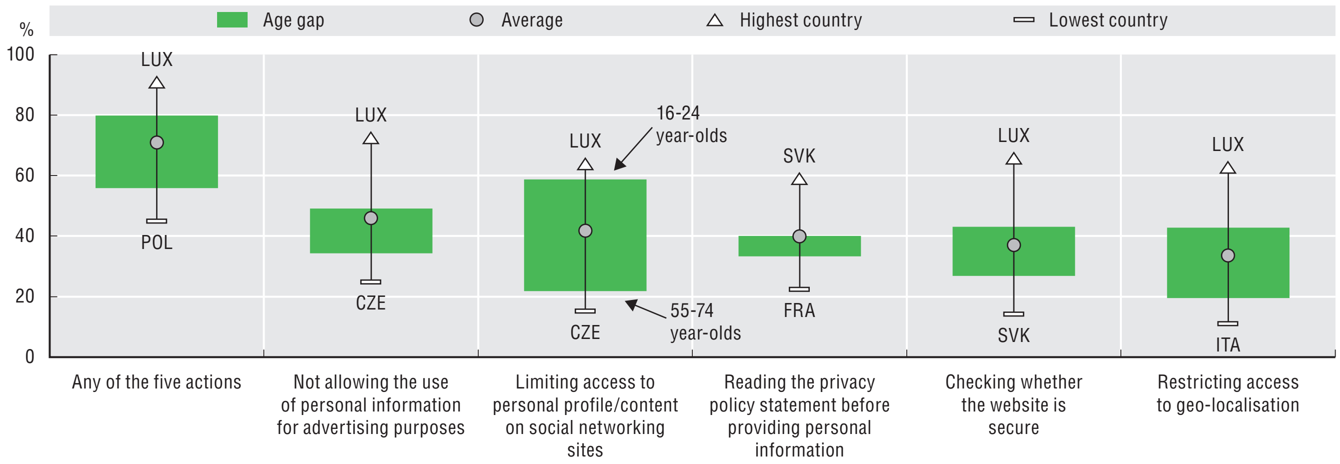


Source: OECD, based on Eurostat, Digital Economy and Society Statistics, Comprehensive Database, July 2017. StatLink contains more data.

StatLink http://dx.doi.org/10.1787/888933620284

Individuals who managed access to their personal information on the Internet, by age, 2016

As a percentage of Internet users in each group



Source: OECD, based on Eurostat, Digital Economy and Society Statistics, Comprehensive Database, July 2017. StatLink contains more data.

StatLink http://dx.doi.org/10.1787/888933620303

Measurability

Information on ICT security policies is collected through the Eurostat's Survey on ICT usage and e-commerce in enterprises. Information on disclosure and protection of personal information online is collected through the ICT usage surveys in households and by individuals.

Both the European and OECD model surveys on ICT usage ask direct questions about security and privacy, including on the use of protection from IT threats, the frequency of security updates and security incidents.

The 2014 revision of the OECD Model Survey on ICT Access and Usage by Households and Individuals includes a specific module on security and privacy, based on policy-relevant indications from the OECD Working Party on Security and Privacy in the Digital Economy.

It is a matter of debate among statisticians whether respondents are able to answer technical questions about IT security. To minimise this problem, coverage of the OECD security module is limited to home use, as this is the ICT environment about which users are more likely to have information, as opposed to ICT use at work or school.

Notes and references

Cyprus

The following note is included at the request of Turkey:

"The information in this document with reference to 'Cyprus' relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognizes the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Turkey shall preserve its position concerning the 'Cyprus issue'."

The following note is included at the request of all of the European Union Member States of the OECD and the European Union:

"The Republic of Cyprus is recognized by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus."

Israel

"The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities or third party. 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.

"It should be noted that statistical data on Israeli patents and trademarks are supplied by the patent and trademark offices of the relevant countries."

6.1. Connectivity

Mobile broadband penetration, by technology, December 2016

For Brazil, China, India, Indonesia, the Russian Federation, Saudi Arabia and South Africa, the data source is ITU World Telecommunication/ICT Indicators Database, July 2017.

For Israel, the data source is GSMA Intelligence.

For Switzerland and the United States, data for December 2016 are estimates.

Households with broadband connections, urban and rural, 2010 and 2016

For Brazil and the United States, data refer to 2015 instead of 2016.

For Chile, data refer to 2012 and 2015.

For Iceland, data refer to 2010 and 2014.

For Switzerland, data refer to 2012 and 2014.

For the United Kingdom, data refer to 2009 instead of 2010.

For Brazil, areas are defined as urban or rural according to local legislation, as compiled by the NSO. Reported data refer to urban (densely populated) and rural (thinly populated).

For Chile, for the year 2012, large urban areas refer to a contiguous set of local areas, each of which has a density superior to 500 inhabitants per square kilometre, where the total population for the set is at least 50 000 inhabitants. Rural areas refer to a contiguous set of local areas belonging neither to a densely populated nor to an intermediate area. An intermediate area refers to a contiguous set of local areas, not belonging to a densely populated area, each of which has a density superior to 100 inhabitants per square kilometre, and either with a total population for the set of at least 50 000 inhabitants or adjacent to a densely populated area.

For France, Latvia, the Netherlands and Sweden, there is a break in series with previous years in 2016 for rural and urban data.

For the United States, population density categories are approximated based on a household's location in a principal city, the balance of a metropolitan statistical area (MSA), or neither. To protect respondent confidentiality, the information has been redacted from some observations in the public use datasets.

Small and medium enterprises with broadband access, fixed or mobile, 2016

Only enterprises with ten or more employees are considered. Unless otherwise stated, size classes are defined as: small (10-49 employees) and medium (50-249 employees).

For Australia, data refer to the fiscal year 2014/15 ending on 30 June.

For Brazil, broadband is defined by type of connection rather than download speed, and includes DSL, cable modem, fibre, radio, satellite and 3G/4G. Data refer to 2015.

For Canada, data include all connection groups except dial-up connection. Responses of 'don't know' were removed from the numerator and the denominator. Data refer to 2013 and medium-sized enterprises have 50-299 employees.

For Japan, data refer to 2015 and to businesses with 100 or more employees instead of ten or more; medium-sized enterprises have 100-299 employees. Data include leased lines and mobile broadband.

For Korea, data refer to 2015.

For Mexico, data refer to 2012.

For New Zealand, data refer to the fiscal year 2015/16 ending on 30 June.

For Switzerland, data refer to 2015. Small firms have 5-49 employees instead of 10-49.

6.3. Internet users

Total, daily and mobile Internet users, 2016

Unless otherwise stated, Internet users are defined for a recall period of 3 months. For Australia, Canada and Japan, the recall period is 12 months. For the United States, the recall period is 6 months for 2015, and no time period is specified in 2006. For Korea and New Zealand, the recall period is 12 months in 2006. For Chile in 2009, China, India, Indonesia, the Russian Federation and South Africa, no time period is specified.

For Australia, data refer to the fiscal years 2006/07 ending on 30 June and 2014/15.

For Brazil, data refer to 2008 and 2015.

For Canada, data refer to 2007 and 2012. In 2007, data refer to individuals aged 16 and over instead of 16-74.

For Iceland and Switzerland, data refer to 2014 instead of 2016.

For Israel, data refer to 2015 instead of 2016 and to individuals aged 20 and more instead of 16-74.

For Japan, data refer to 2015 instead of 2016 and to individuals aged 15-69.

For Korea, data refer to 2015 instead of 2016.

Notes for all users:

For Chile, data refer to 2009 and 2015.

For China, India, Indonesia, the Russian Federation and South Africa, data originate from ITU, ITU World Telecommunication/ICT Indicators Database, and refer to 2015 instead of 2016.

For Indonesia, data relates to individuals aged 5 or more.

For New Zealand, data refer to 2012 instead of 2016.

For Turkey, data refer to 2007 instead of 2006.

For the United States, data refer to 2007 and 2015.

Notes for daily users:

For the Russian Federation, data originate from ITU, ITU World Telecommunication/ICT Indicators (WTI) Database, and refer to 2014 instead of 2016.

Notes for mobile users:

For Israel, data refer to individuals who use the Internet through a mobile phone, from any location.

For New Zealand, data originate from Statistics New Zealand. Data refer to 2012 and to individuals aged 15-74. Data include individuals using cellular and wireless or both.

For Switzerland, data refer to Internet users who have personal use of a mobile device to access the Internet outside home or work.

For the United States, data originate from the NTIA and relate to 2015. Data refer to the proportion of individuals aged 15 or more who use the Internet while travelling between places, as a proportion of individuals aged 15 or more who use the Internet at any location.

Gap in Internet use by educational attainment, 2016

Unless otherwise stated, Internet users are defined for a recall period of 3 months. For Australia, the recall period is 12 months. For the Russian Federation, no time period is specified. For the United States, the recall period is 6 months for 2015.

For Australia, data refer to the fiscal year 2014/15 ending on 30 June.

For Brazil, Chile, Israel, Korea and the United States, data refer to 2015.

For Iceland and Switzerland, data refer to 2014.

For Israel, data refer to individuals aged 20 and more instead of 16-74.

For New Zealand, data refer to 2012.

For the Russian Federation, data originate from ITU, ITU World Telecommunication/ICT Indicators Database. Data refer to 2015 for all Internet users and to 2014 by educational attainment.

Women Internet users, by age, 2016

Unless otherwise stated, Internet users are defined for a recall period of 3 months. For Canada and Japan, the recall period is 12 months. For the United States, the recall period is 6 months.

For Australia, data refer to the fiscal year 2014/15 ending on 30 June.

For Brazil, Chile, Israel, Japan, Korea and the United States, data refer to 2015.

For Canada and New Zealand, data refer to 2012.

For Iceland and Switzerland, data refer to 2014.

For Israel, data refer to women aged 20 and over instead of 16-74, and to 20-24 instead of 16-24.

For Japan, data refer to women aged 15-69 instead of 16-74, and to 15-29 instead of 16-24.

6.4 User sophistication

Diffusion of selected online activities among Internet users in OECD countries, by age and educational attainment, 2016

For a given activity:

(i) Data are computed on the basis of the same group of OECD countries for both age categories.

(ii) For both age categories, data relate to the average of all individuals ("Average"), the average of all individuals with low or no formal education, and the average of all individuals with tertiary educational attainment.

For all activities, the average for all individuals relates to a number of OECD countries ranging from 20 to 24, according to data availability for both age categories. Therefore, the OECD average for a given activity in this figure may differ from values provided in other figures.

Tertiary education refers to ISCED levels 5 or 6 and above. Low or no formal education refers to ISCED levels 0 to 2.

Individuals who purchased online in the last 12 months, by age, 2016

Unless otherwise stated, Internet users are defined for a recall period of 3 months. For Australia, Canada and Japan, the recall period is 12 months. For Chile and the Russian Federation, no time period is specified. For the United States, the recall period is 6 months.

For Australia, data refer to the fiscal year 2014/15 ending on 30 June. The information provided is from a question wording that differs slightly from other countries: "In the last 3 months, did you personally access the Internet for any of the following reasons: Purchasing goods or services?".

For Brazil, data refer to 2015.

For Canada, data refer to 2012.

For Chile, data refer to 2015.

For Iceland, data refer to 2014.

For Israel, data refer to 2015 and to individuals aged 20 and over instead of 16-74, and 20-24 instead of 16-24. Data relate to individuals who used the Internet for purchasing goods or services in the last 3 months, and include all types of goods and services.

For Japan, data refer to 2015 and to individuals aged 15-69.

For Korea, data refer to 2015.

For New Zealand, data refer to 2012.

For the Russian Federation, data originate from ITU, ITU World Telecommunication/B17ICT Indicators Database, refer to 2014 and to individuals aged 15-72.

For Switzerland, data refer to 2014.

For the United States, data refer to 2015. The age gap in lighter blue is reversed. Individuals aged 55-74 have a slightly higher propensity to purchase online than individuals aged 16-24.

Individuals aged 16-24 who attended an online course, 2009 and 2016

For Austria, data refer to 2011 instead of 2009.

For Brazil and Denmark, data refer to 2015 instead of 2016.

For Canada, data refer to 2010 and 2012.

For Chile, data refer to 2012 and 2015.

For Iceland, data refer to 2013 instead of 2016.

For Korea, data refer to 2015.

For Mexico, data refer to 2014 instead of 2016. 2009 data include the category "to support efforts related to education and learning" and 2014 data are integrated into the category "to support education/training".

For the United States, data refer to 2015 with a reference period of 6 months.

6.5 E-consumers across borders

Enterprises having undertaken cross-border e-commerce sales, 2014

E-commerce sales refer to web sales (orders received via websites).

For Iceland, data refer to 2012.

Individuals purchasing online from domestic and foreign markets, 2016

Partner countries refer to other EU countries for countries in the European Statistical System and to the United States for Canada.

For Canada, data refer to 2012.

Business to consumer transactions (B2C), 2009 and 2015

For Iceland, data refer to 2011 instead of 2015.

For Latvia, data refer to 2013 instead of 2015.

For Portugal, data refer to 2014 instead of 2015.

For the United States, data originate from the US Bureau of the Census, Quarterly Retail E-commerce sales, 1st Quarter 2017 (*https://www.census.gov/retail/mrts/www/data/pdf/ec_current.pdf*). The ratios have been calculated using the quarterly values of the respective years of the adjusted values, as provided in Table 1.

6.6. E-government

Individuals using the Internet to interact with public authorities, by age, 2016

Unless otherwise stated, data refer to the respective online activities in the last 12 months.

For Australia, data refer to the fiscal years 2010/11 ending on 30 June and 2012/13. Data refer to "Individuals who have used the Internet for downloading official forms from government organisations' websites, in the last 12 months" and "Individuals who have used the Internet for completing/lodging filled in forms from government organisations' websites, in the last 12 months".

For Brazil and Chile, data refer to 2015.

For Canada, data refer to 2012.

For Iceland and Switzerland, data refer to 2014.

For Israel, data refer to 2015 and to individuals aged 20 and more instead of 16-74. Data relate to the Internet use for obtaining services online from government offices, including downloading or filling in official forms in the last 3 months.

For New Zealand, data refer to 2012 and to individuals using the Internet for obtaining information from public authorities in the last 12 months.

For Japan, data refer to 2015 and to individuals aged 15-69 instead of 16-74 using the Internet for sending filled forms via public authority websites in the last 12 months.

For Mexico, using e-government services includes the following categories: "communicating with the government", "consulting government information", "downloading government forms", "filling out or submitting government forms", "carrying out government procedures" and "participating in government consultations". For "sending forms", data correspond to the use of the Internet in the last 3 months.

For Switzerland, e-government refers only to public administrations at local, regional or country level referred as "public administration or authorities". Data exclude health or education institutions.

Individuals not submitting official forms online due to privacy and security concerns, 2016

For Iceland, data refer to 2014.

For the United Kingdom, data refer to 2014 instead of 2013.

6.7. Trust

Enterprises having a formally defined security policy, by size, 2015

Data for SMEs contracting out digital security services refer to the share of SMEs who have a formal ICT security policy where the security and data protection are mainly performed by external suppliers.

References

Brezzi, M., L. Dijkstra and V. Ruiz (2011), "OECD extended regional typology: The economic performance of remote rural regions", *OECD Regional Development Working Papers*, 2011/06, OECD Publishing, *http://dx.doi.org/10.1787/5kg6z83tw7f4-en*.

Kaiser, M. (2011), Prepared testimony of the National Cyber Security Alliance on the State of Cybersecurity and Small Business before the Committee on House Small Business Subcommittee on Healthcare and Technology, United States House of Representatives, 1 December, *http://smallbusiness.house.gov/uploadedfiles/kaiser_testimony.pdf*.

OECD (2011), *OECD Guide to Measuring the Information Society 2011*, OECD Publishing, Paris, http://dx.doi.org/10.1787/9789264113541-en.

OECD (2015a), *OECD Digital Economy Outlook 2015*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/9789264232440-en*.

OECD (2015b), *The OECD Model Survey on ICT Access and Usage by Households and Individuals, 2nd Revision*, Working Party on Measurement and Analysis of the Digital Economy, OECD, Paris, *https://www.oecd.org/sti/ieconomy/ICT-Model-Survey-Access-Usage-Households-Individuals.pdf*.

OECD (2015c), *The OECD Model Survey on ICT Access and Usage by Businesses, 2nd Revision*, Working Party on Measurement and Analysis of the Digital Economy, OECD, Paris, *https://www.oecd.org/sti/ieconomy/ICT-Model-Survey-Usage-Businesses.pdf*.

Data sources

For information on Measuring Science, Technology and Innovation at the OECD, see *http://oe.cd/sti-stats*

OECD data sources

OECD, Activity of Multinational Enterprises Database, *http://oe.cd/amne*

OECD, ANBERD Database, *http://oe.cd/anberd*

OECD, Annual National Accounts Database, *http://www.oecd.org/std/na*

OECD, Bilateral Trade Database by Industry and End-Use (BTDIxE), *http://oe.cd/btd*

OECD, Broadband Portal, *http://oe.cd/broadband*

OECD, Careers of Doctorate Holders 2017, *http://oe.cd/cdh*

OECD, DynEmp v.2 and v.3 Databases, preliminary data, *http://oe.cd/dynemp*

OECD, Education Database, *www.oecd.org/education/database.htm*

OECD, Entrepreneurship Financing Database

OECD, ICT Access and Usage by Businesses Database, *http://oe.cd/bus*

OECD, ICT Access and Usage by Households and Individuals Database, *http://oe.cd/hhind*

OECD, Inter-Country Input-Output (ICIO) Database, *http://oe.cd/icio*

OECD, International Survey of Scientific Authors, *http://oe.cd/issa*

OECD, Main Science and Technology Indicators Database, *http://oe.cd/msti*

OECD, microBeRD project, *http://oe.cd/microberd*

OECD, PISA 2015 Database, *www.oecd.org/pisa/data/2015database*

OECD, Productivity Database, *www.oecd.org/std/productivity-stats*

OECD, Programme for International Assessment of Adult Competencies (PIAAC) Database, *www.oecd.org/skills/piaac/publicdataandanalysis*

OECD, R&D Tax Incentive Indicators, *http://oe.cd/rdtax*

OECD, Research and Development Statistics database, *http://oe.cd/rds*

OECD, STI Micro-data Lab: Intellectual Property Database, *http://oe.cd/ipstats*

OECD, Structural Analysis (STAN) Database, *http://oe.cd/stan*

OECD, Survey of national innovation statistics, http://oe.cd/inno-stats

OECD, Trade in Employment (TiM), http://oe.cd/io-emp

OECD, Trade in Value Added (TiVA) Database, *http://oe.cd/tiva*

OECD, Scopus Custom Data, Elsevier, Version 4.2017, http://oe.cd/scientometrics

Other data sources

European Commission, World Input-Output Database (WIOD), *www.wiod.org/home*

Eurostat, Community Innovation Survey (CIS-2014), *http://ec.europa.eu/eurostat/web/science-technology-innovation/data/database*

Eurostat, Digital Economy and Society Statistics, Comprehensive Database, *http://ec.europa.eu/eurostat/web/digital-economy-and-society/data/comprehensive-database*

Eurostat, EU-KLEMS Database, *www.euklems.net*

Eurostat, European Labour Force Surveys (EULFS), *http://ec.europa.eu/eurostat/web/lfs/data/database*

Eurostat, Inward FATS Database, *http://ec.europa.eu/eurostat/web/structural-business-statistics/global-value-chains/foreign-affiliates*

Eurostat, Statistics on Research and Development, *http://ec.europa.eu/eurostat/web/science-technology-innovation/data/database*

GMSA Intelligence, *www.gsmaintelligence.com*

INTAN-Invest, Cross-Country Intangible Investment Database, *www.intan-invest.net*

International Federation of Robotics, *https://ifr.org*

ITU, World Telecommunication/ICT Indicators Database, *www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx*

JRC-OECD, COR&DIP© Database v.1., *http://oe.cd/ipstats*

oaDOI API, *https://oaDOI.org*

Smart Public intangibles (SPINTAN), *www.spintan.net*

UNESCO Institute for Statistics, Research and experimental development (full dataset), *http://data.uis.unesco.org/Index.aspx?DataSetCode=SCN_DS*

US Bureau of Economic Analysis (BEA) Satellite Accounts, *www.bea.gov/industry/satdef.htm*

US Census Bureau, United States Current Population Survey (CPS), www.census.gov/cps

US Census Bureau, Quarterly Retail E-Commerce Sales, 1st Quarter 2017, *www2.census.gov/retail/releases/historical/ecomm/17q1.pdf*

World Bank, Word Development Indicators Database, *https://data.worldbank.org/data-catalog/world-development-indicators*

STI Micro-data Lab

The STI Micro-data Lab, a data infrastructure project of the OECD Directorate for Science, Technology and Innovation (STI), gathers and links large-scale administrative and commercial micro-level datasets. These micro-data, which complement and enhance official statistics like macro-aggregated or survey-based data, have the advantage of being granular in nature and comprehensive in time and geographical coverage.

These include administrative data on intellectual property (IP) assets, including patents, trademarks and registered designs that are collected in the framework of the OECD-led IP Statistics Task Force composed of representatives from IP offices worldwide. Bibliometric records on scientific publications and company level information, originating from private providers, complement the micro-data.

The different micro datasets of the STI Microdata Lab can be used in an independent fashion, e.g. to develop indicators related to specific analytical questions, or combined in such a way as to generate new information related to a broader array of issues or to more complex dynamics. By providing detailed information about the behaviour of economic agents and the way science and technology develop, these data help address policy-relevant questions, such as those related to the generation and diffusion of new technologies, the different ways in which firms innovate, science-industry links, researchers' mobility patterns or the role of knowledge-based assets in firms' economic performance.

The STI Micro-data Lab is open to visiting researchers. Access is granted free of charge upon the submission of a formal request, and subject to the respect of confidentiality rules and to the project being of mutual interest to the OECD and the visiting fellow(s).

List of figures

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THE DIGITAL TRANSFORMATION

The biennial OECD Science, Technology and Industry (STI) Scoreboard features indicators traditionally used to monitor developments in science, technology, innovation and industry, and complements them with experimental indicators that provide new insights into areas of policy interest. These include: investment in knowledge-based capital, skills in the digital era, the international mobility of researchers, the digital transformation in firms and industries, innovation strategies, the internationalisation of research, changing patterns in trade competitiveness and productivity, as well as the use of technology in everyday life.

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This publication is a contribution to the OECD Going Digital project, which aims to provide policymakers with the tools they need to help their economies and societies prosper in an increasingly digital and data-driven world.

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