

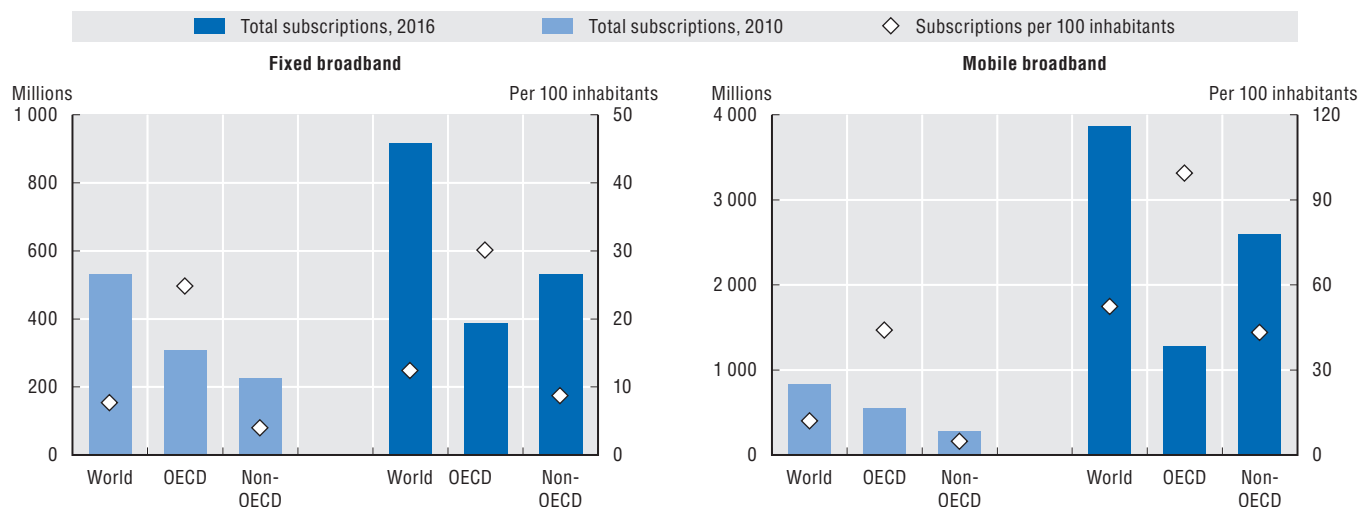
## 1. Science, innovation and the digital revolution

### 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

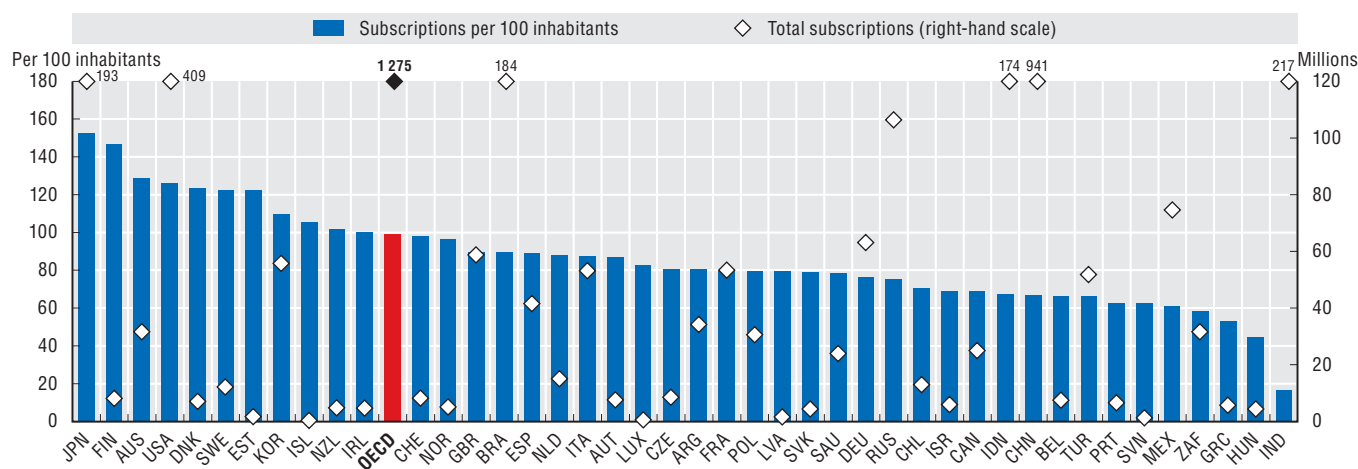


Source: OECD, Broadband Portal, <http://oe.cd/broadband> and ITU, World Telecommunication/ICT Indicators Database, July 2017.

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

### 2. Mobile broadband penetration, OECD, G20 and BRICS, 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.

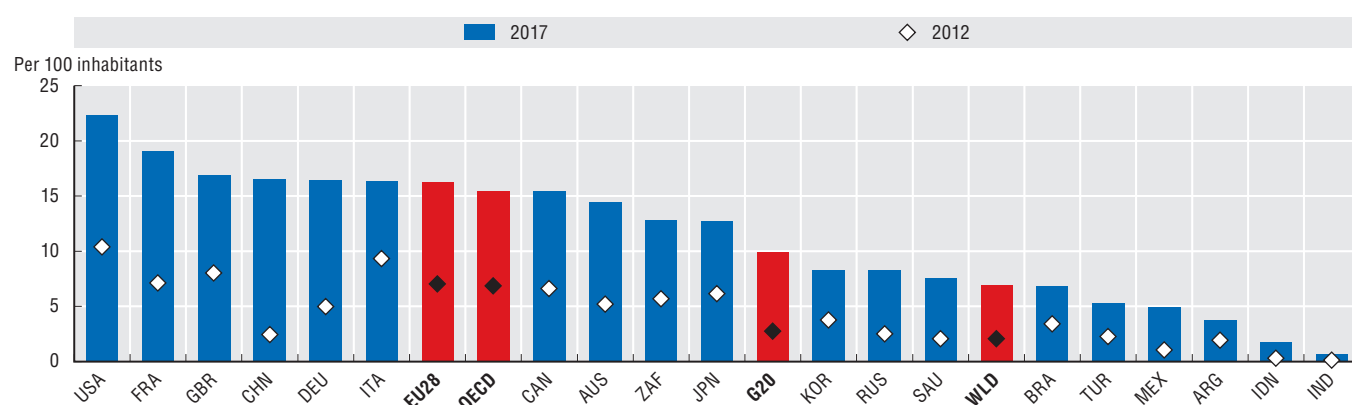
StatLink <http://dx.doi.org/10.1787/888933616883>

### 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

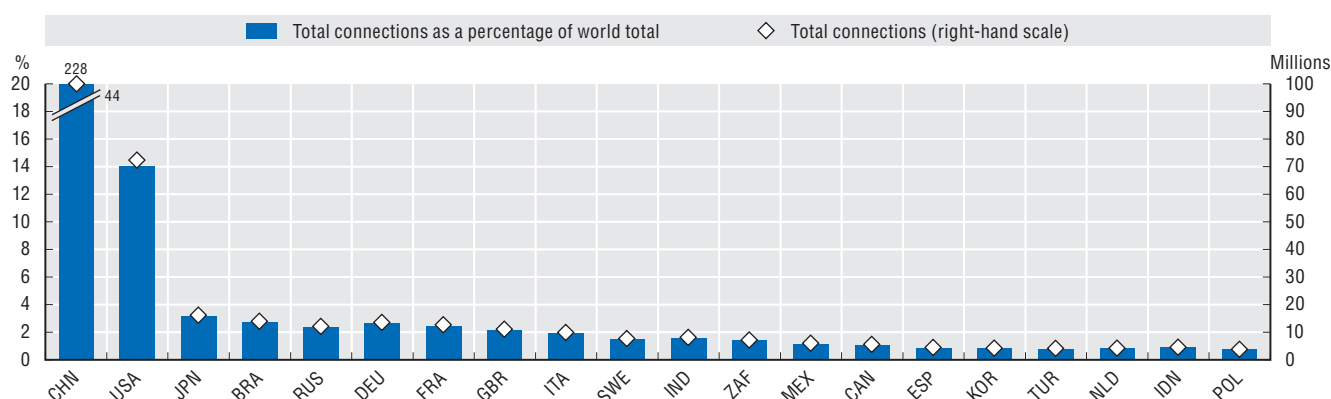


Source: OECD calculations based on GSMA Intelligence, September 2017. StatLink contains more data. See chapter notes.

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](http://www.gsmaintelligence.com).

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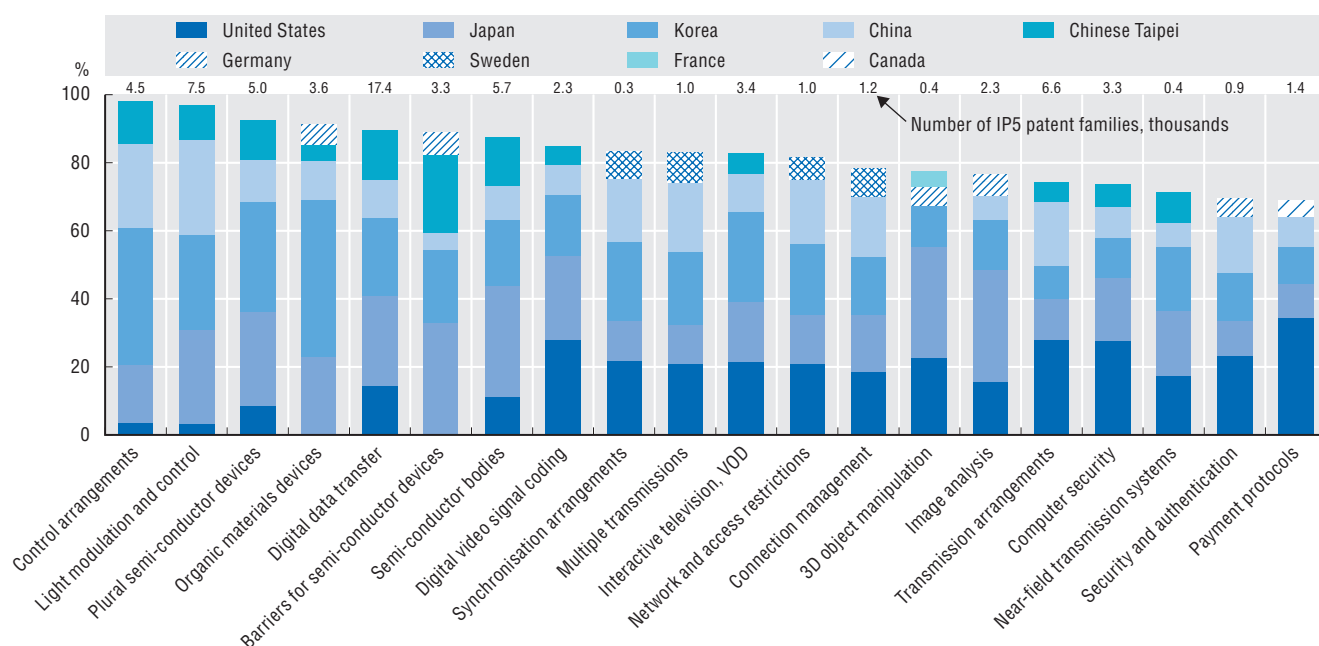
## 1. Science, innovation and the digital revolution

### 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.

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### Identifying acceleration in technological development

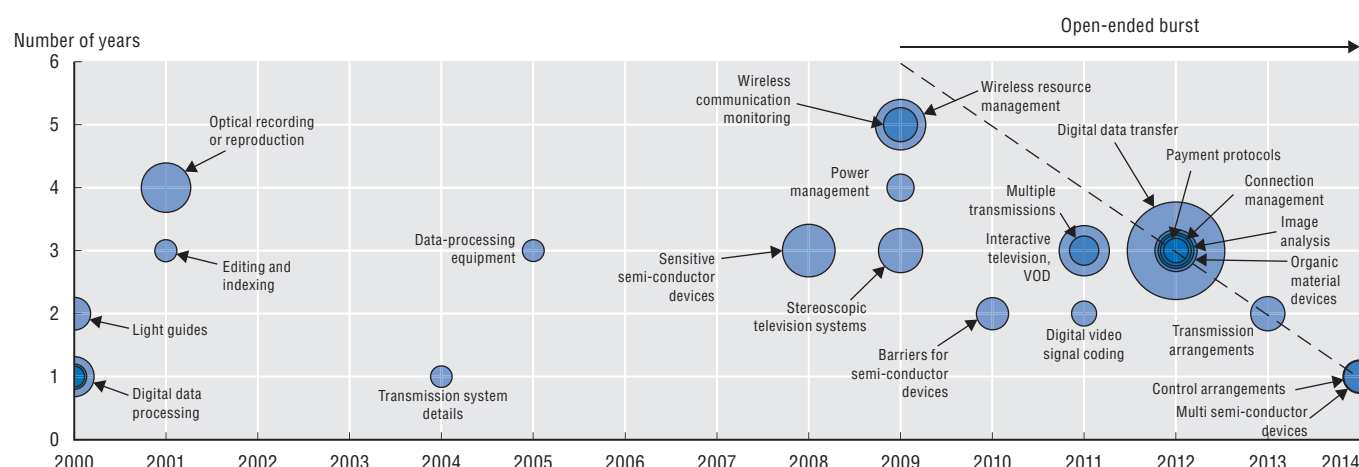
Patents protect novel inventions and technologies, and patent data can help investigate a number of policy-relevant issues related to innovation and technological development. A new data mining approach called “DETECTS” (see Dernis et al., 2016), exploits information contained in patents to identify 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.

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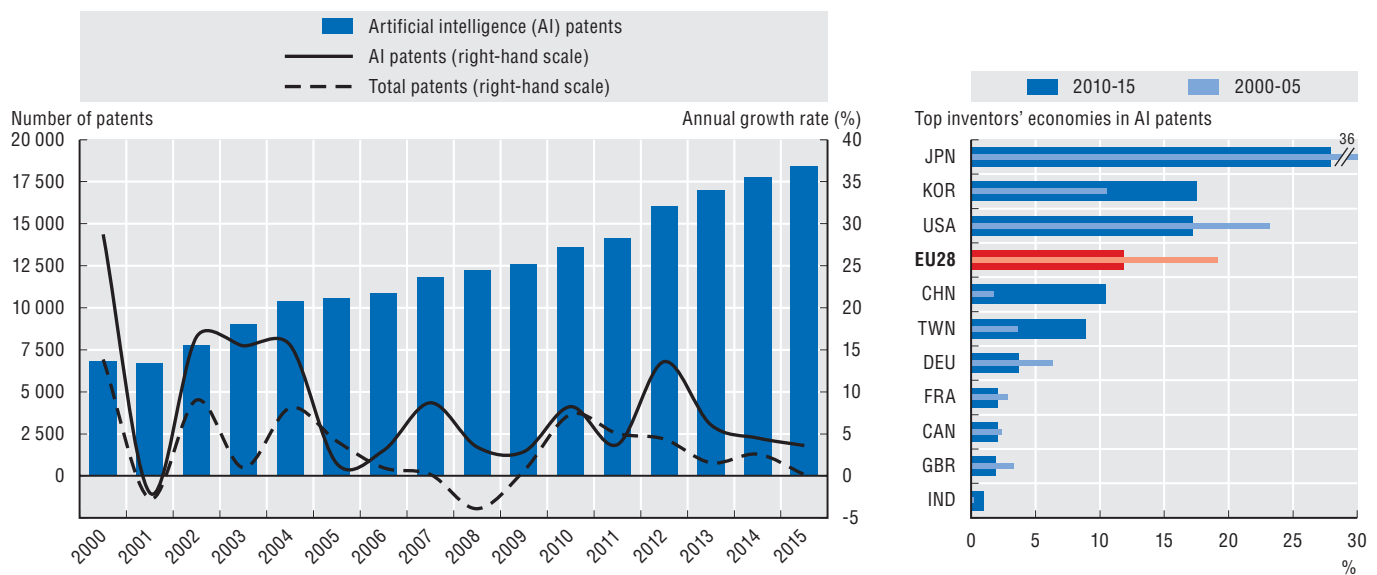
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### Artificial intelligence

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.

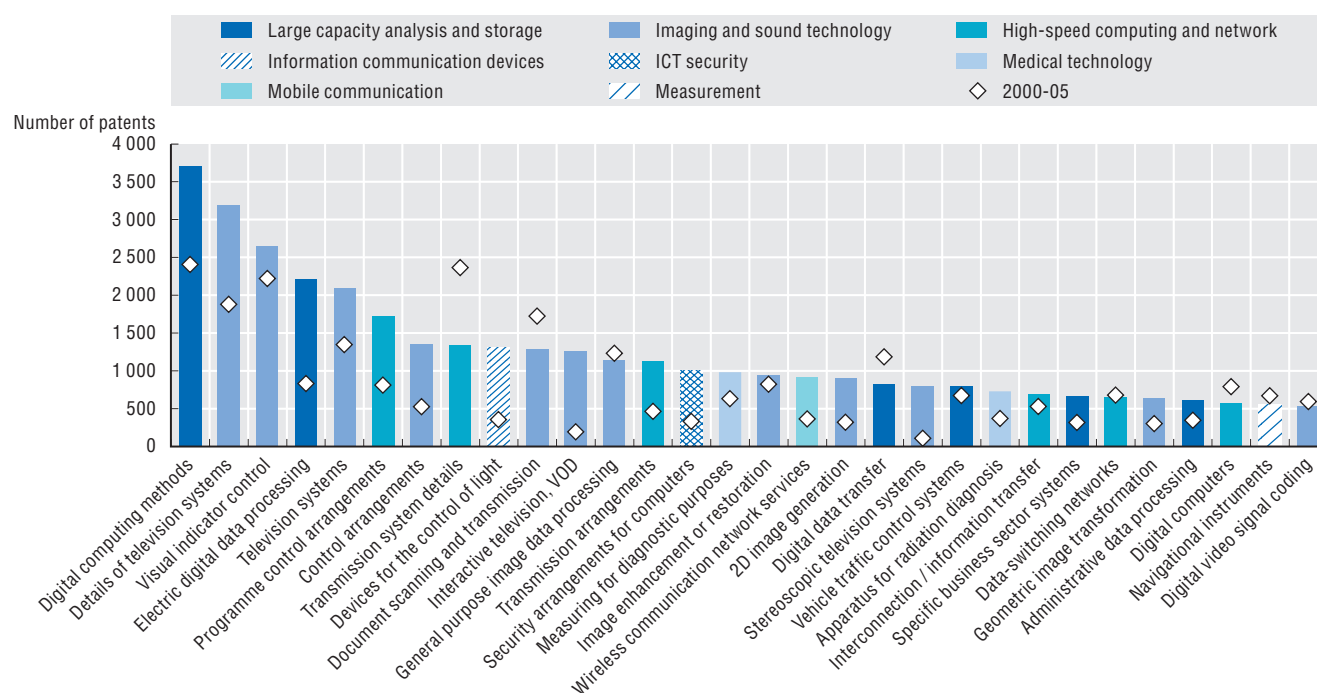
As inventions protected by patents can be assigned to a number of technology classes at the same time, it is possible to investigate the extent to which AI is combined with other technologies by examining the “co-occurrence” of IPC codes in patent families (i.e. the listing of several IPC codes in the 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

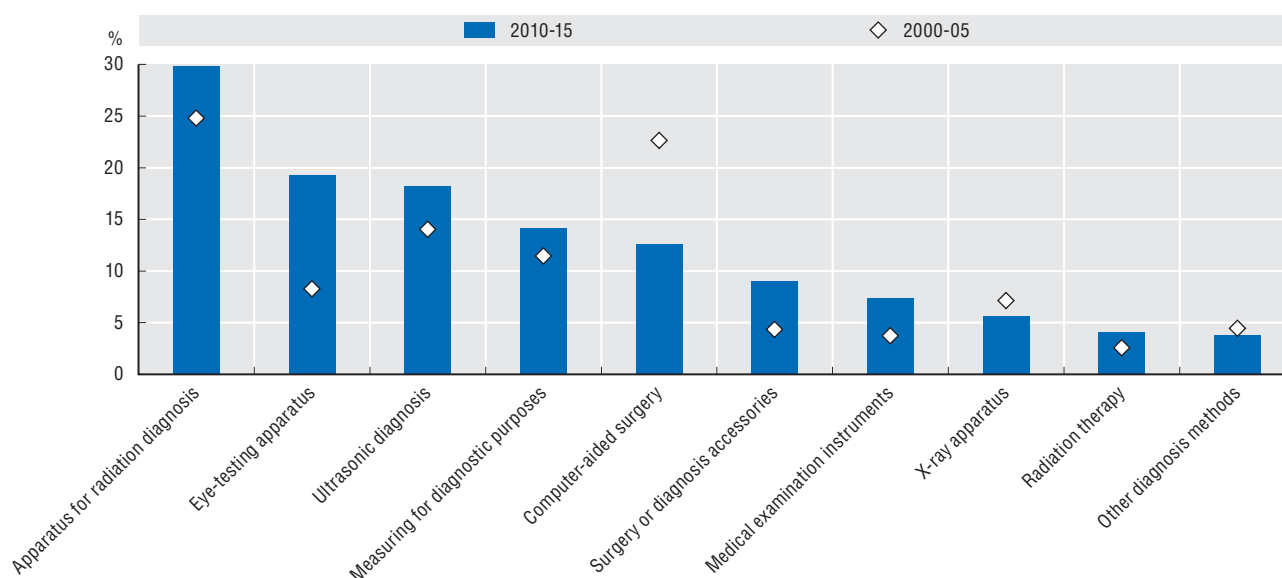


Source: OECD, STI Micro-data Lab: Intellectual Property Database, <http://oe.cd/ipstats>, June 2017. StatLink contains more data. See chapter notes.

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.

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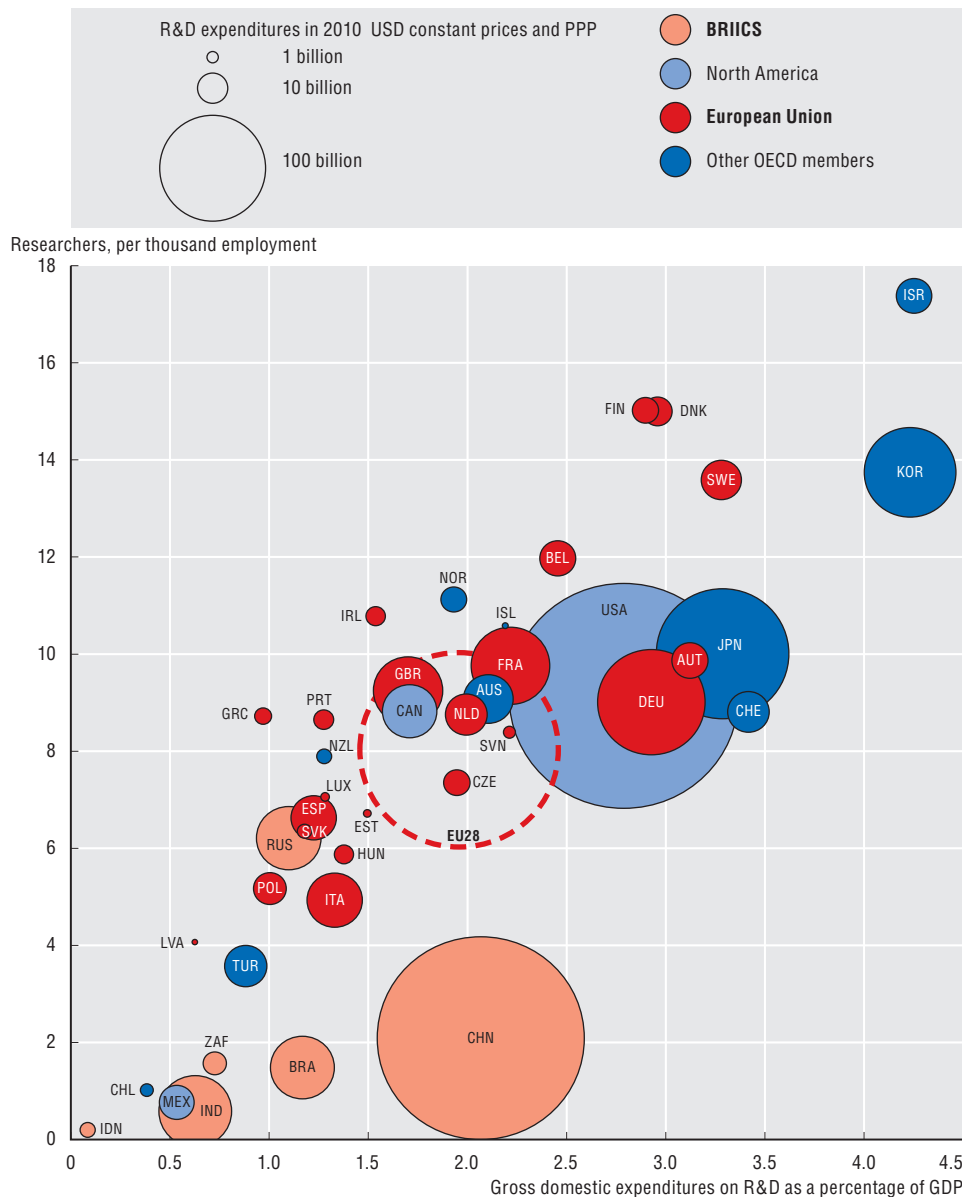
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### Science landscape

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.

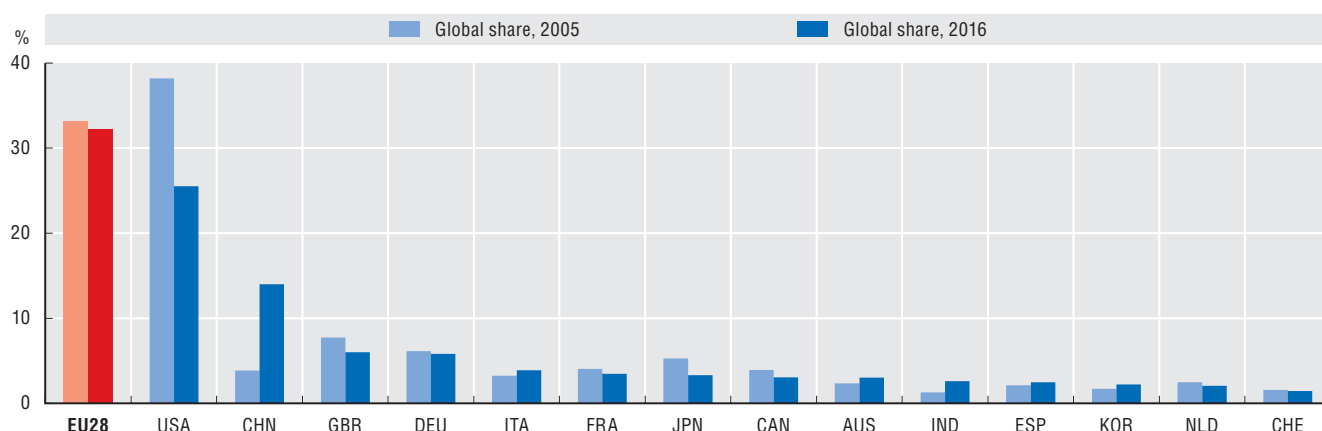
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## Top science

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

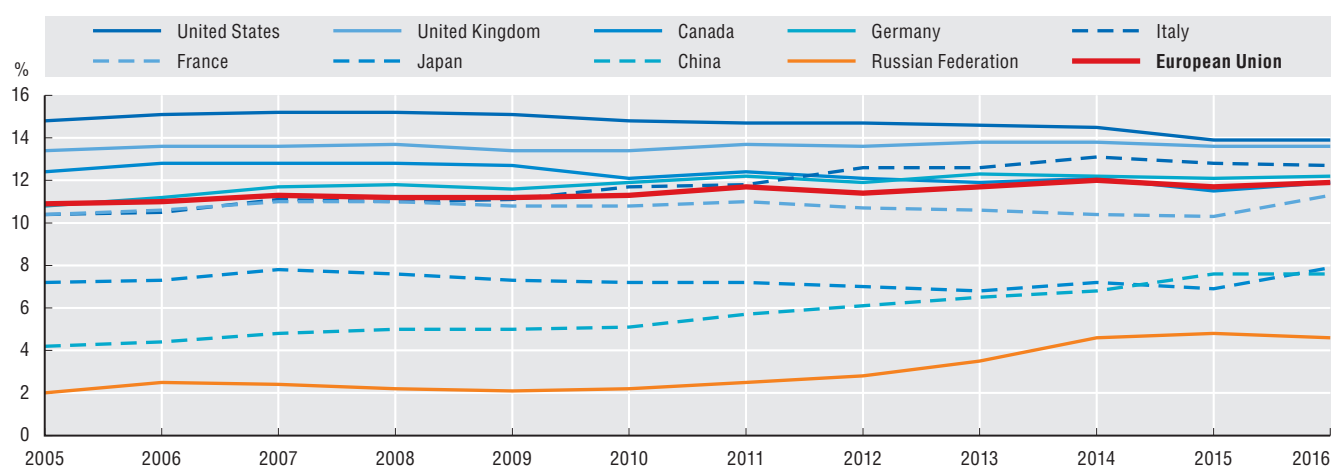


Source: OECD calculations based on Scopus Custom Data, Elsevier, Version 4.2017, July 2017. StatLink contains more data. See chapter notes.

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.



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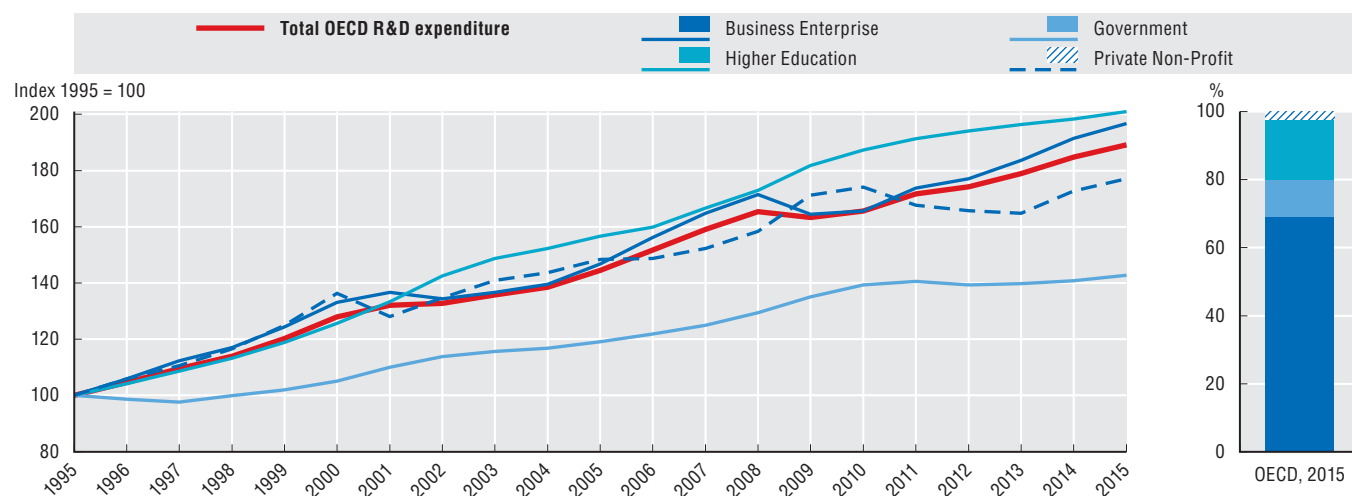
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### R&D trends

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

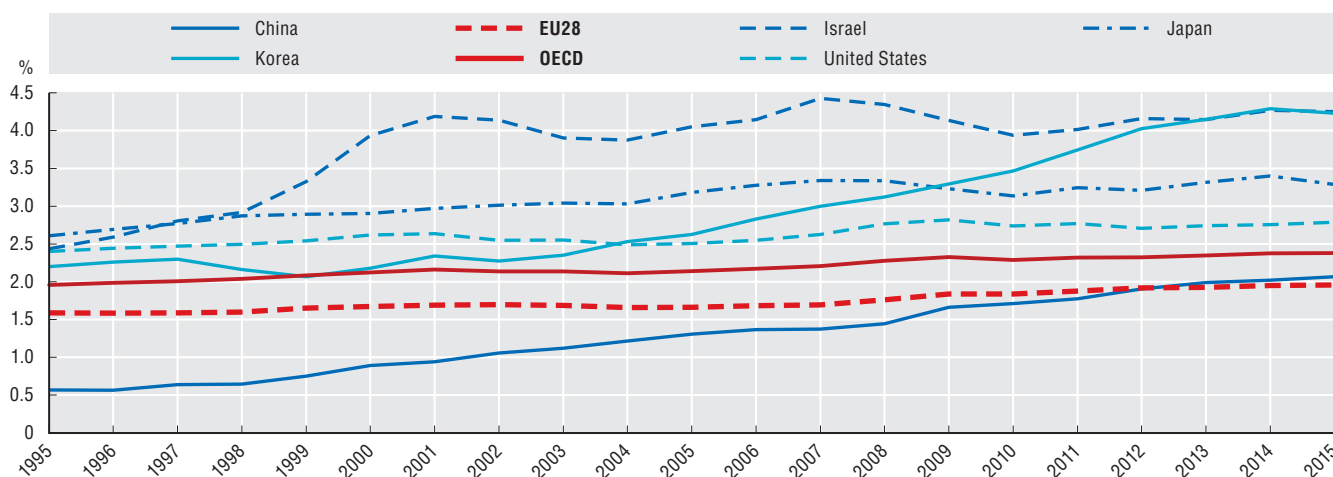


Source: OECD, Main Science and Technology Indicators Database, <http://oe.cd/msti>, July 2017. See chapter notes.

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.

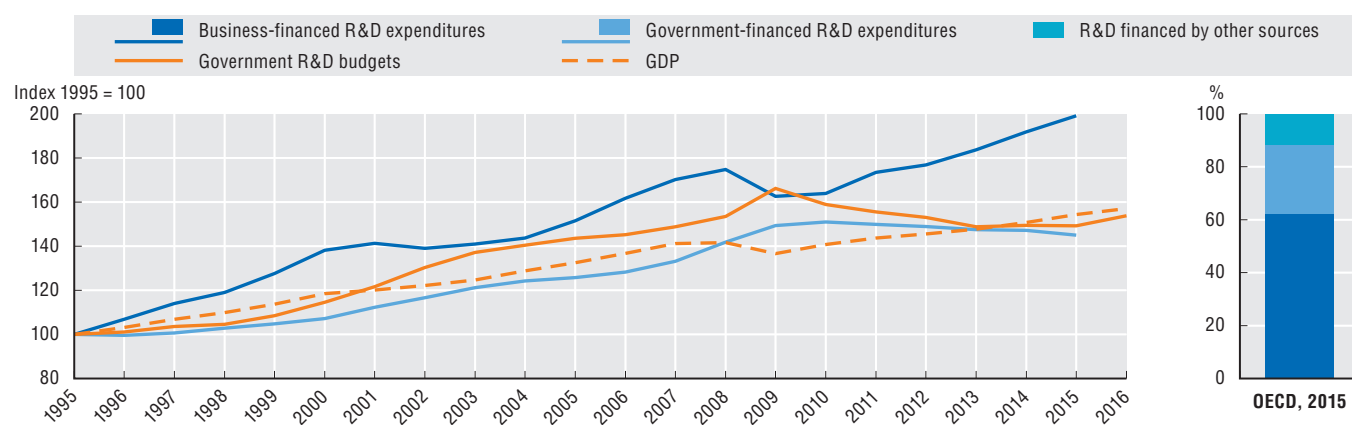
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## R&D trends

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

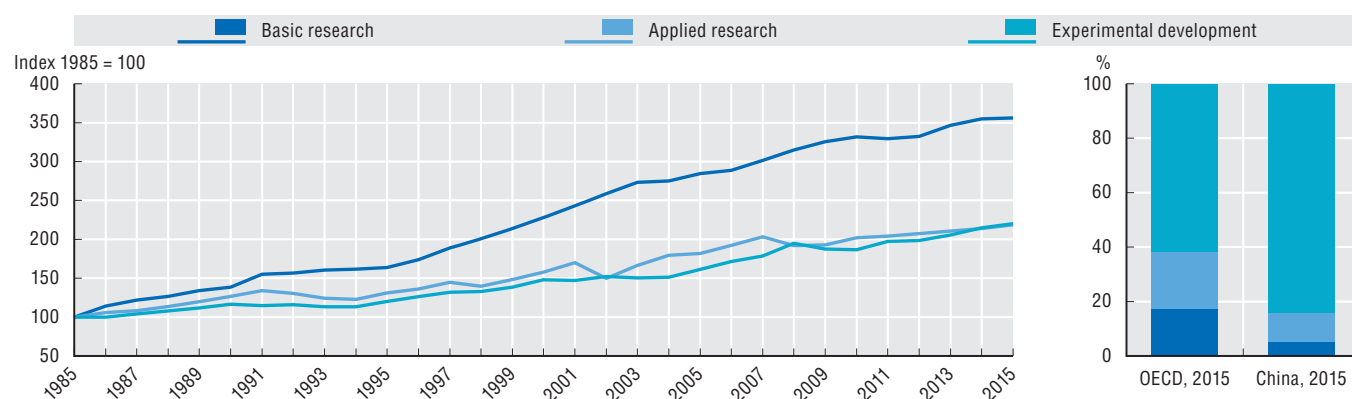


Source: OECD, Main Science and Technology Indicators Database, <http://oe.cd/msti>, July 2017. See chapter notes.

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.

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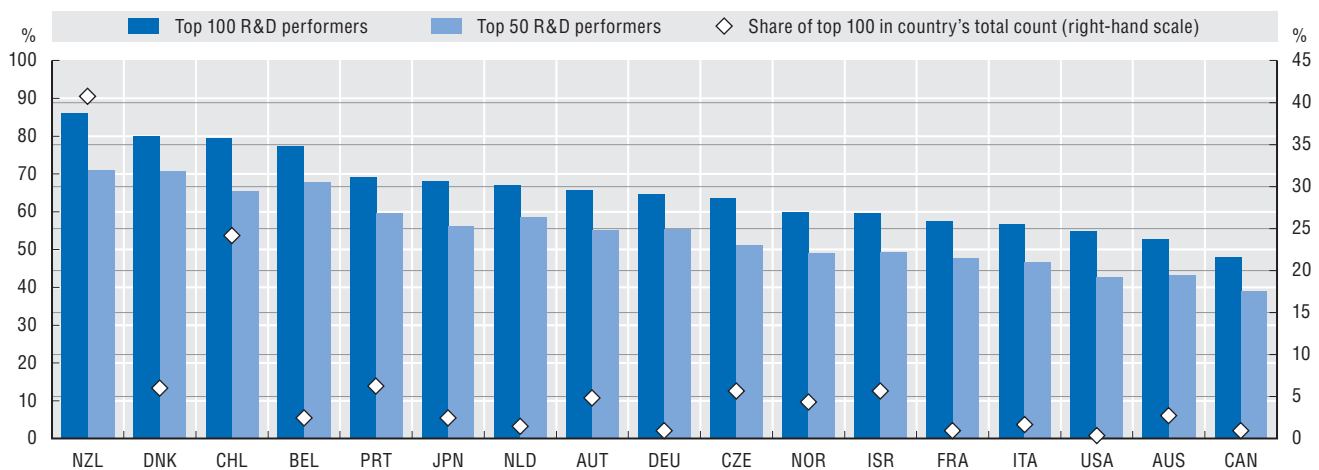
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### Concentration of business R&D

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.

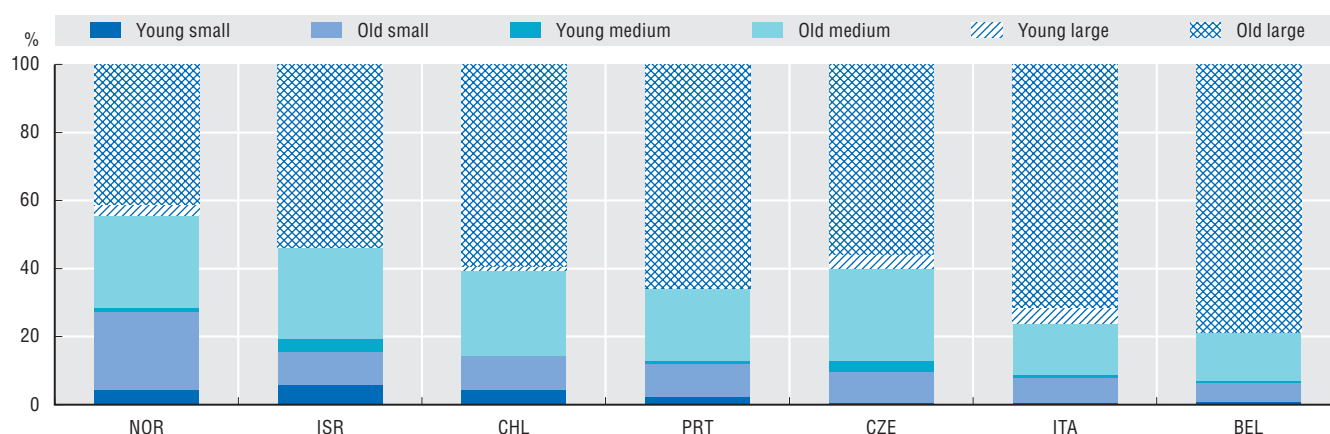
For more information on the microBeRD project, see <http://oe.cd/microberd>.

### 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

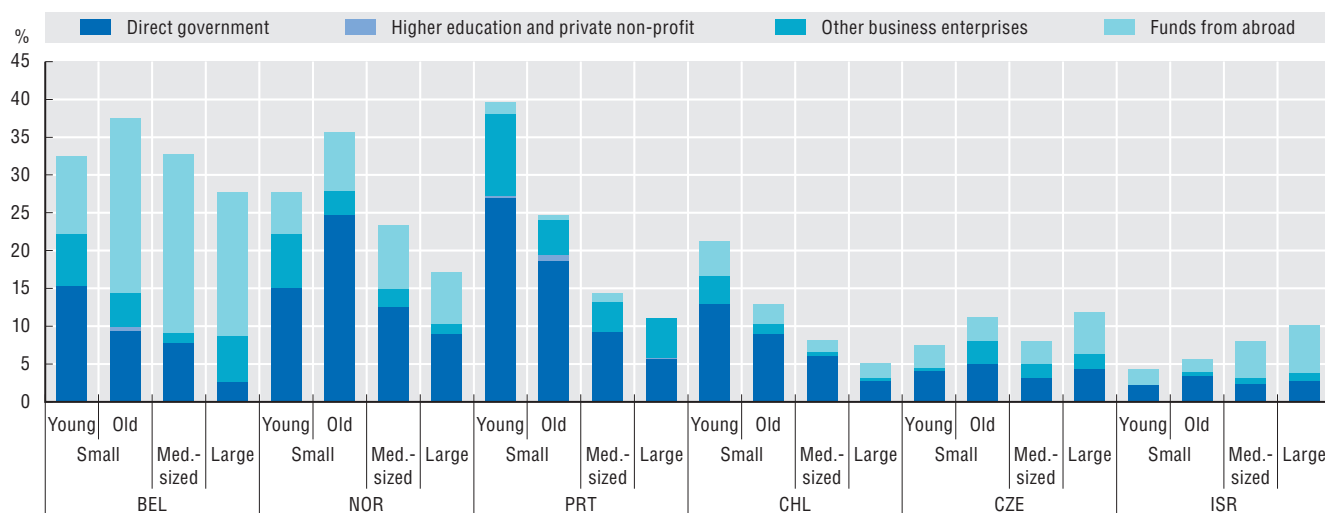


Source: OECD, based on preliminary results from the OECD microBeRD project, <http://oe.cd/microberd>, July 2017. See chapter notes.

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>

# 1. KNOWLEDGE ECONOMIES AND THE DIGITAL TRANSFORMATION

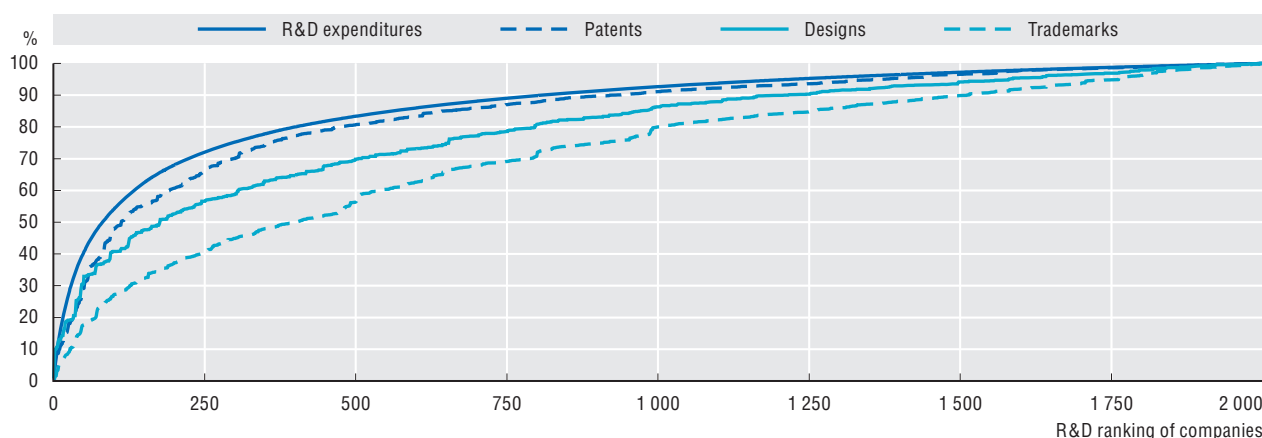
## 1. Science, innovation and the digital revolution

### 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

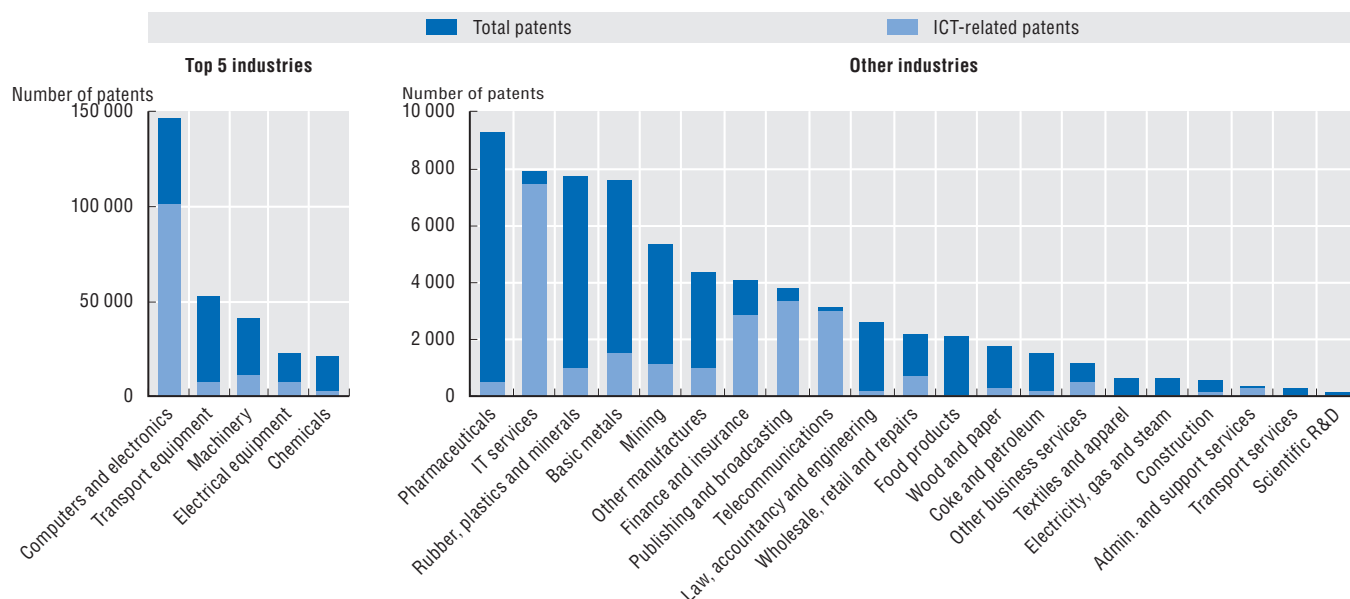


Source: OECD calculations based on JRC-OECD, COR&DIP® Database v.1, July 2017. See chapter notes.

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.

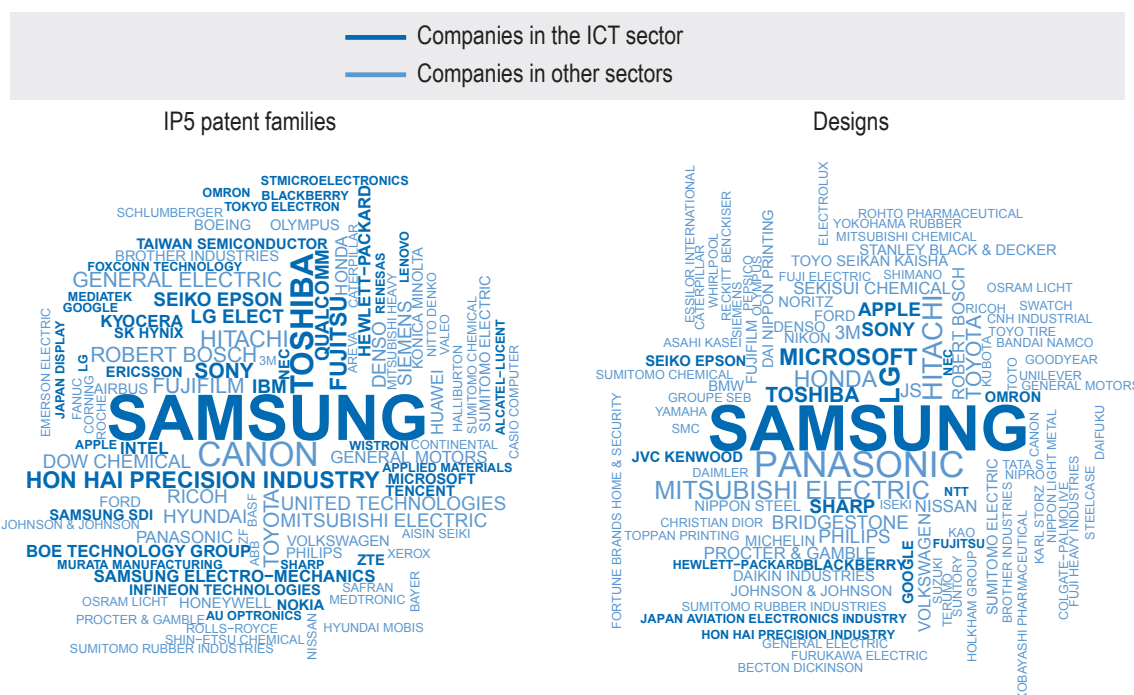
StatLink <http://dx.doi.org/10.1787/888933617244>



### 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).



# 1. KNOWLEDGE ECONOMIES AND THE DIGITAL TRANSFORMATION

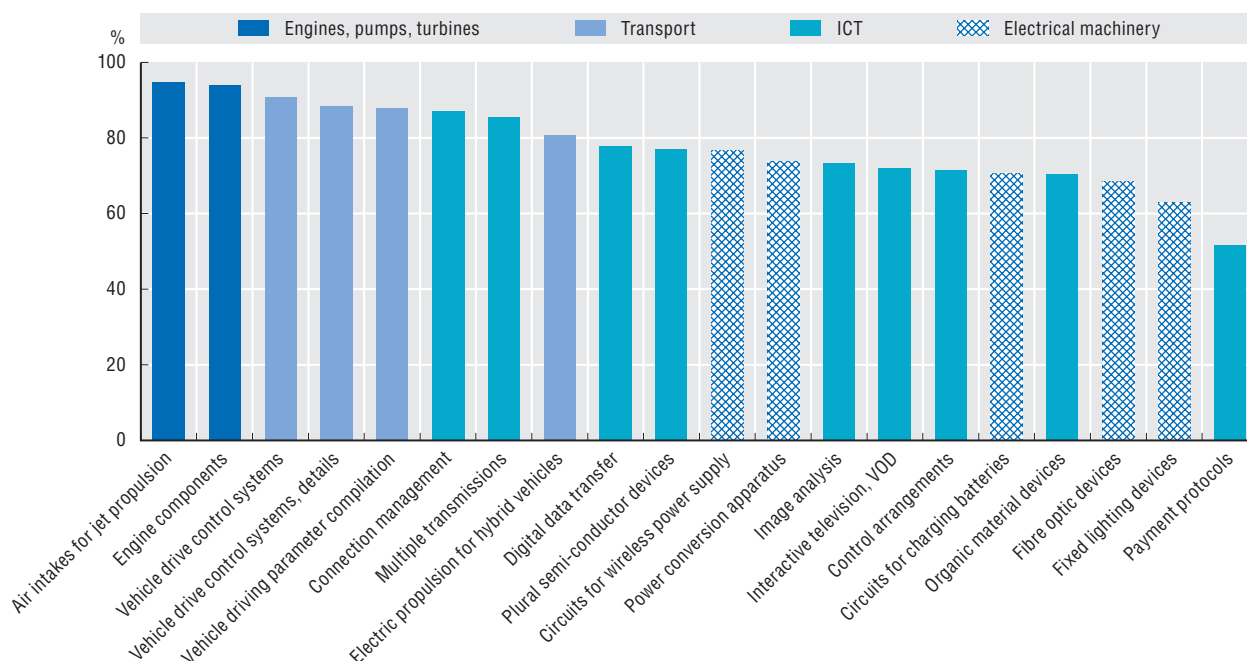
## 1. Science, innovation and the digital revolution

### 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?

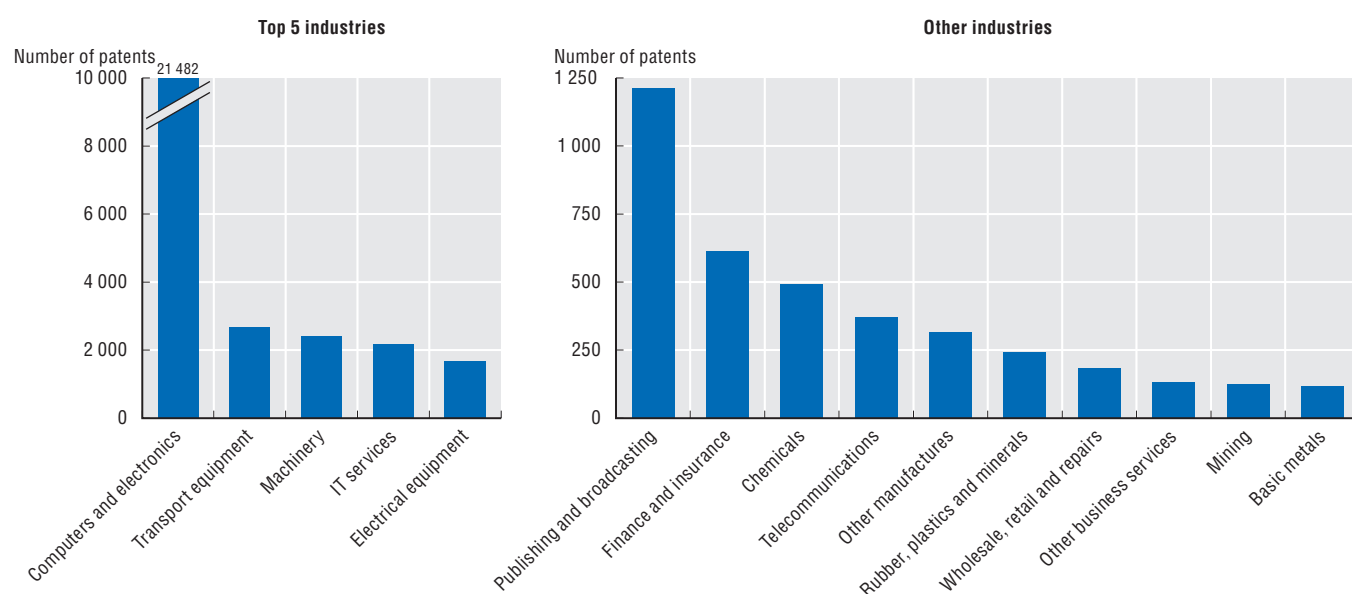
R&D activities undertaken by the world's top corporate R&D investors result in the development of new technologies. The DETECTS methodology (see Dernis et al., 2016, for details) was applied to the portfolio of top 2000 R&D players to highlight technology fields experiencing an accelerated ("bursting") 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

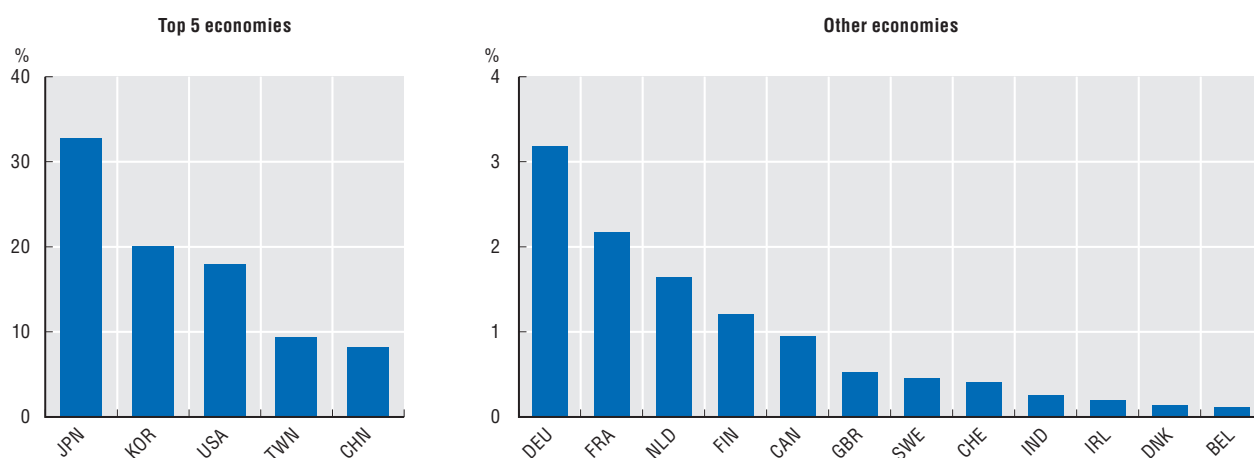


Source: OECD calculations based on JRC-OECD, COR&DIP© Database v.1. and OECD, STI Micro-data Lab: Intellectual Property Database, <http://oe.cd/ipstats>, July 2017. See chapter notes.

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>

# 1. KNOWLEDGE ECONOMIES AND THE DIGITAL TRANSFORMATION

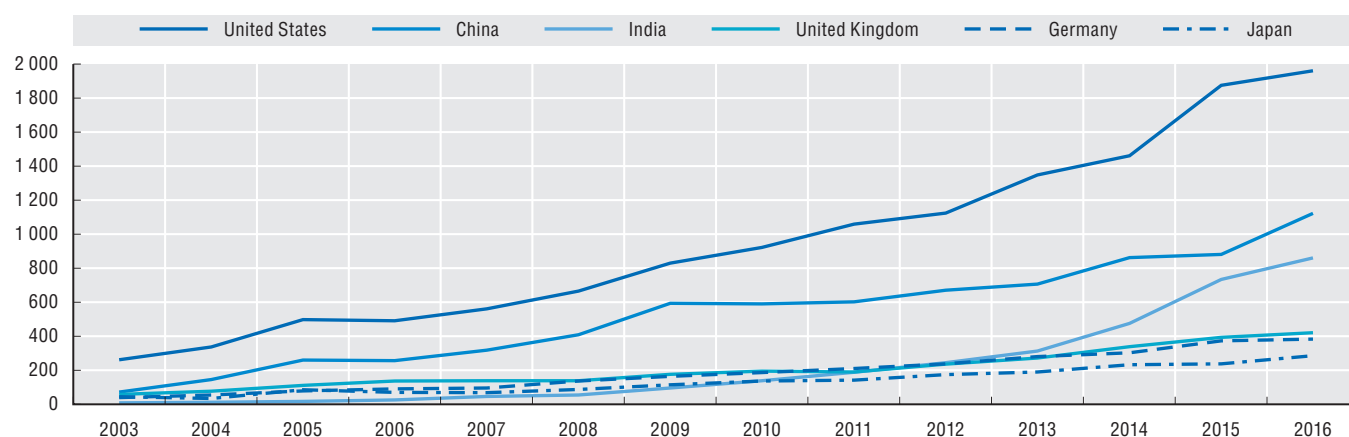
## 1. Science, innovation and the digital revolution

### 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

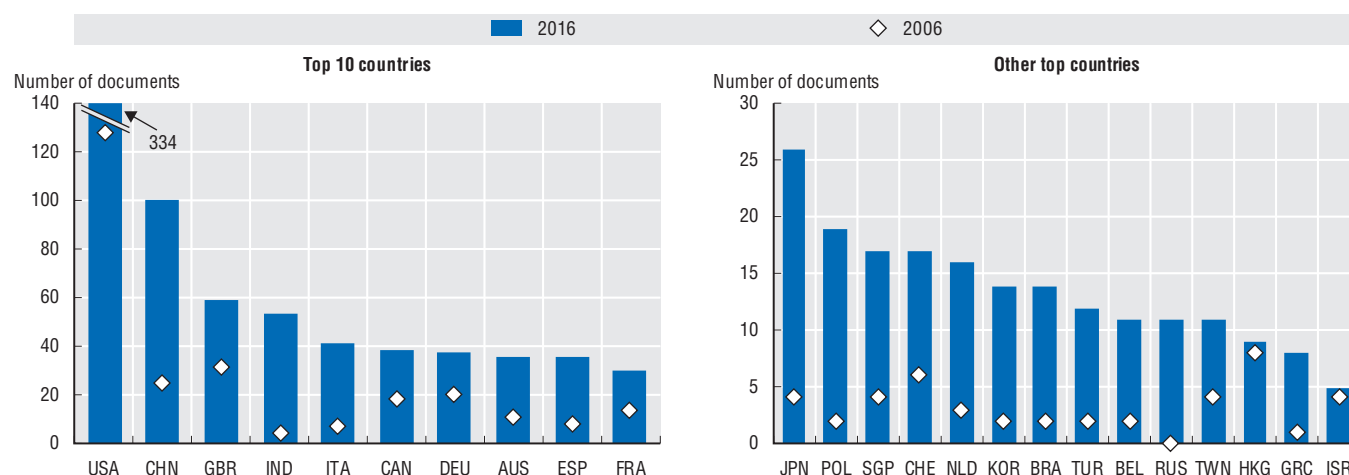


Source: OECD calculations based on Scopus Custom Data, Elsevier, Version 4.2017, July 2017. StatLink contains more data. See chapter notes.

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”.

## 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.gsmainelligence.com](http://www.gsmainelligence.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.gsmainelligence.com](http://www.gsmainelligence.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 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.



### 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 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.

### 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 indicators 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 coefficient 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 (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.

### 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 accommodation; 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 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.

### 68. International 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](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](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](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.

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From:

## OECD Science, Technology and Industry Scoreboard 2017

The digital transformation

Access the complete publication at:

<https://doi.org/10.1787/9789264268821-en>

### Please cite this chapter as:

OECD (2017), “Science, innovation and the digital revolution”, in *OECD Science, Technology and Industry Scoreboard 2017: The digital transformation*, OECD Publishing, Paris.

DOI: [https://doi.org/10.1787/sti\\_scoreboard-2017-4-en](https://doi.org/10.1787/sti_scoreboard-2017-4-en)

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